Cardiac Surgery

The Society for
Cardiothoracic Surgery
in Great Britain & Ireland

Sixth
National Adult Cardiac Surgical Database Report 2008

Demonstrating quality

Prepared by

Ben Bridgewater PhD FRCS
Bruce Keogh KBE DSc MD FRCS FRCP
on behalf of the Society for Cardiothoracic Surgery in Great Britain & Ireland

Robin Kinsman BSc PhD
Peter Walton MA MB BChir MBA
Dendrite Clinical Systems

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Phone: +44 1491 411 288

Fax: +44 1491 411 377

E-mail: publishing@e-dendrite.com

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Demonstrating Quality – the 6th National Adult Cardiac Surgical Database Report

Executive summary

- This report documents the nature of adult cardiac surgical practice in the United Kingdom and Ireland and is a comprehensive update to the 5th National Adult Cardiac Surgical Database Report, which was published in 2004.
- The report contains data up to the end of March 2008, includes returns from 55 hospitals and has complete coverage of all the National Health Service (NHS) hospitals undertaking adult cardiac surgery in the United Kingdom.
- The database now contains just over 400,000 operation records.
- The operative mortality rates for all major operation groups continue to fall despite the patients being sicker, indicating improved quality of in-hospital care.
- The degree of improvement is marked: between 2001 and 2008 the mortality rates decreased from 2.3% to 1.5% for isolated CABG, 2.6% to 1.7% for all CABG, 5.2% to 3.5% for isolated valves and 8.3% to 6.1% for combined valve & graft operations. All of these improvements are statistically significant.
- There are increasing numbers of elderly patients undergoing cardiac surgery of all types. Patients over the age of 75 now make up more than 20% of all cardiac surgery, and over 5% are over 80. Mortality rates in the elderly continue to fall. We have analysed this group in detail and the data provided will support informed consent processes for these patients.
- Coronary artery bypass surgery activity has stabilised out at just under 23,000 operations per year. There have been marked increases in the annual volumes of aortic valve and mitral valve operations.
- The completeness of the data in the database has improved over time and most fields now have a very low incidence of missing data.

Coronary artery bypass surgery

- Between March 2003 and April 2008 we have amassed data on 114,300 isolated coronary artery bypass operations.
- Analyses of patients' risk profiles show quite marked changes, with surgeons operating on progressively higher-risk patients year-on-year, but, despite this, mortality rates are decreasing.
- We are better at treating the elderly: the proportion of patients over 75 and 80 has continued to increase and the operative mortality for these patients continues to fall. The mortality rate for patients over the age of 75 has decreased from 5.0% in 2004 to 3.4% in 2008.
- We are better at treating urgent cases: the proportion of patients who stay in hospital for their surgery has increased, but the in-hospital mortality for these patients has gone down.
- We are better at treating diabetics: between 2001 and 2008 there has been a 50% increase in the proportion of patients who are diabetic, but the associated in-hospital mortality rate has decreased over time.
- We are using more arterial grafts, which are known to be associated with improved outcomes for patients.
- Fewer patients undergoing coronary surgery require repeat operations and the time between first- and second-time operations is increasing, indicating that the grafts are lasting longer.
- The outcomes for patients undergoing coronary artery bypass surgery as an elective operation are excellent, with low mortality, low morbidity and good medium-term survival. The mortality for patients under 70 years of age who are admitted to hospital from home for their surgery is less than 1%.

- Medium-term survival (on an analysis of 88,000 patients) is good with an overall survival rate of over 90% at 5 years after surgery. Survival is worse for patients who are older, female, undergoing urgent surgery, diabetic, suffering from impaired cardiac function or in renal failure.
- The population we are treating is becoming increasingly overweight. Between 2004 and 2008 nearly 25% of patients were obese or morbidly obese.
- Patients who have had a previous heart attack are twice as likely to die at the time of surgery compared to patients who have not had a heart attack.

Aortic valve disease

- Between April 2003 & March 2008 we have recorded data on 30,127 aortic valve operations.
- There has been a greater than two-fold increase in the annual number of patients who had an aortic valve replacement between 2001 and 2008.
- Patients undergoing aortic valve replacement are becoming more elderly, high-risk and are more likely to have aortic stenosis rather than regurgitation.
- Despite this, there has been a significant reduction in operative mortality by 34% over the last 5 years.

Mitral valve disease

- Between April 2003 & March 2008 we have collected data on 19,545 mitral valve operations.
- There has been a greater than two-fold increase in the annual number of patients who had a mitral valve operation between 2001 and 2008.
- Over time there has been a marked increase in the likelihood that patients will undergo mitral valve repair rather than replacement, and repair is associated with both a better short- and long-term outcome.
- There has been a reduction in in-hospital mortality of 19% for patients undergoing isolated repair over the last 5 years.
- Increasing numbers of patients have operations classified as mitral & *other* over time, reflecting the increasing use of techniques to treat atrial fibrillation at the time of heart surgery.
- Overall, one-third of patients with degenerative valve disease undergo mitral valve replacement rather than mitral valve repair. There is significant variation in the use of mitral valve repair for degenerative mitral valve disease between units.
- Just over 40% of patients undergoing isolated mitral valve repair have severe symptoms of breathlessness by the time they are referred and will consequently not derive optimum benefit from surgery. These patients are being referred for surgery too late in the course of their disease.

Aortic disease

- We have analysed the outcomes of 4,967 patients who have undergone major aortic surgery, with 2,245 having surgery for an aortic aneurysm & 1,288 having surgery for an aortic dissection (a major life-threatening event in which blood splits the layers of the aortic wall; aortic dissection is usually fatal if left untreated). The mortality for patients undergoing urgent or emergency surgery for dissection was 23%, which is in line with published international registries.

Risk modelling

- Critical to understanding comparisons of outcomes between hospitals or surgeons is the ability to adjust for differing casemix. Existing risk prediction models have become more inaccurate over recent years and we have explored these issues in some detail.

Equity of access

- For aortic valve surgery, we have found marked variation in access rates and have defined areas of low- and high-access rates, which should be used to change practice to deliver more patients to surgery for potentially curative operations.

Named hospital and surgeon's outcomes

- Surgical mortality data for named hospitals and surgeons are now published on a website hosted by the Care Quality Commission. We have described the history and methods used, and have presented tables of these results by hospital for coronary artery bypass surgery, aortic valve surgery and all cardiac surgery.
- We have explored differences between named hospitals with respect to the age profile of patients, the volume of major aortic surgery performed and the type of mitral surgery undertaken.
- We have described how mortality results for individual surgeons will feed into the systems by which doctors will be regulated under new legislation described in the White Paper *Trust, Assurance and Safety* (2007). We have explored some of the challenges that will arise from implementing *revalidation* of surgeons in this way.
- For patients to get the best treatments from their cardiac surgeons, the very best candidates must be selected into the specialty and trained well. We have described developments within the specialty to improve selection and training for tomorrow's consultants.

The *quality* agenda

Various initiatives over recent years have moved to put the quality of healthcare at the centre of service provision. We have responded to this in our report by:

- Describing how developments in cardiac surgery audit comply with the recommendations from the Bristol Royal Infirmary Inquiry (2001), the Shipman Inquiry (2005), the Chief Medical Officers report *Good Doctors, Safer Patients* (2006), the White Paper *Trust, Assurance and Safety* (2007) and Lord Darzi's review *High Quality Care for All* (2008).
- Describing developments in defining quality in healthcare in the United Kingdom, in the international context of cardiac surgery quality initiatives.
- Analysing our database not solely looking at in-hospital mortality, but also by examining other post-operative outcomes including new post-operative stroke, new post-operative renal failure, post-operative length-of-stay, re-explorations for bleeding or infection and medium-term survival rates.
- Including *good practice examples* of the collection and use of cardiac surgery audit data from hospitals around the United Kingdom; this section includes examples on data validation, feedback, quality *bundles,* performance monitoring, disseminating outcomes to patients, service reconfiguration, clinical leadership development & multi-disciplinary process and outcomes benchmarking.
- Developing a proposed *quality account* for one hospital, incorporating patient outcomes, patient safety and patient experience. This is in line with the planned new legislation, which will require all hospitals to publish these accounts from 2010.

Preface

It is with great pride and excitement that I write the preface to this report. It represents the latest stage on a journey of discovery and understanding, which cardiac surgeons in the United Kingdom began several decades ago. The road has not always been straight nor without obstacles; nor has the ride always been smooth. But we have come a long way – this publication demonstrates what we have achieved.

There have been significant developments in data analysis and presentation since the last report 4 years ago. Linking our database with the Office of National Statistics has allowed us to present data on longer-term outcomes after surgery. Other analyses have focussed on equity of access and some have highlighted the changing pattern of practice with significant increases in both mitral and aortic valve surgery.

As cardiac surgeons our primary aim has always been to provide the highest quality of care for our patients. In addition, we have a professional responsibility to monitor our performance. These goals can only be achieved by collecting and analysing data on the outcomes for our patients – if you don't measure it you can't make it better. We, amongst all the specialties, have led the way in data collection.

In 1977 Sir Terence English, set up a national Register of operations – it is salutary to remember this was the pre-desktop computer era. Data collection was retrospective, accuracy was dubious and crude hospital mortality was the only outcome measure. But it was a start.

In the early 1990s Bruce Keogh and Peter Walton had the vision to develop a comprehensive database, which would allow risk stratification for individual patients – important if outcomes were going to be compared. Over the last decade we have compared outcomes not only between units in the United Kingdom and Ireland but also with international colleagues. More recently we have published independently-analysed individual surgeon's results on the Internet. Our patients can be reassured that their cardiac surgery will be of high quality.

Until now, the focus has been on mortality as the outcome measure. One of the most striking (and intriguing) aspects of the report is that, despite patients being older and sicker, the death rate after surgery has fallen steadily over the years. Many have raised concern that publication of results for units and individual surgeons might lead to higher-risk patients being denied surgery – the data in this report should allay that fear.

With mortality being so low, counting deaths after surgery is no longer a useful measure of quality-of-care. This report shows how we are just beginning to explore the value of looking at the rates of complications after surgery as outcome measures: for example bleeding (and the use of blood products), kidney failure, stroke and the need for re-operation. Outcomes which would have a major impact on the recovery time of our patients and their subsequent quality-of-life.

However, these are aspects of care where we may well find differences between units. Rather than seek to identify units with a high complication rate, our aim will be to learn from those with a low rate. We want to take a positive approach to improving quality – hence the inclusion in this report of a section containing examples of good practice.

It is axiomatic that the key to a good result for a patient is high-quality technical surgery. However, we all recognise that the best overall outcome is achieved by the whole team working closely together. We acknowledge that we could not have reached the standards described in this report without the efforts of our colleagues in anaesthesia, perfusion, nursing, physiotherapy and others in the clinical team.

Leslie Hamilton

President of the SCTS

Demonstrating quality: a patient's perspective

Patient choice is at the heart of Government policy, and when I am asked by prospective patients for cardiac surgery how they should choose their surgeon I always refer them to the Healthcare Commission website, which displays the success rate for both hospitals and surgeons and identifies their specialist interests. This website was developed in consultation with patient representatives and the transparency about quality-of-care and resulting high rate of *visits* is a testament to the cardiac surgeons who pioneered the scheme and persuaded their colleagues to become participants (see appendices of this report). It is an example of openness and professional confidence that enhances the trust of patients as they prepare themselves for serious surgery and enables them to rest easy with their choices.

In the same pioneering spirit *Demonstrating quality* is a comprehensive record of contemporary cardiac surgery in Great Britain and Ireland. It provides compelling evidence that quality-of-care for patients has improved, with decreasing mortality rates despite higher-risk and more elderly patients coming to surgery. During the period since the last database report was published 114,000 patients have come to coronary artery bypass surgery and in the year to March 2008 nearly 20% were over the age of 75 and 5% over 80, and mortality rates continue to fall. More patients have diabetes, but mortality continues to fall. More than twice as many patients have aortic valve replacements and, again, mortality continues to fall, despite these patients becoming increasingly high-risk. There has also been an increase in the number of mitral operations, with more patients undergoing mitral valve repair, which will again improve both short- and longer-term outcomes for patients.

All patients coming to heart surgery have concerns that they may not survive the operation, but they also worry about other outcomes, including infections, renal failure, strokes, bleeding and their likely subsequent relief of symptoms, and as such it is refreshing to see that this report has moved from purely focussing on mortality as an index of quality to include so many other measures, and it will be reassuring to all to see how rigorously the cardiac surgeons plan to regulate their profession as described in the section on page 422.

There is a lot of information in this report, & it will probably not become recommended reading for all patients, but it will be hugely welcomed by patient support groups and its key findings should provide enormous professional satisfaction to the 55 clinical multi-disciplinary teams and their managers, whose service is logged in these annals. It will also be warmly received in the cardiac networks throughout the United Kingdom, not to mention the Heart Team at the Department of Health and the equivalent organisations in the devolved nations and Ireland.

In essence this report reflects the pursuit of excellence in cardiac surgical care. It encompasses the entire patient journey and has lessons that teach that the conduct of procedures and aftercare are both improving. It is of concern, however, that in contrast to these happy developments, patients are becoming more likely to be obese and have diabetes, and these and other adverse lifestyle issues will further increase the demand on services and strain the prospect of successful outcomes. In several sections of the book, it is apparent that women seem to have different access to care, and ultimately achieve worse outcomes than men. Women's cardiac health is obviously a complex issue, and it may be that women often *suffer in silence,* but with women making up more than half of our population I would challenge the surgeons to explore these issues diligently and develop strategies to particularly improve access to and outcomes of cardiac surgery for the fairer sex.

All patient representative and patient support groups are enthusiastic advocates of cardiac rehabilitation. This is a highly beneficial, evidence-based and cost-effective treatment that encompasses not only exercise, but holistic lifestyle and psychological elements. It is widely claimed that cardiac rehabilitation is the component that assists in prolonging life expectancy and seals the quality of surgical and medical care. There is a National Audit of Cardiac Rehabilitation, and their report makes sadder reading because of failures of access, when set against this surgical report. This has led to a concerted campaign to force cardiac rehabilitation into the mainstream. I would strongly urge the surgeons to link with the rehab audit for their next report to benchmark units according to their use of rehabilitation to identify and address shortcomings in access, and to use data about lifestyle and medication issues from the rehabilitation audit to help them better understand the longer-term outcomes of the care that is being delivered.

On behalf on the 400,000 patients whose operations are recorded in the SCTS database I would like to offer a profound vote of appreciation to all the surgical teams who have conducted our operations, and to those who stride the corridors of Whitehall and elsewhere to provide the infrastructure and resources to enable the teams to function. The debt we owe you is the life we now lead. This pioneering audit is an exemplar to other specialities in both medicine and surgery. It is crucial evidence that is driving the quality agenda, and its long-term benefit to patients and their families is overwhelming.

David H Geldard MBE, Immediate Past President, Heart Care Partnership (UK)

General introduction

The last SCTS National Adult Cardiac Surgical Database report was published in 2004 and included data from operations performed up to March 2003. Since then there have been many developments, both inside & outside cardiothoracic surgery. As a specialist society we have changed our name from the Society **of** Cardiothoracic Surgeons of Great Britain and Ireland to the Society **for** Cardiothoracic Surgery, acknowledging the progress in multi-disciplinary care that is now in place to optimise care for patients. There have also been major changes in surgical practice including the introduction of atrial fibrillation surgery into the mainstream, marked increases in the number of patients coming to mitral valve repair & the advent of percutaneous aortic valve implantation.

In addition to these changes, probably the most important developments since the previous *Blue Book* have been external to us and have included the Freedom of Information Act (2000) and emerging legislation underpinning a focus on quality in the NHS, including regular revalidation of doctors. On January 4th 2005 the Freedom of Information Act (2000) became law in England and Wales, with a similar law already in place in Scotland. This was followed within weeks by a request from the Guardian Newspaper for named cardiac surgeon's mortality data from all hospitals, which led to publication of all surgeons' outcomes in April that year. We had been working towards publication of a full analysis once rigorous, validated and risk-adjusted data became available, but this was pre-empted by the Guardian initiative. The SCTS responded by working with the Healthcare Commission to produce a web-based portal to disseminate results to the public. The second iteration of this website was published by the Healthcare Commission last year and it now contains data on outcomes for all the NHS hospitals in the United Kingdom and about 70% of surgeons.

The second legislative change that has affected us is the White Paper *Trust, Assurance and Safety,* which is the government's response to the Chief Medical Officer's report *Good Doctors, Safer Patients.* This will lead to widespread reform of the regulation of healthcare professionals. The way in which this will be implemented is still being developed, but the likely time-course is that a process of re-certification for all cardiothoracic surgeons will be in place by 2011. Individual surgeons' outcomes will form a part of this process.

The issue of *quality* has been central to cardiac surgery thinking for decades, and is the primary reason why the SCTS has engaged in data collection and analysis since the mid 1970s, initially *via* the cardiac and thoracic surgical registers and more recently through the SCTS National Adult Cardiac Surgical Database project. Quality is now firmly at the centre of political thinking in the United Kingdom following the publication in 2008 of Lord Darzi's review *High Quality Care for All,* which aims to make quality the organising principle of the NHS. His report describes an approach to quality that starts with a definition around the three domains of clinical effectiveness, safety and patient experience. A good unit will be good in all three domains. The report specifically focuses on the importance of the measurement of clinical outcomes. This is based on research that has shown high performing clinical teams are characterised by good clinical leadership, management goals expressed as clinical benefit, a focus on measurement of clinical outcomes, a desire to compare their outcomes with their peers and good teamwork. The National Adult Cardiac Surgical Database supports all these aspirations. In order to encourage this throughout the NHS, Lord Darzi has recommended the establishment of *Quality Observatories* in every Strategic Health Authority region in England to aggregate, analyse and disseminate information on quality to healthcare organisations in the region and to provide an analytical facility for individual clinical teams. The philosophy is similar to the National Institute for Clinical Outcomes Research at University College London where some of the data-analyses for this report were performed.

In order to ensure that provider organisations focus on quality & clinical outcomes all provider organisations in the NHS, along with independent organisations providing services for NHS patients, will be obliged by law to publish *Quality Accounts* from 2010. We have drawn up an example of what one hospital's quality accounts might look like.

These developments have far-reaching consequences for all of medicine, but as a specialty this report demonstrates that we are particularly well prepared.

Our latest database report has been formatted to provide information in line with these developments. The introductory sections contain a section that defines *quality* in cardiac surgery in both a United Kingdom and international perspective and we have updated the progress of our specialty against the Public Inquiries into the events at Bristol Royal Infirmary and the serial-killer Dr Harold Shipman, as well as the recommendations in *Good Doctors, Safer Patients* and *Trust Assurance and Safety.* We have included independent perspectives on the SCTS audit from David Geldard (a patient representative), Prof. Harry Hemingway (an academic clinical epidemiologist) and Prof. Nick Black (the Chair of NCAAG, the group that steers national audit strategy in England), along with a discussion of how the data should be used for informed consent from Mr David Richens (Professional advisor to the Parliamentary and Health Service Ombudsman).

We have updated the data sections on coronary artery bypass surgery from previous publications and undertaken an in-depth analysis of outcomes for elective patients undergoing coronary artery bypass surgery, which emphasises what an excellent treatment this is for patients with coronary artery disease. We have included new sections on patient characteristics, risk factors and outcomes for aortic valve surgery, mitral valve surgery and major aortic surgery. Given the rising age of our patients, we present a new dedicated section on cardiac surgery in the elderly, including a lay perspective. We have extended our analyses on all of these procedures away from simply focussing on in-hospital mortality as a measurement of quality to include post-operative length-of-stay, stroke, new post-operative renal failure, surgical re-exploration and medium-term survival.

Secondary care treatments, such as cardiac surgery, are purchased by primary care trusts using an objective commissioning framework called World Class Commissioning. We have used the power of our database to *map* patients' place of residence to look at variations in access to surgery for aortic valve replacement, which we hope will be of interest to surgeons, cardiologists, primary care physicians, local cardiac networks and service commissioners. The more our data are used by others the more valuable they will become.

We have included sections on the implications of publication of surgical outcomes data and current thinking about professional re-certification. We also feel that, to ensure optimum care for patients, it is imperative that we select the very best trainees into the speciality, train them well and monitor the outcomes of practitioners in independent practice. We have therefore described these issues together and explored the themes with examples from the database.

We have included a chapter that gives examples of what we believe is good practice in cardiac surgery, which we hope will be of use to help drive the quality agenda in cardiac surgery, and may have some helpful messages for other specialities.

Finally we feel that the United Kingdom National Adult Cardiac Surgical Database provides a useful benchmark for other countries or units around the world: the SCTS database contains data from all NHS hospitals and surgeons, and has more complete coverage than any other national database worldwide. We have therefore included a section at the end of the book where we have compared the outcomes in one hospital in Hong Kong with pooled United Kingdom data as an illustrative example of an international benchmarking process.

Ben Bridgewater

Consultant Cardiac Surgeon
University Hospital of South Manchester NHS Foundation Trust and

Co-director of National Institute for Clinical Outcomes Research (NICOR) & Honorary Senior Lecturer
University College London

Prof. Sir Bruce Keogh

Immediate Past President of the SCTS
NHS Medical Director

Honorary Professor of Cardiac Surgery
University College London

Acknowledgements

The SCTS Executive since 2004 who have steered the database initiative:

Mr Pat Magee	President	2004-2006
Prof. Sir Bruce Keogh	President	2006-2008
Mr Leslie Hamilton	President	2008-2010
Prof. David Taggart	President-Elect	2008-2010
	Elected Member	2005-2008
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Mr Graham Cooper	Hon. Secretary	2008-2013
Mr Babulal Sethia	Hon. Treasurer	2004-2009
Mr Graham Cooper	Meeting Secretary	2002-2007
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Mr Ben Bridgewater	Elected member	2006-2009
Mr Jim McGuigan	Elected member	2007-2010
Prof. John Pepper	Elected member/Education Secretary	2007-2010

The SCTS database committee 2008-2011:

Mr Ben Bridgewater

Mr Graham Cooper

Mr Danny Keenan

Mr Gavin Murphy

Mr Domenico Pagano

Mr James Roxburgh

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- Our thanks must go to Dr Peter Walton for developing the initial concept of the National Adult Cardiac Surgical Database, publishing the first *Blue Book* in 1998, and for sustaining & funding the delivery of the complete series of reports over the last 10 years, culminating in this book.

- Dr Robin Kinsman, Senior Data Analyst at Dendrite, can be credited with three main tasks:
    - merging clinical records acquired from multiple sources (now including CCAD), to produce the central database, which now incorporates over 400,000 individual surgical records (which equates to well over 40 million individual data-items);
    - executing a suite of data-validation and logic checks to ensure that the data supplied were fit for purpose and suitable for inclusion in the analyses;
    - running the analyses, designing and developing the layout of the book, and assembling the report itself.

- Dendrite have provided a rigorous data management philosophy combined with a robust technological software platform to underpin this cardiac surgical database. The same Dendrite software and data-processing techniques have now been adopted by national cardiac surgical registries in a number of other countries, by the European Association for Cardio-Thoracic Surgery (EACTS) and also across a range of other national and international clinical registries.

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- Stephen Green at Oxford Healthcare Associates for undertaking the analysis on geographical variation of aortic valve surgery.

- All of the database managers whose tireless work has made the availability of the data to produce this book a possibility; they are listed, but we apologise if we have missed anyone out.

- The SCTS representatives from each unit who have contributed to the development of the SCTS cardiac surgery data agenda (the list of current representatives is given below). We recognise that some of these representatives are thoracic surgeons, and we fully understand that in those situations it will be a cardiac surgical colleague who will have led on the cardiac surgical data initiative. Similarly we understand that not all of the unit representatives are the cardiac audit leads, and in those situations we would like to thank you for all your hard work.

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- We would also like to thank Sir Donald Irvine for his comments and insight into the section on selection, training and re-certification.

Current unit representatives

Aberdeen Royal Infirmary	Mr Hussein El-Shafei
Bart's & the London	Mr Alan Wood
Blackpool Victoria Hospital	Mr Franco Sogliani
Bristol Royal Infirmary	Mr Gavin Murphy
Castle Hill Hospital, Hull	Mr Mike Cowen
Cork University Hospital	Mr Aonghus O'Donnell
Derriford Hospital, Plymouth	Mr Clinton Lloyd
Edinburgh Royal Infirmary	Mr Ted Brackenbury
Essex Cardiothoracic Centre, Basildon	Mr Andrew Ritchie
Freeman Hospital, Newcastle	Mr Thasee Pillay
Glenfield Hospital, Leicester	Mr David Waller
Golden Jubilee Hospital, Glasgow	Mr Geoff Berg
Guy's and St Thomas's Hospital, London	Mr Chris Blauth, Mrs Karen Harrison-Phipps
Hammersmith Hospital, London	Mr Jon Anderson, Mr Prakash Punjabi
Harefield Hospital, Middlesex	Mr Ashgar Khaghani
James Cook University Hospital, Middlesbrough	Mr Andrew Goodwin
John Radcliffe Hospital, Oxford	Mr Chandi Ratnatunga
King's College Hospital, London	Mr Ahmed El Gamel
Leeds General Infirmary	Mr David O'Regan
Liverpool Heart & Chest Hospital	Mr John Chalmers
London Bridge Hospital	Mr Graham Venn
Manchester Heart Centre	Mr Nick Odom
Mater Misericordiae Hospital, Dublin	Mr David Luke / Mr Freddie Wood
Morriston Hospital, Swansea	Mr Aprim Youhana
N Staffordshire Royal Infirmary, Stoke-on-Trent	Mr Adrian Levine
New Cross Hospital, Wolverhampton	Mr Moninder Bhabra
Northern General Hospital, Sheffield	Mr David Hopkinson
Nottingham City Hospital	Mr David Richens
Papworth Hospital, Cambridge	Mr David Jenkins
Queen Elizabeth Hospital, Birmingham	Mr Domenico Pagano
Royal Brompton Hospital, London	Mr Simon Jordan
Royal Sussex County Hospital, Brighton	Mr Andy Forsyth, Mr Uday Trivedi
Royal Victoria Hospital, Belfast	Mr Mark Jones
Southampton General Hospital	Mr Cliff Barlow
St George's Hospital, London	Mr Marjan Jahangiri, Mr Robin Kanagasabay
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St Mary's Hospital, London	Mr Andrew Chukwuemeka
The Heart Hospital, London	Mr Shyam Kolvekar
University Hospital of Wales, Cardiff	Mr Dheeraj Mehta
Walsgrave Hospital, Coventry	Mr Ramesh Patel
Wythenshawe Hospital, Manchester	Mr Rajesh Shah

Database managers

Aberdeen Royal Infirmary	Mrs L Lawman
Bart's & the London	Ms E Kuforiji, Mr A Wood
Blackpool Victoria Hospital	Ms C Malpas
Bristol Royal Infirmary	Mr D Finch, Mr C Gummer
Castle Hill Hospital, Hull	Mr N Richards
Cork University Hospital	Ms M Delaney
Derriford Hospital, Plymouth	Mr R Gardner
Edinburgh Royal Infirmary	Ms J Howlett
Essex Cardiothoracic Centre, Basildon	Mr D McCormack
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James Cook University Hospital, Middlesbrough	Mrs T Smailes
John Radcliffe Hospital, Oxford	Mr C Evans
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Leeds General Infirmary	Mr R Higginson, Mr J Peckover
Liverpool Heart & Chest Hospital	Ms L Bond, Ms L Jones, Mr A Ward
London Bridge Hospital	Ms L Katsumbe
Manchester Heart Centre	Ms S Chaisty
Mater Misericordiae Hospital, Dublin	Ms G Aherne, Mr P Marsden
Morriston Hospital, Swansea	Mr S Morris
N Staffordshire Royal Infirmary, Stoke-on-Trent	Ms J Lythgoe
New Cross Hospital, Wolverhampton	Ms L Cloughley
Northern General Hospital, Sheffield	Ms J Daly, Ms L Kirk
Nottingham City Hospital	Ms K Montrose
Papworth Hospital, Cambridge	Ms S Powell
Queen Elizabeth Hospital, Birmingham	Ms V Barnett
Royal Brompton Hospital, London	Mr P Kimberley
Royal Sussex County Hospital, Brighton	Mrs J Gayfer
Royal Victoria Hospital, Belfast	Ms B Scullion
Southampton General Hospital	Ms A Green
St George's Hospital, London	Dr O Valencia
St James's Hospital, Dublin	Ms M Houlihan
St Mary's Hospital, London	Ms J Turnbull
The Heart Hospital, London	Mr M Curtis, Ms M Taylor
University Hospital of Wales, Cardiff	Ms C Bray
Walsgrave Hospital, Coventry	Ms A Nugent
Wythenshawe Hospital, Manchester	Mr S Bullough

How does the NACSD audit fit into the English national clinical audit strategy?

Professionals endeavour to improve the quality of their clinical practice through three principal activities: education, research and audit. While all three are of equal importance, this has not been reflected in the relative funding levels the three have attracted. In England, while about £2.4bn is spent each year on educating the clinical workforce and £800m is spent on research by the NHS, clinical audit attracts only about £6m of central funds (though locally Trusts invest additional resources).

This situation partly reflects the historical lack of a central voice for audit in the Department of Health. Audit activities have been fragmented and dispersed. Many groups of clinicians have managed to establish national clinical audits in their specialties despite rather than because of NHS policies. A good example is the Society for Cardiothoracic Surgery in Great Britain & Ireland and the establishment of the adult cardiac surgery database.

Recognising the lack of a national strategy and of coherent policies, the Department of Health (DH) established an advisory committee in early 2008: the National Clinical Audit Advisory Group. Our remit is to advise the Department and NHS Management Board, to provide strategic management for the centrally funded National Clinical Audit & Patient Outcomes Programme (NCAPOP), and to provide leadership for the re-invigoration of clinical audit, both at national and local levels, in England. The Healthcare Quality Improvement Partnership (HQIP), a small charitable company established by the Royal College of Nursing, the Academy of Medical Royal Colleges, and National Voices (representing patients with long-term conditions) is contracted by the Department of Health to manage the NCAPOP. Our principal activities during the first year have focused in the three areas of the programme: national clinical audits; local audit; and establishing a National Clinical Audit Forum.

We inherited, from the Healthcare Commission, responsibility for funding about 20 national audits. These vary in nature, complexity and quality. They provide good coverage of some areas of healthcare (such as cardiovascular disease), but few or no audits in other areas. Our initial priorities have therefore been to develop explicit criteria for assessing priorities for new audits together with criteria for judging the quality of existing and proposed new audits. These criteria cover methodological aspects, the governance & management of the audit, lay and patient involvement, the format and frequency of outputs and the intended uses. To encourage new audits we have introduced a responsive funding approach to complement the existing commissioning approach. This provides a means of rewarding groups who have managed to design and develop an audit, but now need financial support to make it sustainable. Again, the SCTS audit provides us with an excellent role model of a successful audit that arose in this way from some clinicians' enthusiasm and enterprise.

Helping re-invigorate local audit represents a greater challenge than the re-design of national audit policies. While there are many wonderful examples of local audits that have led to quality improvements, too often a lack of support or know-how has hampered well-intentioned attempts to *make a difference.* HQIP have been endeavouring to identify the needs of local staff, both clinicians and audit staff, so that appropriate support can be provided. This is likely to include education and training, standard software and other generic tools, and the re-invigoration of professional organisations to help enhance the status and situation of audit staff.

The third element of the strategy is the establishment of an inclusive, web-based forum, which is intended to be available from summer 2009. This will enable all staff, patients and others with an interest in audit to communicate and share ideas, problems and solutions and they may wish to create networks around healthcare areas, methodological topics and any other relevant issues. Social networking comes to audit!

So how does the SCTS audit fit in to what I hope will be a new opportunity for audit in England? Well-established, successful rigorous audits such as this one have a crucial role to play. While others do exist, there are still relatively few. Other areas of healthcare can learn a lot from your experiences. While central policy and advisory groups can do a certain amount, if we are going to be successful in advancing the state of national audits much will depend upon the established audits showing the way. For example, the pioneering steps you have taken to disclose identifiable results to the public is the gold standard for others to follow. It has also served to influence national policies about clinical audit in general. Other examples appear in this book: the use of audit data for quality accounts; opportunities for international comparisons; application of audit data in revalidation of professionals; exploitation of audit data for research, a much neglected activity by most audits; and this book itself, which will serve as an example to other more recently-established national audits as to what they might aspire to and achieve in the years ahead.

Nick Black

Professor of Health Services Research, London School of Hygiene and Tropical Medicine
Chair, National Clinical Audit Advisory Group

Contents

Aortic valve surgery

Mitral valve replacement

Quality accounts

Appendices

Demonstrating quality: defining quality in cardiac surgery

Quality in healthcare has been an elusive concept; everyone thinks they know what it is, but it has not been easy to describe. To improve quality, and measure improvements, it must first be defined and Lord Darzi's review has made a major step forward by recommending that the quality of healthcare must be seen from the patient's perspective and include aspects of patient safety, patient experience and effectiveness-of-care.

This database report is all about the quality of cardiac surgical care in Great Britain & Ireland. We have looked at trends over time for operations and risk factors, and studied a number of outcomes, which we believe demonstrate both patient safety and effectiveness-of-care. We have a long history in cardiac surgery of studying in-hospital mortality as an outcome, but we have looked in this report at a number of other outcomes including:

- post-operative length-of-stay
- post-operative stroke rate
- re-exploration for bleeding
- surgery for post-operative sternal wound infection
- new post-operative renal intervention
- medium-term survival rates

To understand outcomes it is essential to look at casemix; young patients with no associated illnesses are likely to do well from treatment, but older patients with multiple co-morbidities and are much more likely to develop complications. Any comparisons made without adjusting for these factors can be potentially misleading. We have explored issues around risk adjustment in some detail throughout the book.

A good patient experience requires satisfactory care to be delivered without developing related complications, but we also believe that a good experience is about much more, including receiving accurate, useful information about the relevant disease and the potential treatment options, and the outcomes of care in each hospital. All of the data on surgical outcomes presented in this report are important in providing contemporary clinical outcomes for patients with different problems and co-morbidities and will be useful in providing information for informed consent. We have also included examples of other developments in these areas in the section on page 429 of this report.

There are a number of areas related to quality that we have not touched upon in the main body of the report as the current incarnation of the NACSD does not encompass the appropriate data-fields. These include measures of patient satisfaction and patient-reported outcomes, which are important indicators of the quality-of-care, and we have included some data on these from one hospital in the *quality accounts* section starting on page 448. Detailed information about risk management, including learning from incident reports and near misses, and reviewing practice from discussions at Morbidity & Mortality Meetings are other important aspects in optimising care, but are outside the scope of this report. These issues have been considered further in the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) report on *CABG: the heart of the matter*.

In the United States there have been several initiatives to improve *quality* in cardiac surgery. The National Quality Forum, a *not for profit* membership organisation aiming to improve reporting of quality and facilitate quality improvement by *fostering system-wide capacity for quality improvement* has looked at cardiac surgery and recommended 21 measures related to good-quality care. These measures include participation in a national database, a standard already achieved in all units in Great Britain & Ireland, and all of the measures they describe have been covered in this report, either in the sections analysing the database itself, or in the *quality accounts* section starting on page 448.

Based on the National Quality Forum (NQF) recommendations, the Society of Thoracic Surgeons in the United States (STS) has also published a comprehensive conceptual framework for measuring quality in adult cardiac surgery, which they suggested should focus initially on CABG surgery and should include measures of peri-operative care, operative care, risk-adjusted mortality and risk-adjusted post-operative morbidity. The STS has gone further by describing a methodology in which these measures can be combined to give a composite score that can be used for comparing provider institutions. Neither the National Quality Forum standards nor the STS measures include the other measures of patient safety or patient experience, both of which we feel are important in describing overall *quality*.

One of the themes in Lord Darzi's report is that hospitals should be rewarded for providing high-quality care. This is in line with experiences in the United States, where paying supplements for achieving various process measures, which comprise an abbreviation of the STS and NQF metrics, has improved compliance rates and also subsequent outcomes for patients. At the time of publication of this book there is a pilot project in Northwest England to determine whether or not this model is effective in the United Kingdom. The *advancing quality* project is underway and is looking at cardiac surgery, along with some other procedures and pathways. The advancing quality measures for cardiac surgery are appropriate prescription of prophylactic antibiotics and anti-platelet mediations at discharge, and will include risk-adjusted mortality outcomes. These are described in the *quality accounts* section starting on page 448.

In addition to professionally-led projects such the as SCTS database initiative, there are now various high-profile organisations that support quality improvement in healthcare in general. The Institute for Healthcare Improvement (IHI) is an independent not-for-profit organization based in Cambridge, Massachusetts, United States of America. It mission statement is:

> *… to accelerate improvement by building the will for change, cultivating promising concepts for improving patient care, and helping health care systems put those ideas into action …*

(http://www.ihi.org). In the United Kingdom the NHS Institute for Innovation and Improvement has a similar brief to:

> *… support the NHS to transform healthcare for patients and the public by rapidly developing and spreading new ways of working, new technology and world class leadership …*

(http://www.institute.nhs.uk/).

i NCEPOD: Coronary Artery Bypass Grafts: The heart of the matter (2008). http://www.ncepod.org.uk/2008cabg.htm

ii http://www.qualityforum.org/pdf/reports/cardiac.pdf

iii Shahian DM, Edwards FH, Ferraris VA, Haan CK, Rich JB, Normand ST, DeLong ER, O'Brien SM, Shewan CM, Dokholyan RS, and Peterson ED. Report of the STS quality measurement taskforce: Quality Measurement in Adult Cardiac Surgery: Part 1—Conceptual Framework and Measure Selection. *Ann Thorac Surg.* April 2007; **83:** S3-S12.

iv O'Brien SM, Shahian DM, DeLong ER, Normand ST, Edwards FH, Ferraris VA, Haan CK, Rich JB, Shewan CM, Dokholyan RS, Anderson RP, and Peterson ED. Report of the STS quality measurement taskforce: Quality Measurement in Adult Cardiac Surgery: Part 2—Statistical Considerations in Composite Measure Scoring and Provider Rating. *Ann Thorac Surg.* April 2007; **83:** S13-S26.

v http://www.advancingqualitynw.nhs.uk

Progress against the Bristol Royal Infirmary report

Dame Janet Smith's Inquiry into Harold Shipman, & the White Paper *Trust, Assurance & Safety*

In June 1998 the Government announced the establishment of a Public Inquiry into the management of care of children receiving complex cardiac surgery at the Bristol Royal Infirmary between 1984 and 1995. The subsequent report, published in July 2001, had a profound effect on the whole of healthcare in the United Kingdom. There followed a further Inquiry into the events surrounding Dr Harold Shipman, led by Dame Janet Smith. There have also been a series of reports on the regulation of doctors and quality improvement in the health service published since the last SCTS database report including the Chief Medical Officer's report *Good Doctors, Safer Patients* (2006), the White Paper on regulation of Healthcare professionals *Trust, Assurance and Safety* (2007) and the recent review *High Quality Care for All* by Lord Darzi. In our last report we reviewed the progress of our specialty against the recommendations in the BRI Inquiry report, and feel it is useful for us to repeat this exercise for this report.

Recommendation 145 clinical audit should be compulsory for all healthcare professionals providing clinical care and the requirement to participate in it should be included as part of the contract of employment.

Comment achieved: involvement in clinical audit is included as standard in all consultant contracts and all NHS units in the United Kingdom now submit comprehensive data to the national cardiac surgery audit.

Recommendation 148 the dual system of collecting data in separate administrative and clinical systems is wasteful and anachronistic.

Recommendation 149/150 steps should be taken nationally and locally to build the confidence of clinicians in the data recorded in the Patient Administration Systems (PAS) in Trusts (which is subsequently aggregated nationally to form the Hospital Episode Statistics; HES).

Comment virtually all units now have some link between their local audit databases and the administrative database. This is discussed in more detail in the *good practice examples* section on page 429. The advent of *Payment by Results,* which determines financial flows within the NHS in England, has also been a major driver to improve the quality of the administrative data. Mortality outcomes of CABG surgery from the HES data have also been used by the Department of Health, the Healthcare Commission and the Dr Foster organisation for analyses of comparative outcomes of cardiac surgery by hospital.

Recommendation 151 systems for clinical audit and monitoring rely on accurate and complete data. Competent staff trained in clinical coding and supported in their work are required. The status, training and professional qualifications of coding staff should be improved.

Comment the completeness of the data used in this database report is good, & has improved from the previous report. The incidence of missing data in the database is given on page 39. The SCTS and CCAD have supported database managers in the hospitals by providing online feedback tools, a CCAD helpdesk and a heavily-subsidised database managers meeting at the annual SCTS meeting each March.

Recommendation 152 there should be a system of incentives and penalties to encourage better data quality.

Comment the incidence of missing data by unit was published in the previous report and this has helped to drive more complete data collection. We have again published a centre-by-centre comparison of the completeness of the ***EuroSCORE*** risk modelling fields here, on page 40. Involvement in the national adult cardiac surgery audit and the outcomes of coronary artery bypass surgery by hospital have been used by the Healthcare Commission as part of their performance monitoring system.

Recommendation 153	indicators of performance should be comprehensible to the public as well as healthcare professionals.
Comment	we have worked with the Healthcare Commission to produce a public portal for the dissemination of cardiac surgery results, which is described in detail in the appendices of this report. There was extensive patient consultation about the style of presentation as part of this process. This website now receives about 26,000 visits per month.
Recommendation 154	good IT systems, which facilitate data collection, validation and provide aggregated feedback are required.
Comment:	the high-quality data and complete coverage of all NHS units indicates that these systems are now available. The CCAD software provides aggregated online feedback to units, and this has been supplemented by the Healthcare Commission website and this report.
Recommendations 27 & 155	patients must be able to obtain information as to the relative performance of the trust … and consultant units within the trust.
Comment	these data are now available for all Trusts, and 70% of all surgeons in the United Kingdom and are included in this book.

The public Inquiry into Dr Harold Shipman, the Chief Medical Officers report *Good Doctors, Safer Patients* (2006) and the subsequent White Paper on the regulation of healthcare professionals also have far and wide-reaching recommendations and implications. However, at the heart of all of these reports is the robust collection of clinical outcomes data, and the use of these data for quality improvement, personal appraisal and professional re-certification. The SCTS data collection initiative is completely in line with these themes, and particularly with recommendations 22 to 24 about mortality measurement and recommendation 25 about appraisal in Dame Janet Smith's 5th report into Shipman and recommendations 17, 18, 26, 31, 33 and 37 of *Good Doctors, Safer Patients* (2006). The way SCTS data will feed into professional re-certification as described in *Trust Assurance and Safety* is described in detail in the section starting on page 422.

I The Bristol Royal Infirmary Inquiry. http://www.bristol-inquiry.org.uk/

ii The Shipman Inquiry. http://www.the-shipman-inquiry.org.uk/reports.asp.

iii Good Doctors, Safer Patients (2006): Proposals to strengthen the system to assure and improve the performance of doctors and to protect the safety of patients. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_4137232.

iv The White Paper Trust, Assurance and Safety: The regulation of health professionals. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_065946.

An epidemiological view of the cardiac surgery audit initiative: oxymoron or opportunity?

Oxymoron springs to the mind of some if the words epidemiology and surgery are uttered in the same breath. But the results presented in this edition of the Blue Book, and even more importantly the culture among clinicians and policy-makers that have fostered their evolution, present a set of opportunities for epidemiological research that might help challenge current notions of quality and inform new ones. A central theme running through these research opportunities is the importance of enriching the existing registries through linkage – with Hospital Episode Statistics (HES), with primary care data – as well as through new data collection, including biomarkers and DNA.

Quality paradox – shifting the mean

An axiom in epidemiology, articulated by Geoffrey Rose in relation to the prevention of chronic disease, is that interventions in whole populations, while delivering small benefits for individuals, may have profound impact on the rate of disease at the population level. For example, lowering the mean blood pressure in the population by only 5 mmHg may reduce the incidence of cardiovascular disease by 20%. Conversely a focus on high-risk individuals may benefit those who are treated, but because they are a small proportion of the whole population, make only a small difference to overall disease rates. This has been described as the prevention paradox.

There is an important analogy in quality improvement. While some continue to focus on the need in cardiac surgery to identify a small number of outlying individuals or institutions, this should not detract from system-wide quality initiatives. By every surgeon, surgical team and institution improving just slightly the distribution of quality metrics (such as operative mortality) might be expected to shift downwards.

What are the practical implications of the quality paradox? We need to move beyond examining individuals and dichotomizing them yes / no as outliers. Ask not: is this an outlier? but, rather, what is the mean overall, and what can be done for all institutions to shift the curve to the left (operative mortality) or to the right (measures of benefit, see below)? The answer to the second question is necessarily multi-faceted. But it does at least point to a locus of intervention, which is different from the name-and-shame culture that still has some adherents.

Quality and dysquality

Epidemiology is concerned with the broad range of health *states, traits and rates* beyond those currently reported in the Blue Book. The historical focus on short-term mortality is to some extent a focus on harms (dysquality), and in the future complementing this with data on benefits (quality) of surgery is vital, and the medium-term mortality data examined in this book is a step along the way. With linkages to the administrative datasets (HES data in England), long-term effects on different forms of non-fatal cardiovascular events could become a reality, and enriching registry data with symptom status and patient-reported functioning measures would be low in cost and high in value for demonstrating the impact of surgery.

Epidemiology is agnostic about treatments. Rigorous use of registry data should be further used to elucidate the relative roles of surgical and less invasive procedures, using techniques such as instrumental variable analysis, and propensity scoring to attempt to address the non-randomised nature of the data. The methodology of the CCAD data collection initiative is ideally configured to support this by linkage and comparisons across surgery and cardiology databases.

Quality and the patient journey

Epidemiology is concerned with the evolution of health and disease over the lifecourse. A surgical procedure is a remarkable punctuation on this patient journey – one which is often late (as Shakespeare put it: *diseases desperate grown* need *desperate remedies*) in the disease process, and has benefits that persist for many years. A focus on surgical quality quite rightly begins in the peri-operative period, but does not end there. Better understanding how the patient came to need surgery, and what happens in terms of symptoms, events, and evolution of risk in the months and years after the surgical interlude may help develop the surgery itself. Linkage of the surgical registries to primary care data (such as the General Practice Research Database), allows the before and after to be scrutinised.

Quality, quantity and the population prevalence of indications

Epidemiology is democratic: every citizen gets a vote. It helps us delineate the geometry of the clinical iceberg – and for CABG at least it is clear that the submerged portion is large. Thus many people in the general population with symptoms of stable angina do not present to their GP, once presented they are not diagnosed, once diagnosed they do not see a surgeon. With the widespread advent of 64-slice or higher CT angiography, particularly as radiation doses decline, there is the opportunity for the first time to measure the need for coronary artery bypass surgery in the general population. It is likely that this would uncover substantial unmet need – providing a quality service demands a titration of quantity to need. Alongside this is the ongoing importance of assessing potential inequalities in access to, content of, and outcome of surgery, in line with the analysis described here on page 406.

Genomics and bluesky quality research

Epidemiology is a basic science. Discovery medicine with virtually zero probability of false positives has been a feature of the recent genome-wide association findings in large-case control studies. These have been dramatically successful over the last two years in identifying new *loci* for common chronic disease. The cardiac registries represent case collections in which different diseases, usually in severe form, are well phenotyped and in the kind of numbers that are necessary for identifying plausible gene, and, indeed, gene-environment effects. Already registries in other countries are incorporating DNA data, with patient consent, as a platform for a range of research questions. Understanding the genetic architecture of valve disease, different forms of coronary disease and so on, may have implications for prevention (avoiding surgery), for better selection of patients for existing surgical techniques or evolution of these techniques. One near-term translational benefit might be in using genetic information in risk prediction, and one advantage of cardiac surgery is that existing risk prediction models have been widely tested. This means that any incremental information from DNA or biomarker panels can be evaluated in the light of current risk models. What is exciting here is that cardiac surgical registries could become focal points at early and late stages of translational medicine.

Conclusion

The next edition of the Blue Book might, I hope, be able to report on some of these opportunities for epidemiological approaches to inform quality developments. We currently have an epidemic of obesity and diabetes beginning in childhood; when these patients develop coronary disease (a progression that currently seems inescapable), we need to ensure that new surgical responses are informed by critical, research-led scrutiny of current practice.

Professor Harry Hemingway

Professor of Clinical Epidemiology, University College, London

Conventions used in the report

There are a number of conventions used in this report in an attempt to ensure that the data are presented in a simple and consistent way. These conventions relate largely to the tables and graphs, and some of these conventions are outlined below.

Wherever analyses are confined to a particular time-period, the dates covered are reported in the tables and titles of the charts presented; all analyses of mortality and all analyses relating to the operations on the aorta utilise data from the financial years ending 2004-2008 only as this is the period covered by latest version of the dataset.

Conventions used in tables

On the whole, unless otherwise stated, the tables in this report record numbers of patient-entries (see the example below).

Isolated CABG: age and gender; financial year 2008

		Gender			
		Male	Female	Unspecified	All
Age at surgery / years	<56	2,794	456	0	**3,250**
	56-60	2,536	388	0	**2,924**
	61-65	3,290	561	0	**3,851**
	66-70	3,348	841	0	**4,189**
	71-75	3,245	1,004	0	**4,249**
	>75	2,871	1,079	0	**3,950**
	Unspecified	342	91	0	**433**
	All	**18,426**	**4,420**	**0**	**22,846**

The numbers in each table are colour-coded so that patient-entries with complete data for all of the components under consideration (in this example both the age and the gender) are shown in regular black text. If one or more of the database questions under analysis is blank, the data are reported as unspecified in purple text. The totals for both rows and columns are highlighted as bold text.

Some tables record percentage values; in such cases this is made clear by the use of an appropriate title within the table and a % symbol after the values. Yet other tables might report average numbers (the patient's age at a given time, for example) and, again, this is made clear by the use of an appropriate title within the table.

Rows and columns within tables have been ordered so that they are either in ascending order (calendar years; Low, Medium, High) or with negative response options first (No; None) followed by positive response options (Yes; One or more).

Row and column titles are as detailed as possible within the confines of the space available on the page. Where a title in either a row or a column is not as detailed as the authors would have liked, then footnotes have been added to provide clarification.

There are some charts in the report that are not accompanied by data in a tabular format. In such cases the tables are omitted for one of a number of reasons:

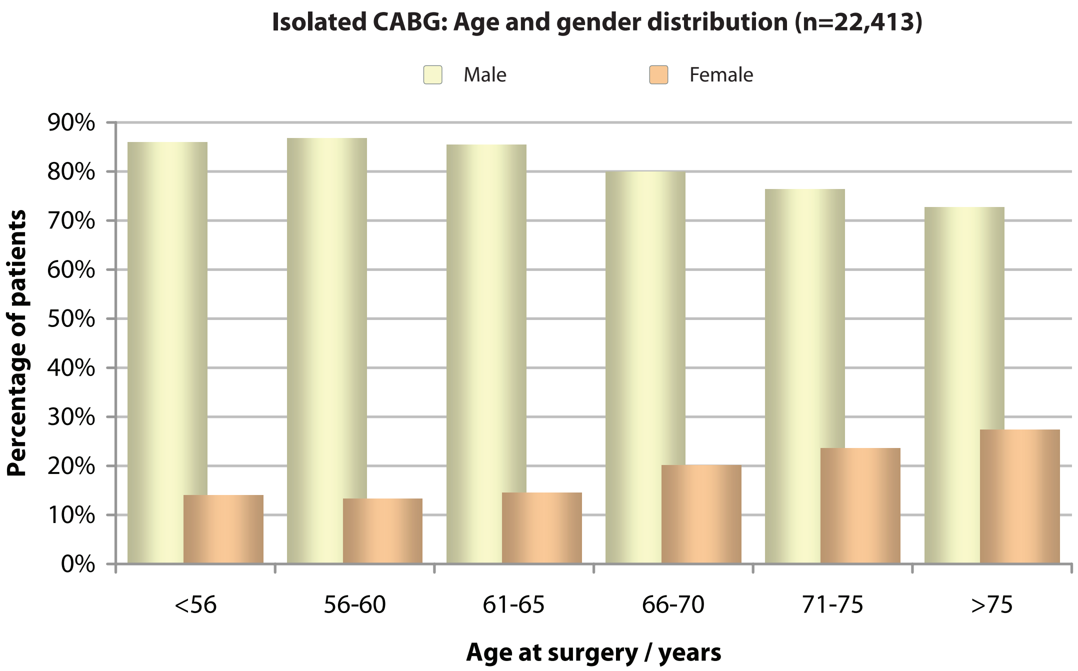
- insufficient space on the page to accommodate both the table and graph.
- there would be more rows or more columns of data than could reasonably be accommodated on the page (for example post-operative length-of-stay).
- the tabular data had already been presented elsewhere in the report.

Conventions used in graphs

The basic principles applied when preparing graphs for the report were based, as far as possible, upon William S. Cleveland's book *The Elements of Graphing Data* [i]. This book details both best practice and the theoretical bases that underlie these practices, demonstrating that there are sound, scientific reasons for plotting charts in particular ways.

Counts: The counts (shown as n= in each graph's title) associated with graphs are affected by a number of independent factors and will therefore vary from chapter to chapter and from page to page. Most obviously, many of the charts in the report are graphic representations of results for a particular group (or sub-set) extracted from the database, such as male patients, patients undergoing coronary artery bypass surgery, and so on. This clearly restricts the total number of database-entries available for any such analysis. In addition to this, some entries within the group under consideration have data missing in one or more of the database questions being examined (reported as unspecified in tables); entries with missing data are excluded from the analysis used to generate the graph because they do not add any useful information.

For example, in the graph below, only the patient-entries with both the patient's age data and gender recorded are included in the analysis; this comes to 22,413 patient-entries (2,794 + 2,536 + 3,290 + 3,348 + 3,245 + 2,871 + 456 + 388 + 561 + 841 + 1,004 + 1,079 from examining the table; the remaining 433 patient-entries with one or more unspecified data-items are excluded from the chart).



Confidence interval: In the charts prepared for this report, most of the bars plotted around rates (percentage values) represent 95% confidence intervals. The width of the confidence interval gives us some idea of how certain we can be about the calculated rate of an event or occurrence. If the confidence intervals around two rates do not overlap, then we can say, with a specified level of confidence, that the rates in these two populations are different; if the bars do overlap, we cannot make such an assertion.

Survival curves: Using encrypted patient-identifiers stored in the data held by CCAD, patients' operation data can be matched with long-term outcome data on the United Kingdom population held by the Office for National Statistics (ONS); these long-term outcome data are returned to the CCAD database to facilitate analyses such as the Kaplan-Meier survival curves presented in this report. These processes are only applied to the data that pass through the CCAD database and therefore all the survival analyses relate only to the data supplied *via* CCAD (consequently to operations performed in the United Kingdom in the financial years 2004 through 2008).

i. Cleveland WS. The Elements of Graphing Data. 1985, 1994. Hobart Press, Summit, New Jersey, USA.

Informed consent

Informed consent, the process in which patients and their carers are given the appropriate information to make decisions about available treatment options, is a fundamental part of healthcare delivery. There have been a number of significant publications relating to consent since the last edition of the Blue Book in 2004. The Society for Cardiothoracic Surgery, together with the Parliamentary and Health Service Ombudsman, jointly published Consent in Cardiac Surgery *A good practice guide to agreeing and recording consent* in 2005. The *Mental Capacity Act*, a wide-ranging piece of legislation, was implemented on the 1st October 2007, and some of its provisions are relevant to consent. In February 2008 the Royal College of Surgeons of England published the latest version of *Good Surgical Practice.* This includes a specific section on consent, detailing 14 overriding duties and principles covering the consent process. In June 2008 the GMC published *Consent: patients and doctors making decisions together.* This guidance places great emphasis on shared decision-making and the communication of risks.

In January 2009 the *NHS Constitution* laid out rights to which NHS patients are entitled, including the right to be given information about proposed treatment in advance, any significant risks and any alternative treatments that may be available, and the risks of doing nothing. In February 2009 the Ombudsman republished her Principles of Good Administration, Principles of Good Complaint Handling and Principles for Remedy. These are broad statements of what she considers public bodies should do to deliver good administration and customer service, and how to respond when things go wrong.

In addition to these pieces of generic legislation and guidance, the National Confidential Enquiry into Peri-operative Deaths has investigated mortality following CABG surgery, and their report *The Heart of the Matter 2008* recommends that a **consultant** should obtain consent for CABG and that the risk of death and any potential likely complications must be recorded on the consent form. This should detail the incidence of these complications based on local data.

This edition of the Blue Book puts cardiac surgeons in an unrivalled position with regards to informing patients of predicted risk and outcomes of any proposed intervention, based on data derived from both local and national outcomes. However, such is the detail and volume of the report that there is a requirement to make the data more readily accessible, perhaps in a web-based format. The message from the publications listed above is clear: failure to relay data on predicted outcomes to the patient, data which the surgeon has access to, may well constitute an infringement of the patient's rights.

Over the same time-period cardiological practice has altered. The routine practice of *angiography query proceed to percutaneous coronary intervention (PCI)* without a multi-disciplinary review of treatment options, the introduction of transcatheter aortic valve implantation and percutaneous mitral valve repair all place heavy responsibilities on those clinicians who need to apply the same standards when obtaining informed consent as surgeons advising about operations. The SCTS has had preliminary discussions with the British Cardiovascular Society and the British Cardiac Intervention Society about developing a joint guidance document on consent for such procedures.

The cardiac surgeon is faced with an ever-increasing outpouring of guidelines and standards from a wide range of bodies and agencies. The important documents related to consent are listed above and we have a duty to read and apply these. To do so we require information and we are fortunate in having this report as a resource available to us. Our challenge now is to extract the data that are relevant to each individual patient facing us in the clinic or ward and to use it in a way that allows them to come to informed decisions about what treatment, if any, to have.

David Richens

Consultant Cardiothoracic Surgeon &

Internal Professional Advisor to the Parliamentary and Health Service Ombudsman

The National Adult Cardiac Surgical Database

Introduction to the database

In the previous blue book, published in 2004, there were 211,033 patient-records in the database. Since then the totals have continued to grow. Between April 2003 and March 2008 a further 189,361 patient-records have been added. All United Kingdom hospitals providing NHS care now submit to the database, as well as 2 private hospital groups and most hospitals in the Republic of Ireland. We have also had a submission from the Prince of Wales Hospital at the Chinese University in Hong Kong, whose lead surgeon is a member of the SCTS. We have used different subsets of this total dataset for the appropriate analyses in the remainder of the book. For the majority of the analyses we have pooled data from the United Kingdom and Ireland. For analysis of geographical variation in surgery we have simply looked at data from English centres. We have included the data from Hong Kong only in an analysis included in the appendices, which is given as an example of how a single centre anywhere in the world could benchmark themselves against the SCTS of Great Britain & Ireland database.

Growth of the National Adult Cardiac Surgical Database (n=400,394)

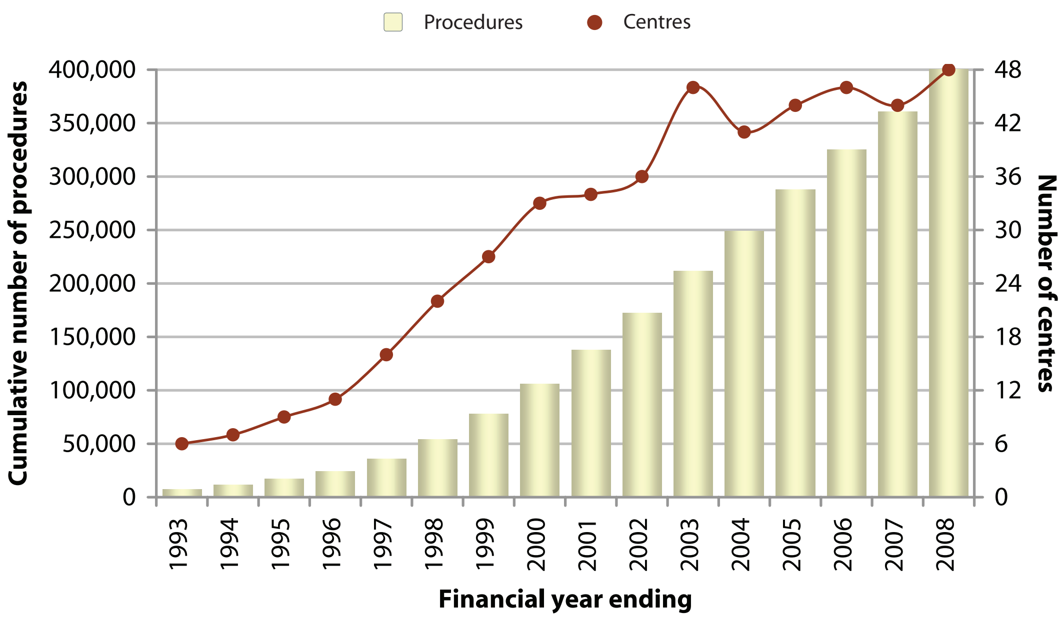


Table of contributing centres: United Kingdom and Ireland

City	Hospital	Year of contribution					Total cases
		2004	2005	2006	2007	2008	
Aberdeen	Royal Infirmary	●	●	●		●	2,432
Basildon	Essex Cardiothoracic Centre			Centre opened in 2008 ⇨		●	514
Belfast	Royal Victoria Hospital	●	●	●	●		2,833
Birmingham	Queen Elizabeth Hospital	●	●	●	●	●	4,520
Blackpool	Victoria Hospital	●	●	●	●	●	4,983
Brighton	Royal Sussex County Hospital	●	●	●	●	●	3,478
Bristol	Royal Infirmary	●	●	●	●	●	6,967
Cambridge	Papworth Hospital	●	●	●	●	●	8,862
Cardiff	University Hospital of Wales	●	●	●	●	●	4,257
Cork	University Hospital	●	●	●	●	●	2,281
Coventry	Walsgrave Hospital	●	●	●	●	●	3,979
Dublin	Mater Misericordiae Hospital		●	●	●	●	2,277
Dublin	St James's Hospital	●	●	●	●	●	2,317
Edinburgh	Royal Infirmary	●	●	●		●	3,558
Glasgow	Golden Jubilee Hospital	●	●	●		●	1,353
Glasgow	Royal Infirmary	●	●	●	●	●	2,929
Glasgow	Western Infirmary	●	●	●	●	●	3,955
Hull	Castle Hill Hospital	●	●	●	●	●	4,626
Leeds	General Infirmary	●	●	●	●	●	5,847
Leicester	Glenfield Hospital	●	●	●	●	●	5,853
Liverpool	Heart & Chest Hospital	●	●	●	●	●	8,449
London	Barts & the London	●	●	●	●	●	8,045
London	Guy's & St Thomas's Hospital	●	●	●	●	●	7,185
London	Hammersmith Hospital	●	●	●	●		2,171
London	Kings College Hospital	●	●	●	●	●	3,379
London	The Heart Hospital	●	●	●	●	●	5,047
London	Royal Brompton Hospital	●	●	●	●	●	4,949
London	St George's Hospital	●	●	●	●	●	5,153
London	St Mary's Hospital				●	●	914
Manchester	Heart Centre	●	●	●	●	●	4,714
Manchester	Wythenshawe Hospital	●	●	●	●	●	5,259
Middlesbrough	James Cook University Hospital	●	●	●	●	●	5,656
Middlesex	Harefield Hospital	●	●	●	●	●	4,408
Newcastle	Freeman Hospital	●	●	●	●	●	5,199
Nottingham	City Hospital	●	●	●	●	●	3,295
Oxford	John Radcliffe Hospital	●	●	●	●	●	4,570
Plymouth	Derriford Hospital	●	●	●	●	●	5,218
Sheffield	Northern General Hospital	●	●	●	●	●	5,437
Southampton	Southampton General Hospital	●	●	●	●	●	4,289
Stoke-on-Trent	N Staffordshire Royal Infirmary	●	●	●	●	●	4,833
Swansea	Morriston Hospital	●	●	●	●	●	3,822
Wolverhampton	New Cross Hospital	Centre opened in 2005 ⇨	●	●	●	●	2,994
	Totals	**38**	**40**	**40**	**38**	**40**	**182,807**

Table of contributing centres: Private and overseas hospitals

City / Country	Hospital	Year of contribution					Total cases
		2004	2005	2006	2007	2008	
Galway	Galway Clinic		●	●	●	●	103
London	Harley Street Clinic	●	●	●	●	●	1,111
London	London Bridge Hospital	●	●	●	●	●	1,452
London	St Anthony's Hospital			●	●	●	340
London	Wellington Hospital	●	●	●	●	●	1,603
Southampton	Chalybeate Hospital				●	●	867
Hong Kong	Prince of Wales Hospital			●	●	●	729
	Totals	**3**	**4**	**6**	**7**	**7**	**6,205**

i The data from Aberdeen Royal Infirmary, Edinburgh Royal Infirmary and Glasgow Jubilee Hospital for the financial year ending 2007 were not included in this report. The data were collected locally and successfully transferred to CCAD, and have been published on the Healthcare Commission website (see appendix 1). However, due to a CCAD systems error with data transfer, they were not transferred to the analytical unit at Dendrite Clinical Systems.

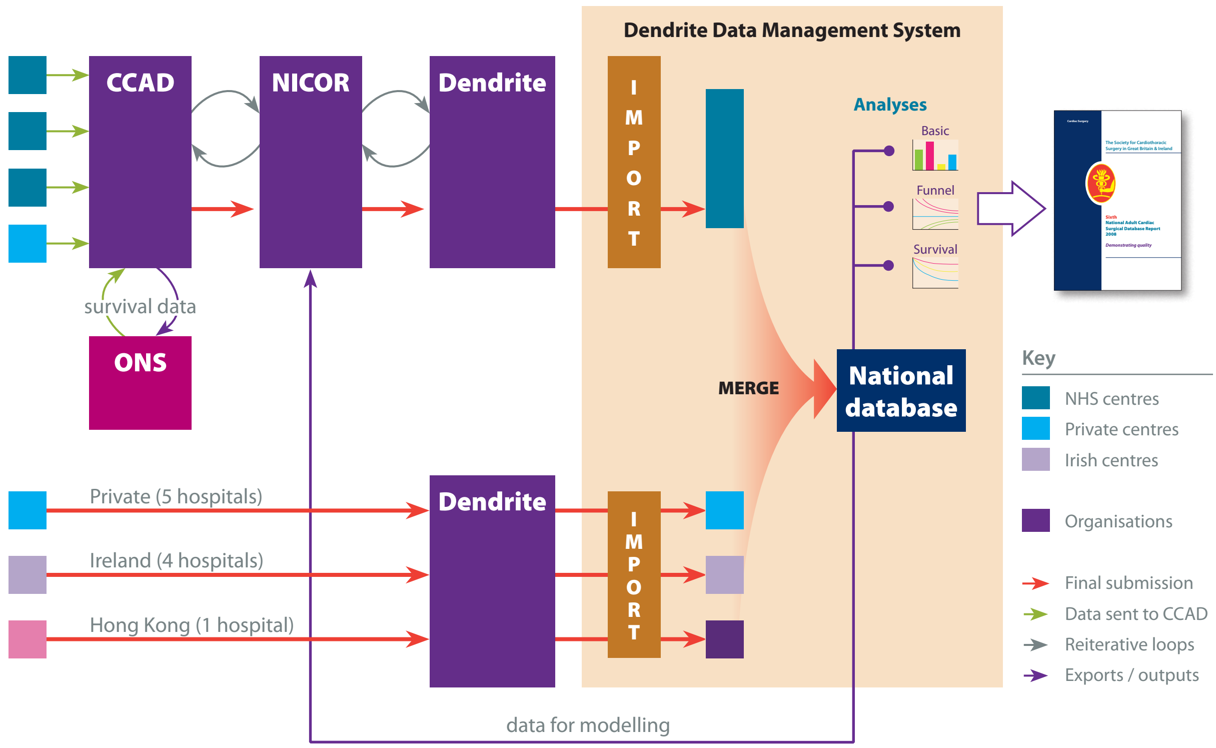
Mechanisms of data submission, merger and analysis

In line with the vision described at that time, the mechanisms of collection, submission, merger and analysis of data have evolved since the publication of the previous National Adult Cardiac Surgical Databases Report (the 5th Blue Book). All centres performing adult cardiac surgery in England, Scotland, Wales and Ireland, both NHS and private, now collect cardiac surgery procedure and outcome data through a variety of local specialised cardiac database systems, which are either available commercially (40 hospitals use Dendrite, 7 use TOMCAT, 2 use DataCam, one uses Infoflex and one uses iSoft) or developed in-house (4 hospitals have their own databases).

Historically all data submissions were routed straight to Dendrite Clinical Systems for merging and data analysis. Dendrite have developed a National Registry Data Management System, comprising a central data-repository that incorporates a sophisticated data import module, a correspondence facility for mapping data fields between registries along with an integrated data analysis armoury. More recently, all of the United Kingdom NHS centres along with a couple of the private centres now submit batch files on-line to the Central Cardiac Audit Database (CCAD), which is part of the NHS Information Centre. Once data have been uploaded from a hospital to the CCAD portal, some preliminary data screening is performed to check data quality before further data-cleaning and mapping of various fields into a consistent format. Encrypted patient identifiers are then submitted to the Office for National Statistics (ONS) for record linking, specifically to gain long-term mortality tracking data. These data are then merged back into the CCAD cardiac surgery data so that an anonymised extract with long-term outcome information can be prepared for export. These data were transferred to an interim analytical unit, the National Institute of Clinical Outcomes Research at University College Hospital London, where the data were further manipulated into a different format, some further cleaning was undertaken and some exploratory analyses were performed. Finally, these data were then transferred to Dendrite's clinical data analytical unit.

The diagram below illustrates the data flow between the various main organisations responsible for handling the cardiac surgery data. Some hospitals – namely the Irish cardiac surgery centres, a number of the United Kingdom private hospitals and one guest contribution from the Prince of Wales Hospital in Hong Kong – still route their data straight to Dendrite's analytical unit for merging and analysis. The data handling procedures described above for both routes of data transmission (either direct to Dendrite or *via* CCAD and NICOR to Dendrite) comply in full with patient confidentiality principles and the Data Protection Act.

Necessarily the data were recycled a number of times back from Dendrite to CCAD *via* NICOR to rationalise duplicate deaths, data errors and duplicate or inadmissible records that had been inadvertently created either through the initial CCAD upload procedure or during the centralised data re-processing at CCAD.

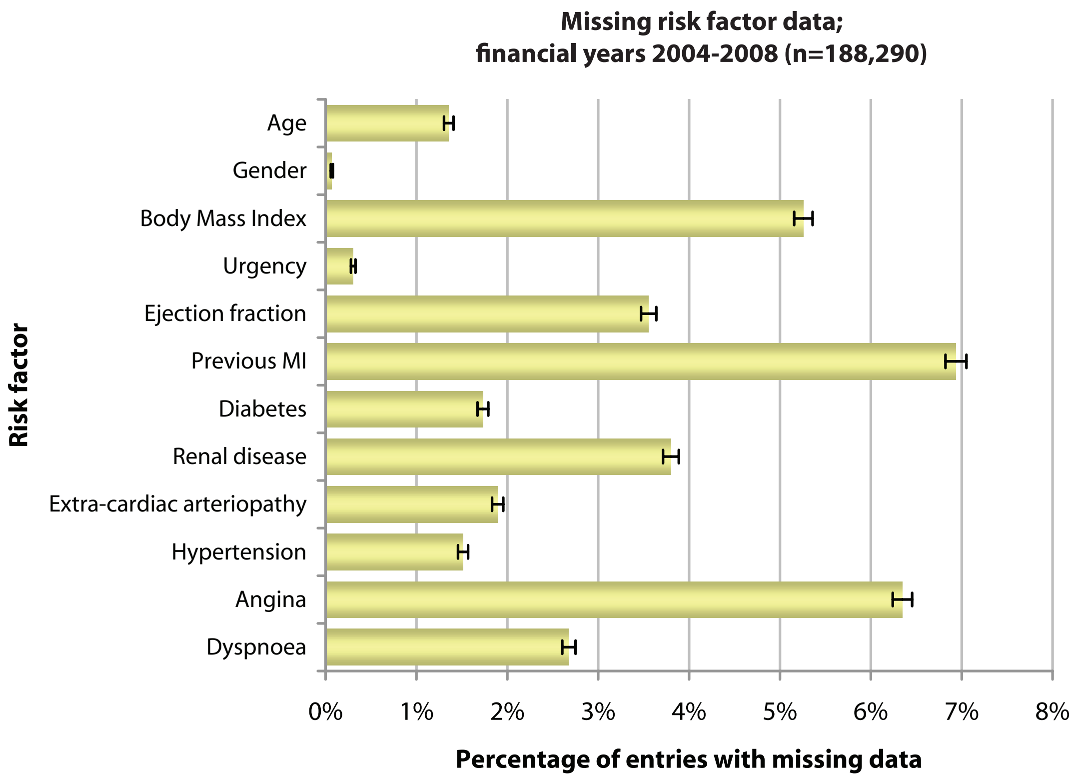


Data quality

Critical to any analysis of a database is the quality of the records included in that database. There are really 2 separate indicators of data quality: data completeness and data accuracy. The tables below describe the incidence of missing risk factor data in the database. It is not possible from analysing the pooled data to make any assessment about the accuracy of the data, but Fine *et al*. have published thoughts on how to improve data quality and some of the processes in place to ensure and validate risk factor data are given in the *good practice examples* section on page 429. By the standards of large databases the data completeness is really very good. The incidence of missing data for all data submitted from 2004 varies between fields from a tiny 0.07% for gender up to 6.9% for previous MI. The table also shows that the incidence of missing data is decreasing over time.

Missing risk factor data in the data acquired since the publication of the last report

		Financial year ending					
		2004	2005	2006	2007	2008	**Total**
Risk factor	Overall counts	37,767	38,725	37,144	35,253	39,401	**188,290**
	Age	1.8%	1.5%	1.5%	0.0%	1.9%	**1.4%**
	Gender	0.28%	0.01%	0.05%	0.01%	0.00%	**0.07%**
	Body Mass Index	11.4%	5.7%	3.6%	2.9%	2.5%	**5.3%**
	Urgency	0.6%	0.5%	0.2%	0.1%	0.1%	**0.3%**
	Ejection fraction	4.3%	3.7%	4.4%	2.1%	3.2%	**3.6%**
	Previous MI	8.6%	6.3%	12.7%	3.3%	3.8%	**6.9%**
	Diabetes	4.0%	2.5%	0.9%	0.8%	0.5%	**1.7%**
	Renal disease	6.2%	3.7%	4.5%	2.2%	2.3%	**3.8%**
	Extra-cardiac arterioapthy	5.0%	1.9%	0.9%	1.0%	0.8%	**1.9%**
	Hypertension	2.1%	2.2%	1.2%	1.0%	1.1%	**1.5%**
	Angina	6.9%	7.6%	7.1%	6.5%	5.9%	**6.8%**
	Dyspnoea	4.2%	3.6%	3.2%	1.6%	0.9%	**2.7%**



i Fine LG, Keogh BE, Cretin S, Orlando M, Gould MM. UK Cardiac Surgery Experience. How to evaluate and improve the quality and credibility of an outcomes database: validation and feedback study on the UK Cardiac Surgery Experience. *BMJ*. 2003; **326(7379):** 25-8.

Missing *Euroscore* data

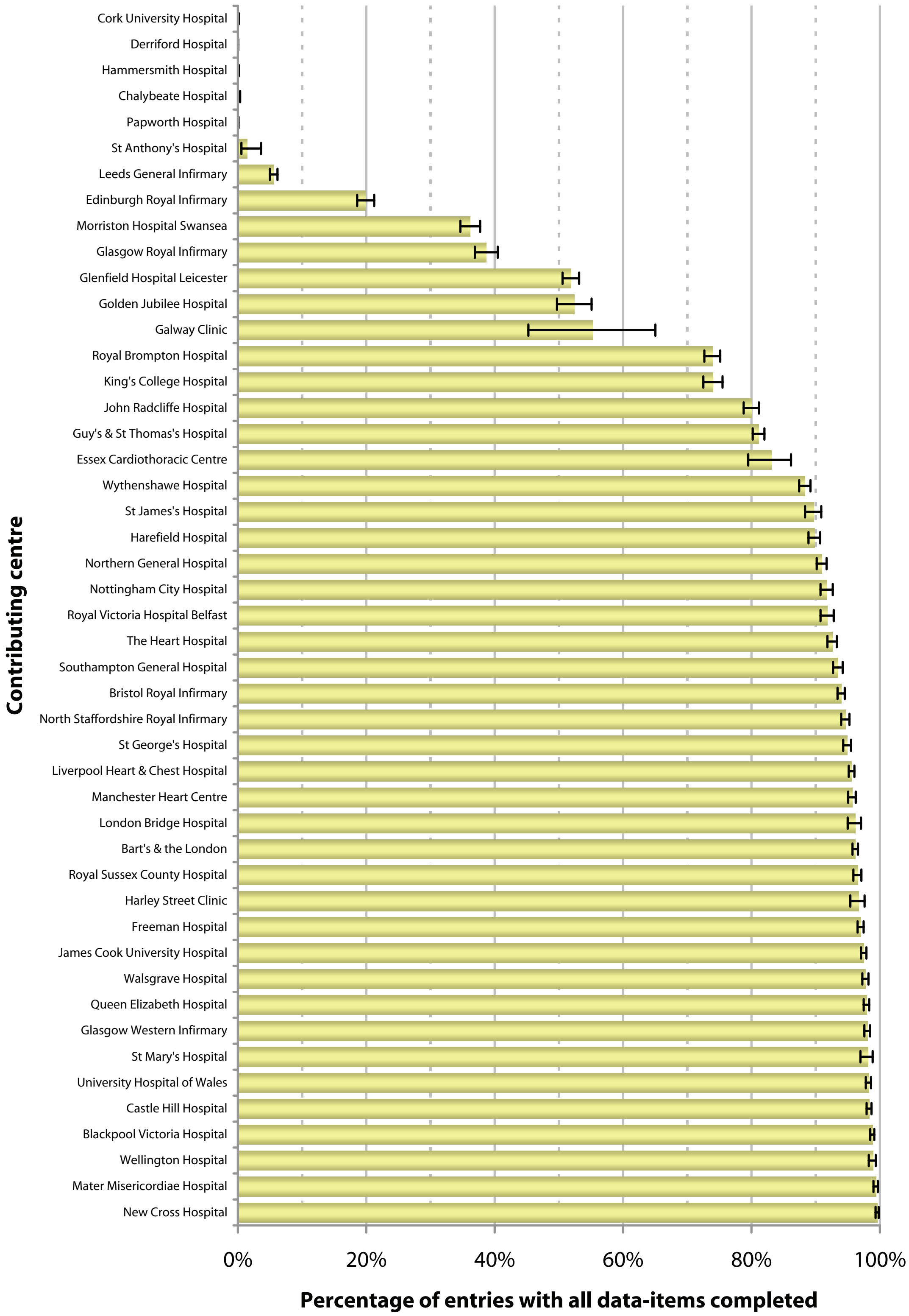
For an accurate ***EuroSCORE*** to be calculated, all of the risk fields must be completed (see page 486). Absence of any field means that the calculated ***EuroSCORE*** for that particular patient may be inaccurate; in reality it is likely that when a ***EuroSCORE*** field is missing, that risk factor is probably absent. This assumption is backed up by some of the information presented later in this book (see page 152). Whilst there are quite a number of units with some degree of missing data, in the majority of cases this is due to only one ***EuroSCORE*** item being missing.

City	Hospital	Number missing				% complete
		0	1	2	>2	
Basildon	Essex Cardiothoracic Centre	427	84	3	0	83.1
Belfast	Royal Victoria Hospital	2,598	205	11	15	91.8
Birmingham	Queen Elizabeth Hospital	4,424	80	5	8	97.9
Blackpool	Victoria Hospital	4,908	48	0	9	98.9
Brighton	Royal Sussex County Hospital	3,353	117	3	0	96.5
Bristol	Royal Infirmary	6,547	352	15	52	94.0
Cambridge	Papworth Hospital	2	8,146	557	123	0.0
Cardiff	University Hospital of Wales	4,171	26	2	46	98.3
Cork	University Hospital	0	0	0	2,281	0.0
Coventry	Walsgrave Hospital	3,889	88	0	0	97.8
Dublin	Mater Misericordiae Hospital	2,256	13	0	0	99.4
Dublin	St James's Hospital	2,075	237	2	0	89.7
Edinburgh	Royal Infirmary	707	2,474	346	31	19.9
Glasgow	Golden Jubilee Hospital	709	17	11	616	52.4
Glasgow	Royal Infirmary	1,133	966	796	34	38.7
Glasgow	Western Infirmary	3,867	75	0	1	98.1
Hull	Castle Hill Hospital	4,540	71	5	0	98.4
Leeds	General Infirmary	324	5,009	445	65	5.5
Leicester	Glenfield Hospital	3,011	715	105	1,975	51.9
Liverpool	Heart & Chest Hospital	8,075	355	15	1	95.6
London	Barts & the London	7,726	269	6	32	96.2
London	Guy's & St Thomas's Hospital	5,816	1,271	81	2	81.1
London	Hammersmith Hospital	0	30	1,761	373	0.0
London	Kings College Hospital	2,496	310	6	560	74.0
London	The Heart Hospital	4,673	295	27	52	92.6
London	Royal Brompton Hospital	3,645	1,234	18	35	73.9
London	St George's Hospital	4,873	120	137	3	94.9
London	St Mary's Hospital	894	17	0	0	98.1
Manchester	Manchester Heart Centre	4,505	182	3	18	95.7
Manchester	Wythenshawe Hospital	4,580	511	41	53	88.3
Middlesbrough	James Cook University Hospital	5,488	124	7	9	97.5
Middlesex	Harefield Hospital	3,920	298	10	136	89.8
Newcastle	Freeman Hospital	5,036	152	2	0	97.0
Nottingham	City Hospital	3,015	277	9	205	91.0
Oxford	John Radcliffe Hospital	3,543	716	72	98	80.0
Plymouth	Derriford Hospital	0	4,786	386	32	0.0
Sheffield	Northern General Hospital	4,983	277	9	205	91.0
Southampton	Southampton General Hospital	3,993	275	3	0	93.5
Stoke-on-Trent	N Staffordshire Royal Infirmary	4,563	210	18	30	94.6
Swansea	Morriston Hospital	1,377	198	10	2,221	36.2
Wolverhampton	New Cross Hospital	2,983	11	0	0	99.6
Galway	Galway Clinic	57	15	15	16	55.3
London	Harley Street Clinic	1,074	37	0	0	96.7
London	London Bridge Hospital	1,396	55	1	0	96.1
London	St Anthony's Hospital	5	183	78	73	1.5
London	Wellington Hospital	1,586	0	0	0	100.0
Southampton	Chalybeate Hospital	0	623	212	32	0.0

i We are unable to assess the ***EuroSCORE*** data quality for Aberdeen Royal Infirmary. Age data were collected in the unit and transferred successfully to CCAD; however, due to technical issues within CCAD, these data were not transferred to the analytical unit at Dendrite Clinical Systems.

Any hospital that does not comprehensively complete all the risk fields, leaves themselves open to the possibility that the predicted risk of their patient population will be underestimated. Centre-by-centre data completeness is given below. For the purposes of this table, when any one field is missing then the *comprehensive* ***EuroSCORE*** cannot be calculated, so a small incidence of missing data in several different fields, could potentially lead to quite a high level of missing ***EuroSCORE*** data overall.

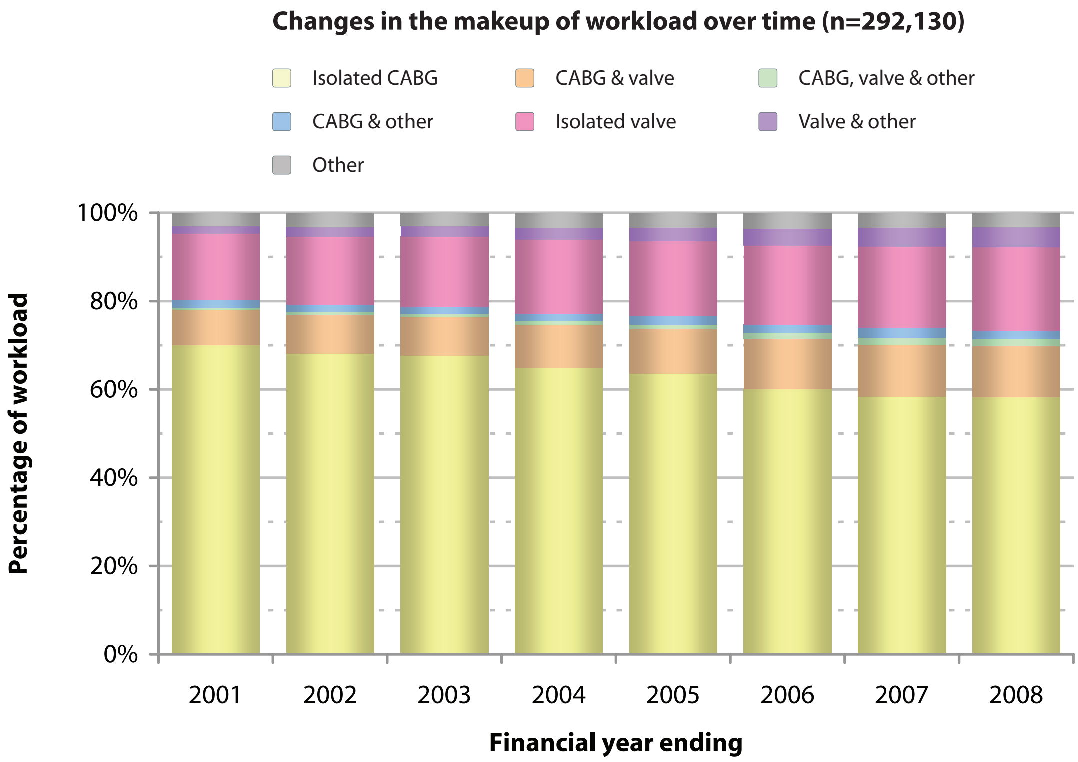
Complete *EuroSCORE* risk factor data; financial years 2004-2008 (n=187,656)



Database overview

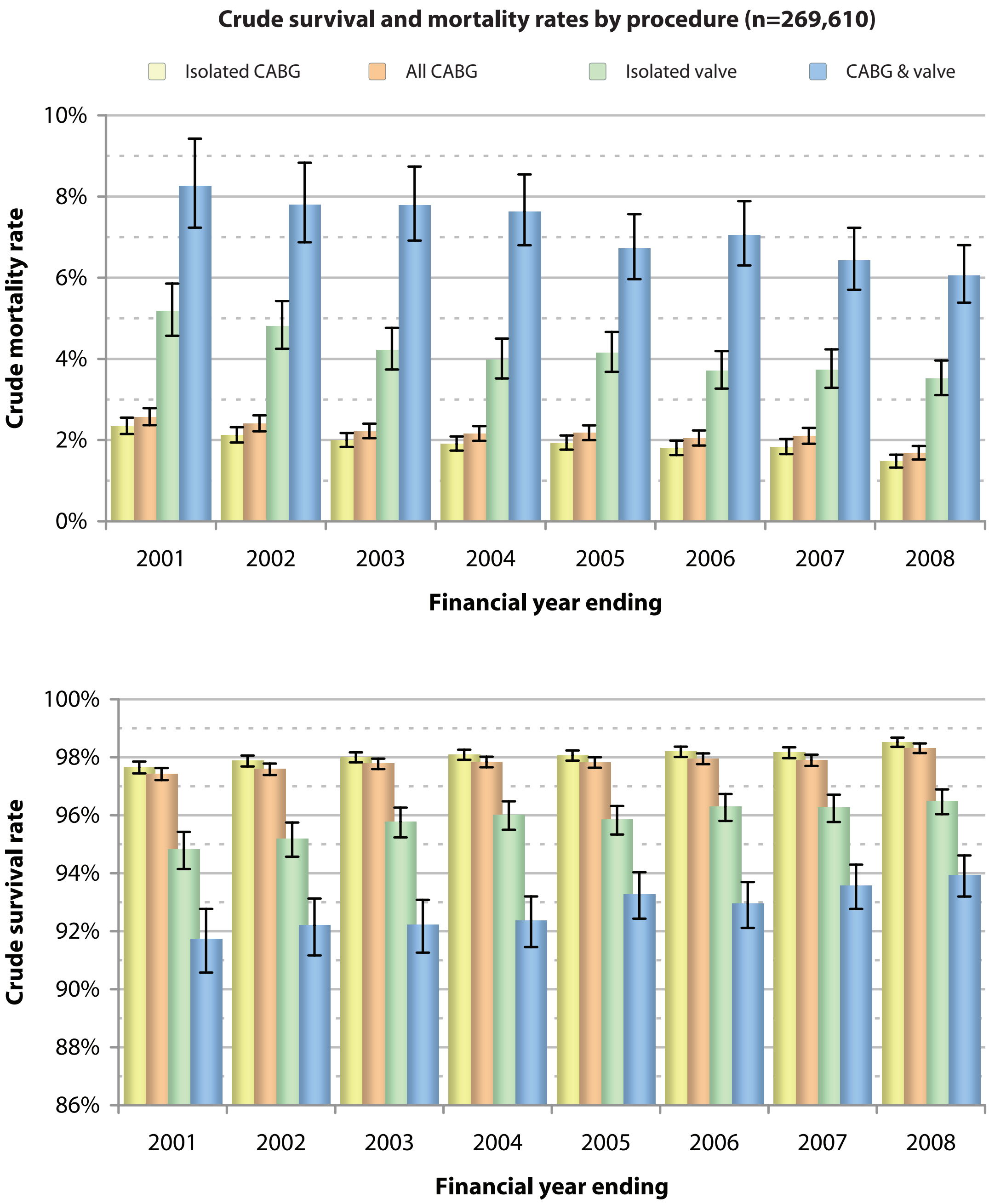
Workload

There has been a year-on-year decrease in the proportion of cardiac surgery workload that is isolated coronary artery bypass surgery, from 70% in 2001 to just under 60% in 2008. There has been a corresponding increase in valve surgery, including both isolated valves and valve surgery in combination with other procedures. The actual changes in valve surgery are described in more details in the relevant sections below.



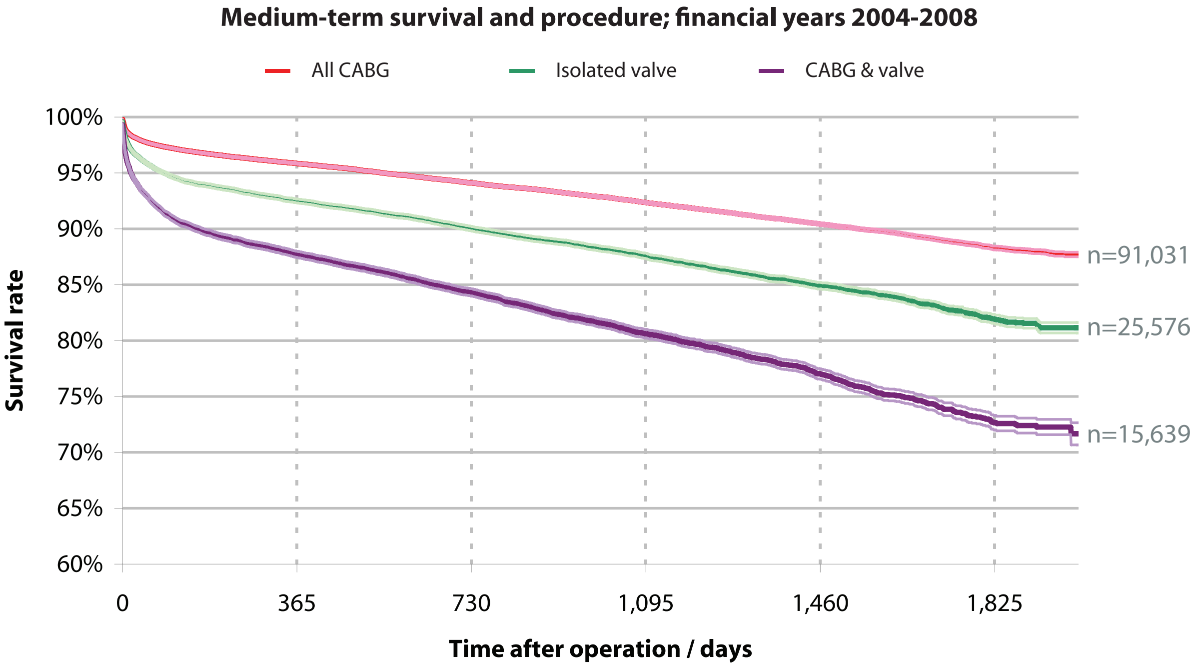
Mortality by procedure

The graphs below show improvements in mortality for all the main operation groups over time. The degree of improvement is marked; between 2001 and 2008 the rates changed from 2.3% to 1.5% for isolated CABG (χ^2-test $p<0.001$), 2.6% to 1.7% (χ^2-test $p<0.001$) for all CABG, 5.2% to 3.5% for isolated valves (χ^2-test $p<0.001$) and 8.3% to 6.1% (χ^2-test $p<0.001$) for combined valve & CABG. All of these improvements are statistically significant.



Medium-term survival by procedure

As well as the difference in in-hospital mortality for the different procedures shown above, there is also a marked difference in medium-term survival. At 5 years about 90% of all patients undergoing coronary artery bypass surgery remain alive; for isolated valve surgery it is just over 80%; and for combined valve & CABG surgery the survival is worse, at just over 70%.



Analysis of cardiac surgery by procedure

Previous editions of the Blue Book have analysed coronary artery bypass grafting procedures in detail from data included in the database, and have included a more superficial analysis of patients with valvular disease from the cardiac surgical register. Because of the progression in data collection through the clinical database we now have sufficient volumes of patients, with satisfactory data completeness, that we can examine the valve operations in the same way that we have previously analysed coronary artery bypass surgery. This is particularly important at this stage as the proportion of total cardiac surgery practice that is due to valvular surgery has increased from 24% to 30% between 2000 and 2008.

The following sections contain analyses of coronary artery bypass surgery, aortic valve replacement and mitral valve surgery, which have been conducted in a consistent manner. Each section contains data on the risk factors associated with surgery for that particular procedure and describes changes in those risk factors over time. Outcomes are then described including mortality, length-of-stay and morbidity, along with medium-term survival. For coronary artery bypass surgery we have examined all risk factors and for the other procedures we have examined a few, selected risk factors in detail and then included a summary of outcomes associated with the other risk factors in tables at the end of the section. We have also undertaken analyses of interest to the specific procedures within each section; for example, outcomes for elective patients undergoing CABG surgery and patients undergoing mitral valve surgery for degenerative mitral disease. We have looked at the predictive ability of the ***EuroSCORE*** for each different procedure, and undertaken some logistic regression modelling to look at the associations between risk factors and in-hospital mortality.

Isolated coronary artery bypass graft surgery

Isolated coronary artery bypass graft surgery

Coronary artery bypass surgery: the best treatment for multi-vessel coronary artery disease

Coronary artery bypass grafting (CABG) is now entering its fifth decade and remains the most intensively studied and documented surgical procedure ever undertaken. Indeed, no other surgical operation continues to be subjected to such intense scrutiny through randomized trials and registries, and the United Kingdom leads the way in producing the most comprehensive and complete outcome data for CABG anywhere in the world. In comparison to the Society of Thoracic Surgeon's database, which is estimated to capture around 90% of CABG operations performed in the United States of America [1], the United Kingdom registry has outcome data on 100% of over 114,000 CABG procedures over the last five years. The authors of this current *Blue Book* should be applauded for this outstanding achievement.

Although first performed in the 1960s it was the meta-analysis of seven randomised trials of CABG *versus* medical therapy by Yusuf and colleagues in the Lancet in 1994 [2] that firmly established the superior symptomatic and prognostic benefits of CABG in complex coronary artery disease. The meta-analysis reported a significant survival benefit for CABG in patients with two- or three-vessel coronary artery disease involving the proximal left anterior descending artery and / or significant left main stem stenosis and that the benefits were exaggerated in patients with severe symptoms, a strongly positive exercise test and impaired left ventricular function. However, the role of CABG as the *gold standard* intervention for severe coronary disease is increasingly questioned in today's clinical practise because of:

1. Substantial improvements in medical therapy
2. Patients are now older with far more co-morbidities
3. CABG is being increasingly challenged by developments in percutaneous coronary intervention (PCI)

Over the last two decades there have been at least 15 trials of PCI *versus* CABG in patients with *multi-vessel* disease deemed equally suitable for revascularisation with either intervention [3]. During this period PCI has evolved from balloon angioplasty to coronary stenting initially with bare metal stents (BMS) and latterly with drug eluting stents (DES). Three meta-analyses of these trials have consistently reported that in comparison to PCI, CABG offers a three- to four-fold reduction in the need for re-intervention [4-6]. With regards to longer-term survival they have variably reported that CABG gives a small [4] or no [5] survival advantage or a survival benefit only to older patients (over 65 years) and those with diabetes [6].

However, these trials all had important limitations that mitigated against the prognostic benefit of CABG in many patients with multi-vessel and /or more complex disease:

- only around 5-10% of the total eligible population were enrolled
- the trial patients were predominantly those with single- or double-vessel disease and normal left ventricular function, a population in whom it had already been clearly established that there was no survival benefit of revascularisation [3]

In other words, the trials were stacked against the prognostic benefit of CABG that was known to exist in patients with more severe coronary artery disease, and particularly in those with impaired left ventricular function. Nevertheless, these fundamental limitations were largely ignored in the literature [7], but, instead, the trial results were inappropriately generalized [8] from their highly select populations to the wider population of patients with multi-vessel coronary artery disease leading, at least in part, to an explosive growth of PCI in developed countries. And the results of the trials are also at odds with the frequently ignored reports from nine large registries, of non-diabetic and diabetic patients, of a consistent survival benefit and up to seven-fold reduction in re-intervention in propensity matched patients with more complex coronary artery disease, with an initial strategy of CABG rather than PCI [9-17]. While registry data are unquestionably more susceptible to both known and unknown confounding factors, even in propensity matched patients, the consistency of their observations is nevertheless striking. And the findings of these registries are also consistent with the one-year interim analysis of the Syntax trial, which confirms a survival benefit of CABG in patients with more severe coronary artery disease [18]. Furthermore, the benefits of CABG in terms of survival and freedom from re-intervention have led health economists to conclude that CABG remains a far more cost effective therapy than PCI over the longer term [19,20].

Why does CABG offer a survival benefit over PCI? There are three likely reasons: the most important is that placing bypass grafts to the mid coronary vessel not only nullifies the complexity of proximal disease but additionally protects whole zones of vulnerable proximal myocardium against the development of new proximal disease.

In contrast, PCI can only deal with anatomically suitable proximal culprit lesions and provides no protection against the development of new disease proximal, within or immediately distal to the stent. The third important reason is that CABG allows more complete revascularisation and this has important prognostic implications as incomplete revascularisation with PCI has been shown to correlate strongly with subsequent mortality [21]. And these facts are also the most likely explanations for the observation that, in terms of survival and freedom from myocardial infarction, bare metal stents have no benefit over balloon angioplasty [22] and drug eluting stents have no benefit over bare metal stents [23].

However, while there have been significant advances in the conduct of PCI, potentially beneficial developments in CABG have been much less widely adopted. The current results in the *Blue Book* are a testament to the safety of CABG with an overall elective mortality of around 1%. However, mortality is higher in patients with more risk factors, yet the uptake of off-pump surgery, which, as subsequently discussed, appears to reduce operative risk in these higher-risk patients [24,25], has remained relatively low (17% of United Kingdom patients) and in marked contrast to practice in Asian countries. Likewise, while 95% of patients receive at least one internal mammary artery, the use of both internal mammary arteries, where there is strong evidence for a potential survival benefit at least in certain patient groups [26], has remained stubbornly low.

In summary, the current state of knowledge still supports CABG as the optimum revascularisation strategy, clinically and economically, in most patients with complex coronary artery disease, and particularly in those with involvement of the distal left main, the proximal LAD and the presence of impaired ventricular function. As such, it should be the standard of care that patients who require revascularisation are offered the benefit of a surgical opinion as well as that of the interventional cardiologist. The most robust way of ensuring transparency, real patient choice and genuine informed consent in the decision-making process are that all patients with complex coronary disease should have a treatment plan recommended by a multi-disciplinary team (as would be the case for lung cancer).

The data shown in this book give extensive information about contemporary outcomes of coronary artery bypass surgery, which should be used to inform this multi-disciplinary decision-making process. As the ***EuroSCORE*** systematically over-predicts observed mortality it should not now be used for risk prediction for consent purposes. The analysis presented later shows, for example, that elective patients under the age of 60 undergoing CABG have an in-hospital mortality of 0.3% and a medium-term survival of 95% re-enforcing that all suitable patients with multi-vessel coronary disease should be informed of the contemporary outcomes of coronary artery bypass surgery before consenting to PCI. In elective patients this will necessitate separation of the diagnostic angiogram from the immediate decision to proceed to intervention to allow time for a truly informed decision.

Prof. David Taggart

Professor of Cardiovascular Surgery, University of Oxford
Consultant Cardiac Surgeon, John Radcliffe Hospital, Oxford

i For references see the end of the section on CABG surgery, pages 160-161.

Introduction

Coronary artery bypass surgery has traditionally made up the majority of cardiac surgical practice. As shown in the figure on page 42, this proportion has fallen over time due to increasing treatment of coronary disease by percutaneous techniques and also because we now undertake greater volumes of valve surgery. However, isolated CABG still comprised 58.3% of all cardiac surgical operations in 2008, and so the following sections analyse this in more detail. We have included analyses of each major risk factor, describing changes in the incidence of these risk factors over time, and the association of each factor with in-hospital mortality. We have also shown the association of each risk factor with length of post-operative stay and medium-term survival.

Risk factor analyses

Age

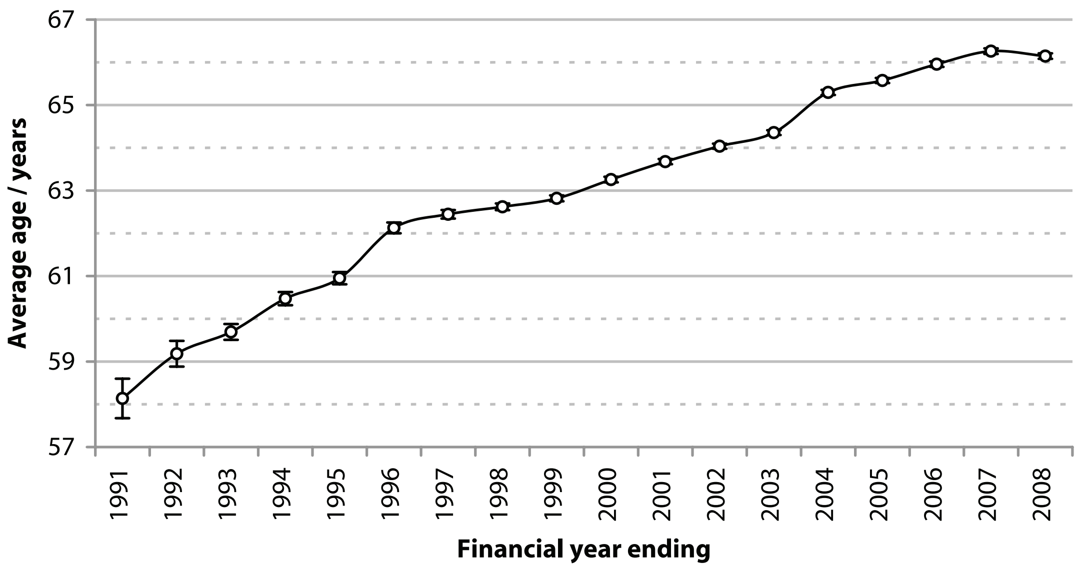
Key points from age analyses

- Age is a very well recorded variable. In 2007 all patient records submitted to the database had the patient's age recorded. Overall the incidence of missing data in the period since 2004 was 1.4%.
- The mean age of patients undergoing isolated CABG has increased from just over 63 years in 2000 to just over 66 in 2008.
- In 2008, 25% of all patients undergoing coronary artery bypass surgery were over 75 years of age. This has increased from 10% in 1999.
- There is a gradually increasing number of patients over the age of 80 years undergoing CABG, and they made up 4.4% of all operations in 2008.
- Despite the increase in the age of the patients, mortality has fallen from 1.9% in 2004 to 1.5% in 2008. There has been a marked fall in the mortality of patients over the age of 75 from 5.0% in 2004 to 3.4% in 2008.
- Increasing age is strongly associated with longer in-hospital post-operative stay and reduced medium-term survival. However, the medium-term survival rate for patients over 80 years is better than 65% at 5 years.

Average age

There has been a year-on-year increase in the average age of patients undergoing isolated CABG between 1991 and 2007, from 58 to 66 years of age. It is possible that this trend may not continue, with there being a small decrease in average age between 2007 and 2008.

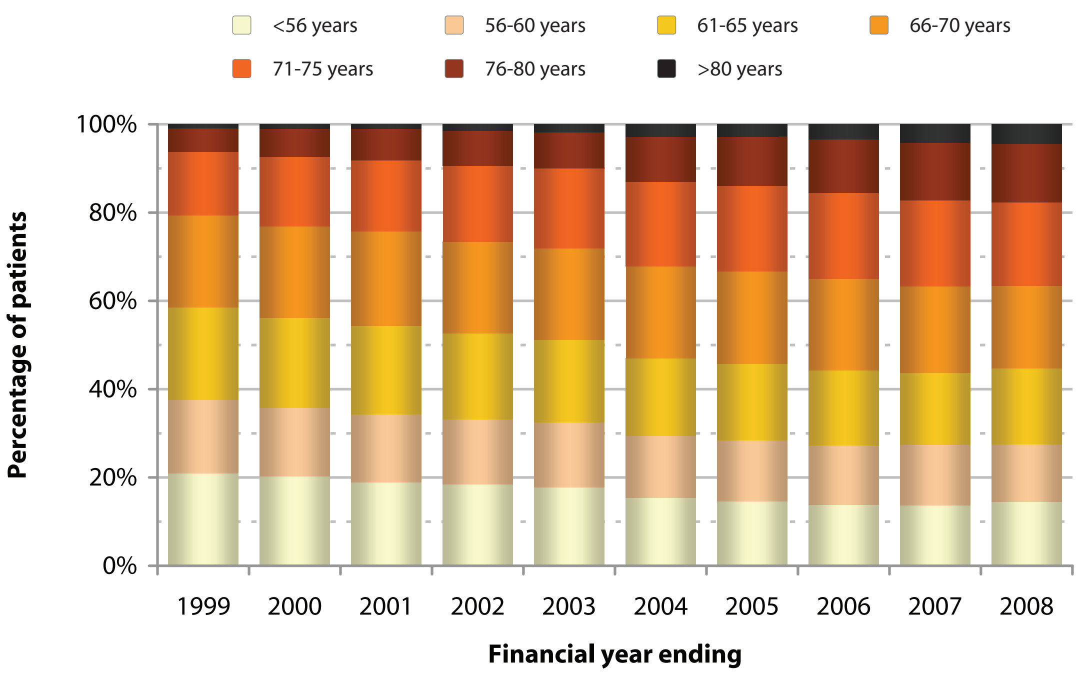
Isolated CABG: Average age; bars denote standard error (n=257,362)



Age categories

There has been a marked increase in the number of elderly patients undergoing CABG. The proportion of patients over 75 has increased between 2004 and 2008 from 13.0% to 17.6%; segmenting out the over 80-year-olds shows an increase in this age group from 2.8% to 4.4% over the same period. These are important changes as advanced age is an important risk factor for operative mortality and increased resource utilisation.

Isolated CABG: Age categories (n=220,175)

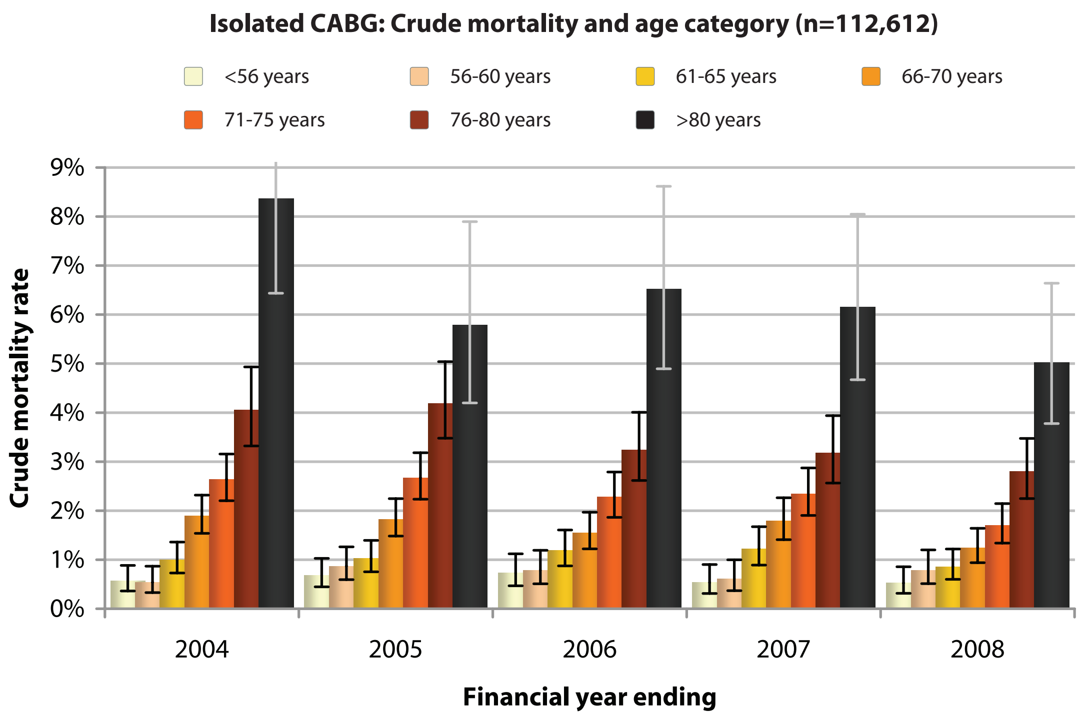


Mortality and age

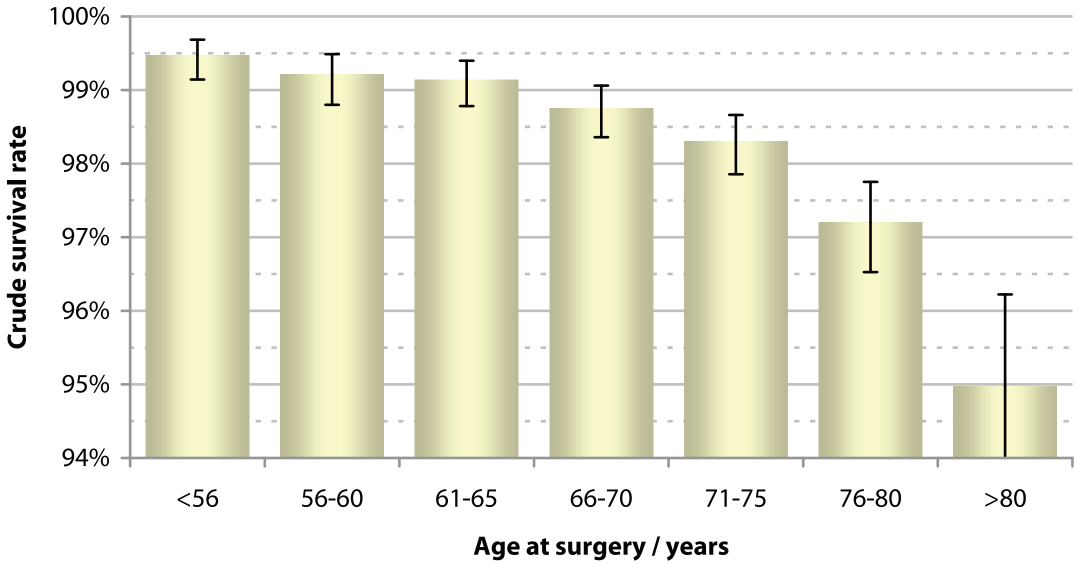
There has been a marked decrease in overall mortality over time, with the most marked improvement being seen in the elderly.

Mortality, age and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

Age / years	Financial year 2004	2005	2006	2007	2008	All
<56	0.57% 3,692	0.68% 3,526	0.73% 3,019	0.53% 2,805	0.52% 3,245	**0.61% 16,287**
56-60	0.54% 3,345	0.87% 3,337	0.78% 2,940	0.61% 2,781	0.79% 2,919	**0.72% 15,322**
61-65	1.00% 4,208	1.03% 4,186	1.19% 3,703	1.22% 3,351	0.86% 3,846	**1.05% 19,294**
66-70	1.89% 4,974	1.83% 5,037	1.55% 4,509	1.79% 3,971	1.24% 4,180	**1.67% 22,671**
71-75	2.64% 4,585	2.67% 4,683	2.28% 4,249	2.34% 3,973	1.70% 4,244	**2.34% 21,734**
76-80	4.05% 2,443	4.19% 2,672	3.24% 2,653	3.18% 2,671	2.80% 2,966	**3.47% 13,405**
>80	8.37% 669	5.79% 674	6.52% 736	6.15% 845	5.03% 975	**6.26% 3,899**
Unspecified	3.01% 465	2.45% 408	2.62% 382	0.00% 0	1.62% 433	**2.43% 1,688**
All	**1.91% 24,381**	**1.93% 24,523**	**1.80% 22,191**	**1.83% 20,397**	**1.47% 22,808**	**1.79% 114,300**

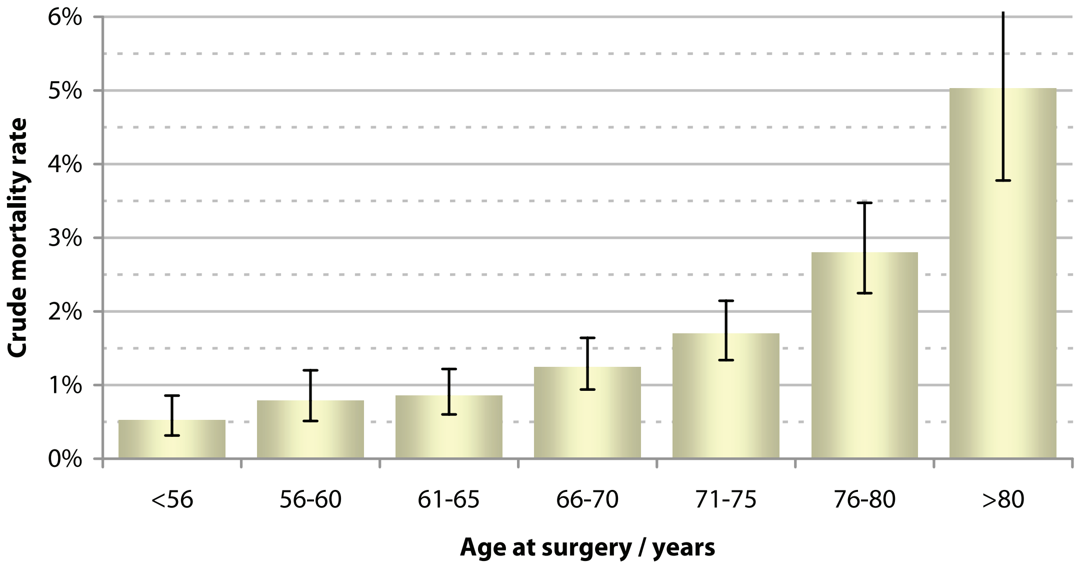


Isolated CABG: Crude survival and age for the financial year 2008 (n=22,375)



These graphs show the excellent results currently being achieved for patients undergoing isolated coronary artery bypass surgery. Overall improvements of care now mean that the risk of death from surgery in patients over the age of 75 is 3.4% and for patients over 80 years of age 5.0%. Age does, however, remain an important risk factor, with elderly patients at significantly higher risk of not coming through surgery than their younger counterparts. These issues need to be considered when making decisions about whether bypass surgery is in a patient's best interests, and should be used to help give informed consent about the likely risks of surgery.

Isolated CABG: Crude mortality and age for the financial year 2008 (n=22,375)

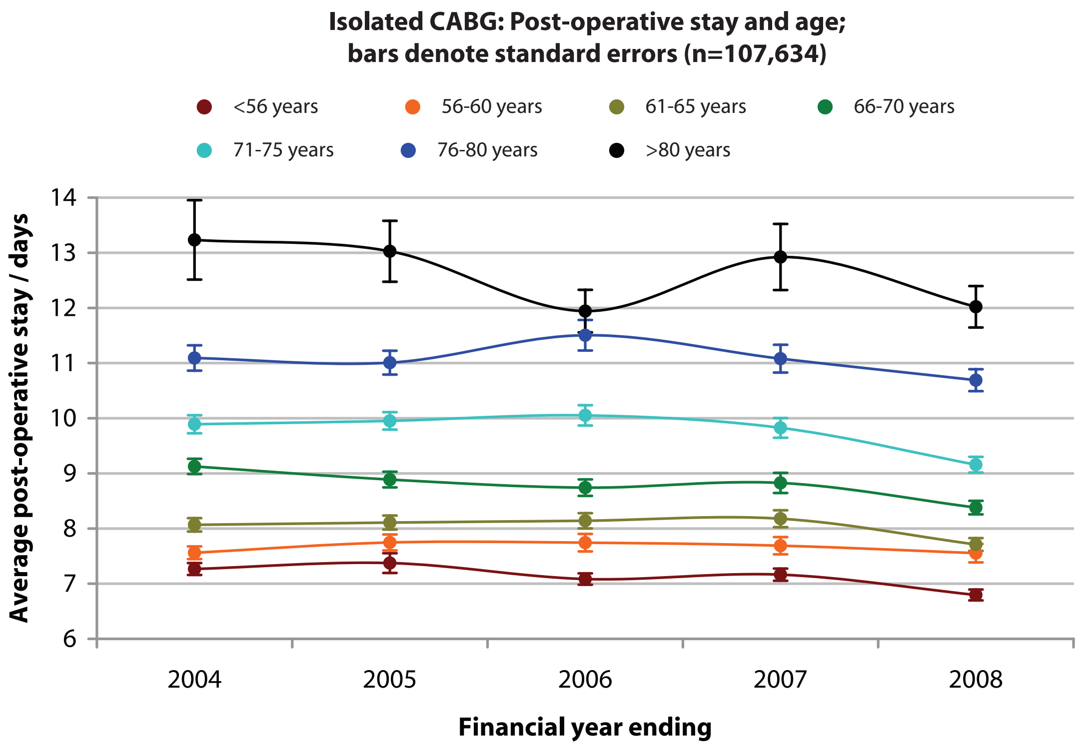


Post-operative stay and age

As well as there being a higher mortality in the more elderly groups, there is also a marked increase in in-hospital stay. This is a consistent trend with the length-of-stay increasing with increasing age. These findings are of significance as a progressively more elderly population undergo coronary artery bypass surgery.

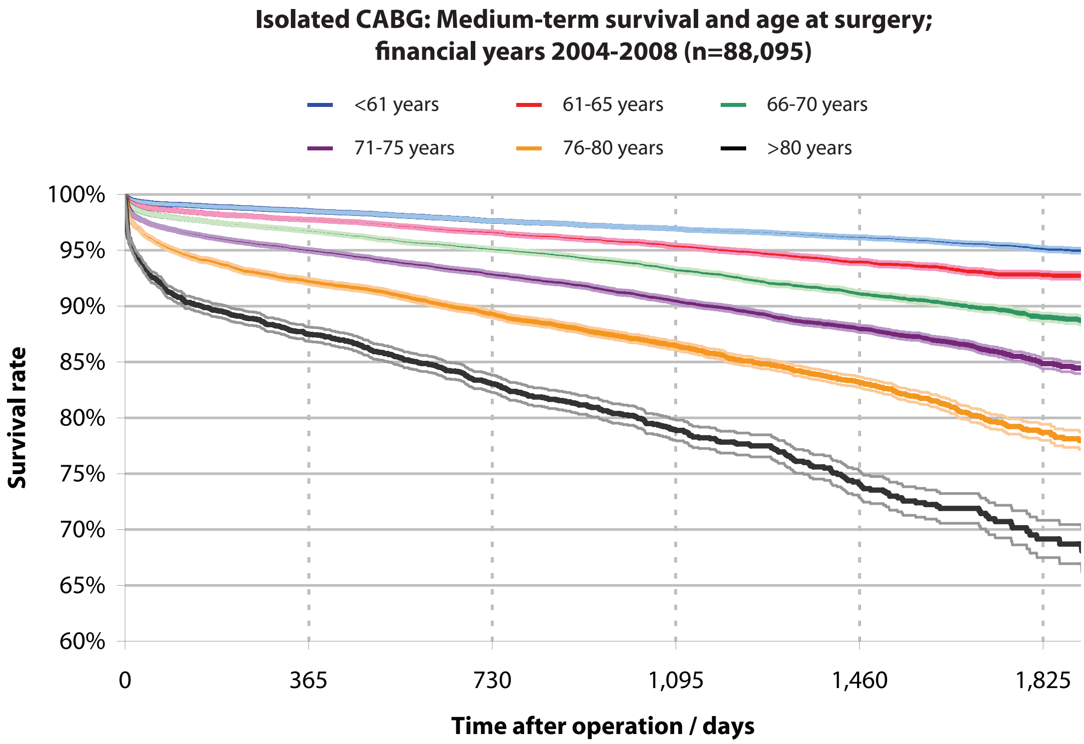
Post-operative stay, age and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

		Financial year				
		2004	2005	2006	2007	2008
Age / years	<56	7.3 3,517	7.4 3,402	7.1 2,806	7.2 2,647	6.8 3,202
	56-60	7.6 3,192	7.7 3,215	7.7 2,747	7.7 2,602	7.6 2,882
	61-65	8.1 4,004	8.1 4,028	8.1 3,440	8.2 3,168	7.7 3,783
	66-70	9.1 4,738	8.9 4,869	8.7 4,162	8.8 3,714	8.4 4,126
	71-75	9.9 4,378	10.0 4,518	10.1 3,941	9.8 3,779	9.2 4,191
	76-80	11.1 2,348	11.0 2,591	11.5 2,452	11.1 2,515	10.7 2,930
	>80	13.2 647	13.0 663	11.9 679	12.9 793	12.0 965
	Unspecified	8.6 465	9.4 407	10.3 377	0.0 0	9.5 433



Survival and age

The overall medium-term survival is 88.8% as shown on page 44. The following graph shows that survival is critically dependent on age at surgery. For patients who are less than 66 when they undergo surgery the Kaplan-Meier survival rate at 5 years post-surgery is more than 90%. For those over 80 it is 69%.



Gender

Key points from gender analyses

- Gender remains a very well recorded variable with no missing data in the most recent year of submissions.
- There are marked changes in the proportion of female patients with increasing age: in patients under the age of 51 years of age 13% of patients are female, in those over the age of 80 it rises to nearly 30%.
- Women consistently have an in-hospital mortality that is nearly twice that of their male counterparts.
- Women have slightly, but statistically significantly, worse medium-term survival than men.

Gender distribution

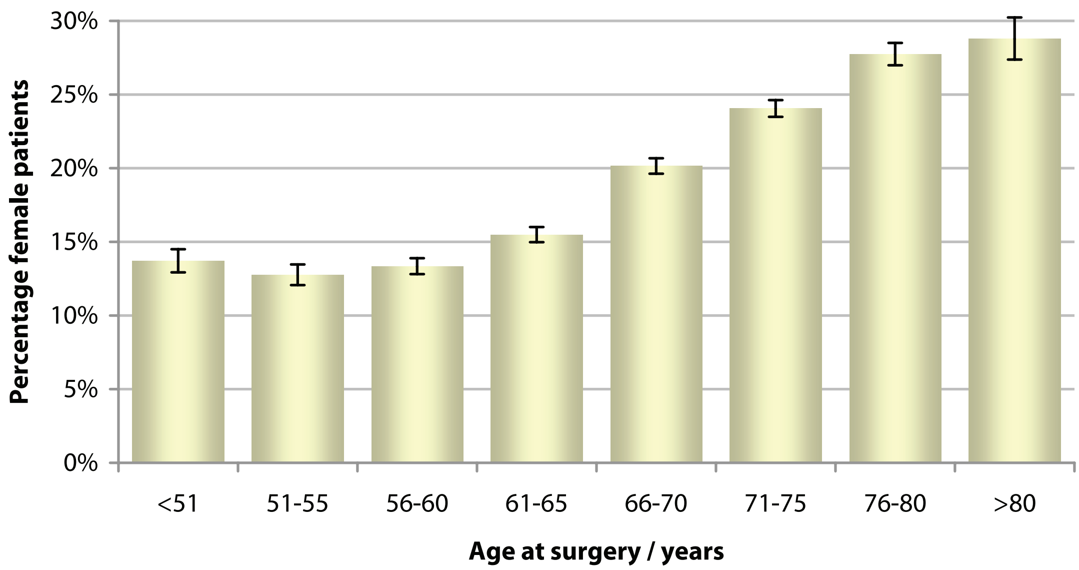
Women make up around one-quarter of all patients undergoing isolated CABG. This proportion has not changed over time.

In the younger age groups, women comprise only 13% of the patient-population; in the older, post-menopausal age groups, this proportion rises, and nearly one-third of octogenarians undergoing isolated CABG are female.

Gender distributions over time

		Financial year							
		2001	2002	2003	2004	2005	2006	2007	2008
Gender	Male	17,623	18,603	21,055	19,544	19,756	17,882	16,649	18,426
	Female	4,414	4,799	5,104	4,815	4,776	4,356	3,861	4,420
	Unspecified	1	1	79	72	4	13	2	0
	All	**22,038**	**23,403**	**26,238**	**24,431**	**24,536**	**22,251**	**20,512**	**22,846**

Isolated CABG: Gender distributions; financial years 2004-2008 (n=112,798)



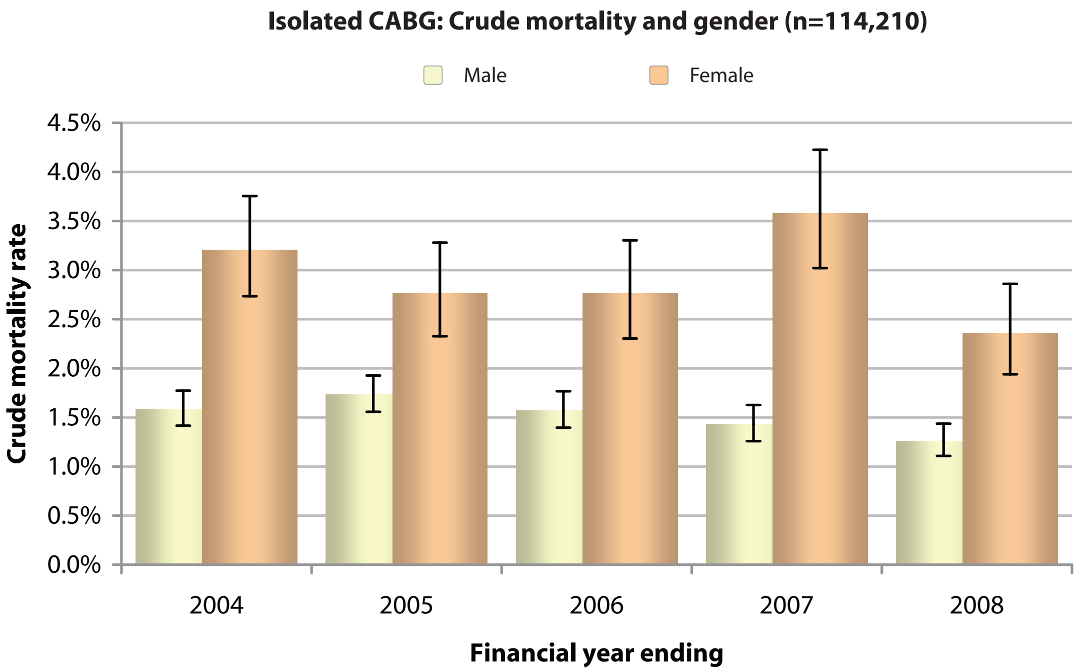
Mortality and gender

The in-hospital mortality rate for females remains almost twice as high as that for males. This difference has not changed over time, despite ongoing improvements in the quality of outcomes. The reasons for this are not completely understood, but almost certainly the increasing proportion of women in the older age groups is an important factor. The association of female gender and in-hospital mortality is explored in more detail in the logistic modelling section on page 394.

Over time the observed in-hospital mortality for male patients has fallen significantly (χ^2 test for trends $p<0.001$), but there has been no such decrease for female patients ($p=0.213$).

Mortality, gender and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	**All**
Gender	Male	1.6% 19,507	1.7% 19,744	1.6% 17,831	1.4% 16,564	1.3% 18,396	**1.5%** **92,042**
	Female	3.2% 4,803	2.8% 4,775	2.8% 4,347	3.6% 3,831	2.4% 4,412	**2.9%** **22,168**
	Unspecified	2.8% 71	0.0% 4	0.0% 13	0.0% 2	NA 0	**2.2%** **90**
	All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**



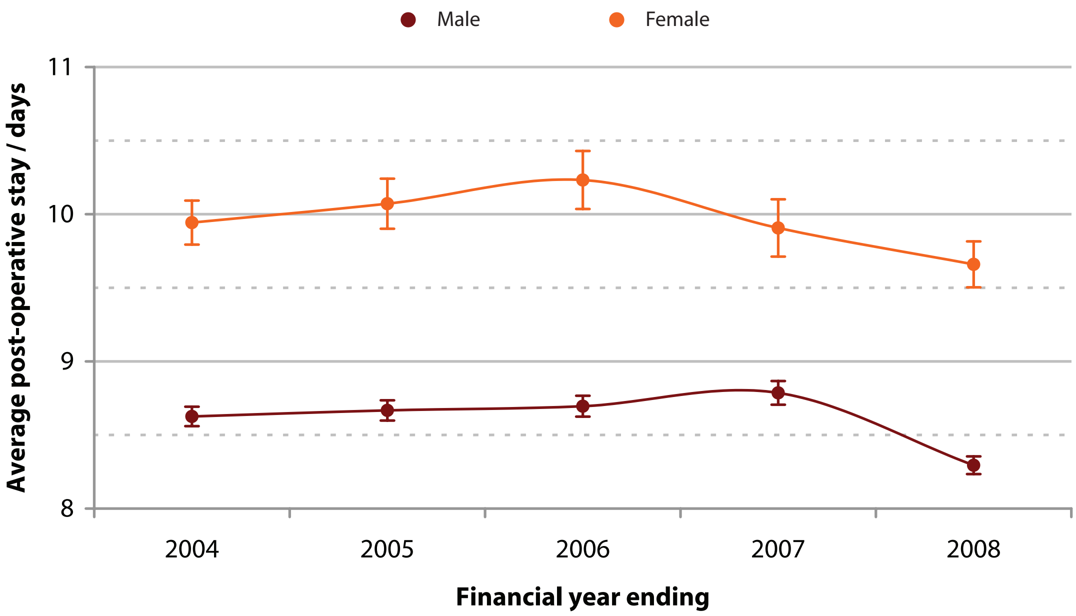
Post-operative stay and gender

Women consistently stay longer in hospital than men. This difference has marked statistical significance, but represents an average difference of about 1 day.

Post-operative stay, gender and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

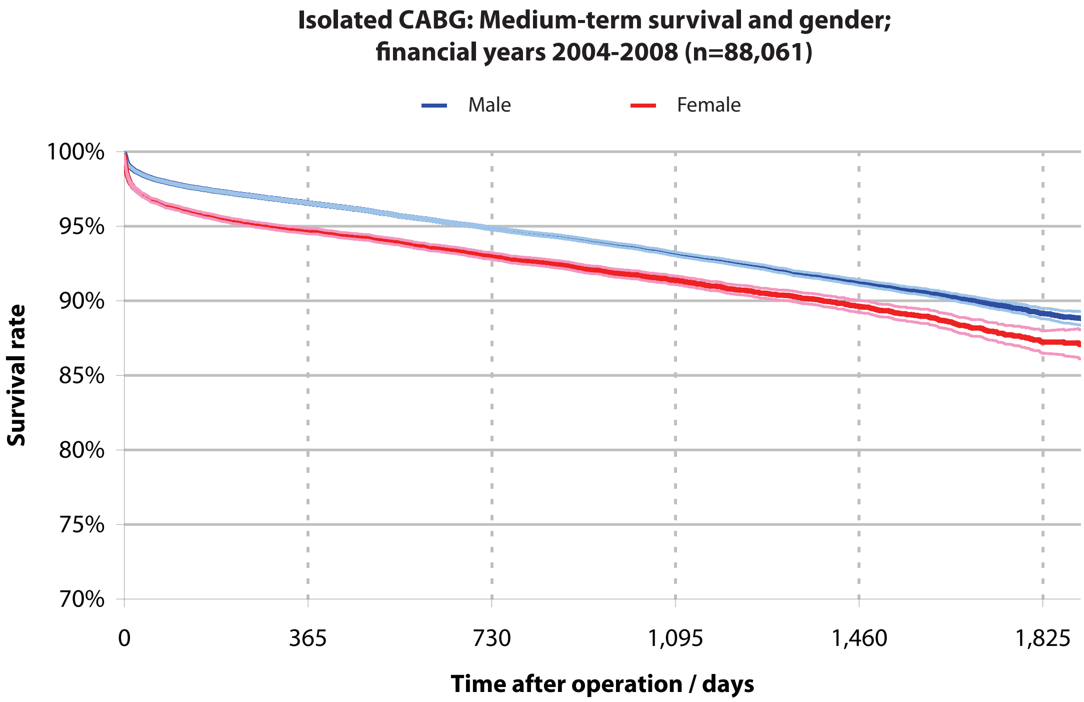
		Financial year				
		2004	2005	2006	2007	2008
Gender	Male	8.6 18,660	8.7 19,065	8.7 16,548	8.8 15,632	8.3 18,143
	Female	9.9 4,618	10.1 4,624	10.2 4,043	9.9 3,584	9.7 4,369
	Unspecified	25.9 10	14.5 4	6.4 13	29.0 2	0.0 0

Isolated CABG: Post-operative stay and gender; bars denote standard errors (n=109,286)



Survival and gender

The overall medium-term survival is significantly lower for women than it is for men, but this difference is small. This may be due to the increasing incidence of women in the older age groups.



Body size

Key points from body size analyses

- The body mass index (BMI) is an indicator of whether or not patients are overweight. There is increasing concern in the UK & other developed nations about an epidemic of obesity.
- 75% of patients undergoing isolated CABG are overweight & about one-third are obese.
- The proportion of patients undergoing CABG who are obese and morbidly obese has increased over time (χ^2 test for trend $p<0.001$).
- The mortality of patients who are underweight is relatively high at 4.1%, but, surprisingly, obesity is not associated with a high mortality.
- Underweight & morbidly obese patients stay longer in hospital than other patients.
- Patients who are underweight at the time of their coronary surgery have a worse medium-term survival than other patients. Of interest, obese and morbidly obese patients have the same medium-term survival rates as patients of normal weight.

Body Mass Index distributions

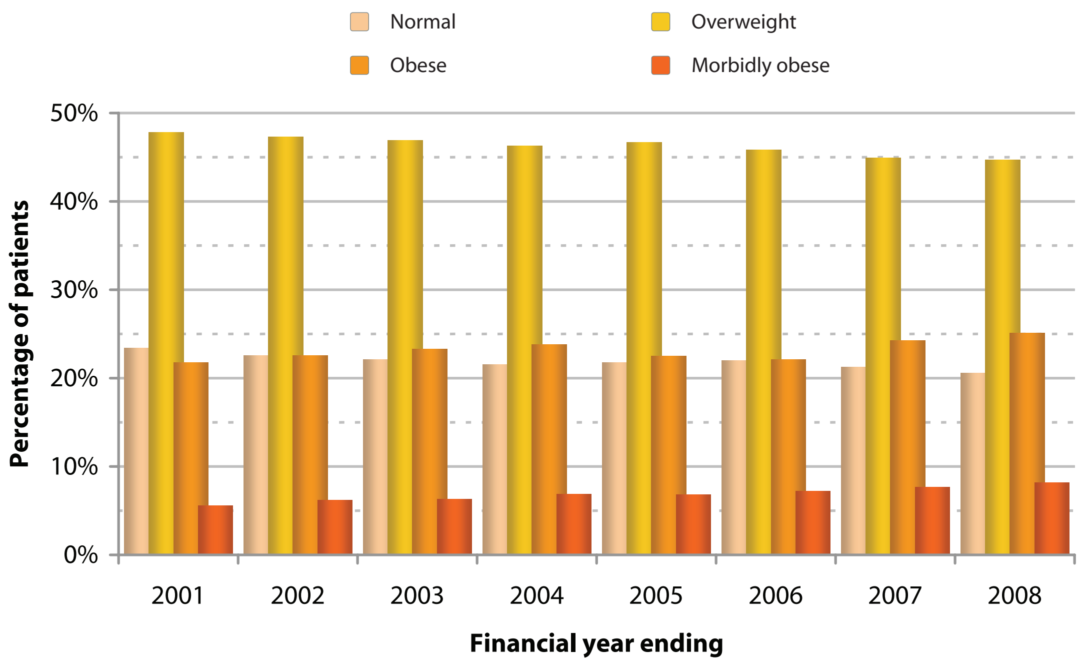
The Body Mass Index (BMI) is an indicator of whether patients are overweight or not, and it has been used in some models designed to predict operative mortality. There is growing concern in the United Kingdom and other developed nations about the increasing incidence of patients who are obese. BMI is a function of the patient's height and weight and is calculated by:

BMI = the patient's mass in kg ÷ (the patient's height in metres)^2

A BMI of less than 25 is defined as healthy, but less than 20 is underweight. A BMI greater than 25 is overweight; more than 30 is obese and over 35 is morbidly obese.

Over time, the proportion of patients who are of normal weight has decreased; correspondingly, there are greater proportions of patients who are obese & morbidly obese. The underweight patients comprise only 1.7% of the population undergoing CABG and are omitted from the following chart to avoid making it overly confusing.

Isolated CABG: Body mass index (n=174,498)



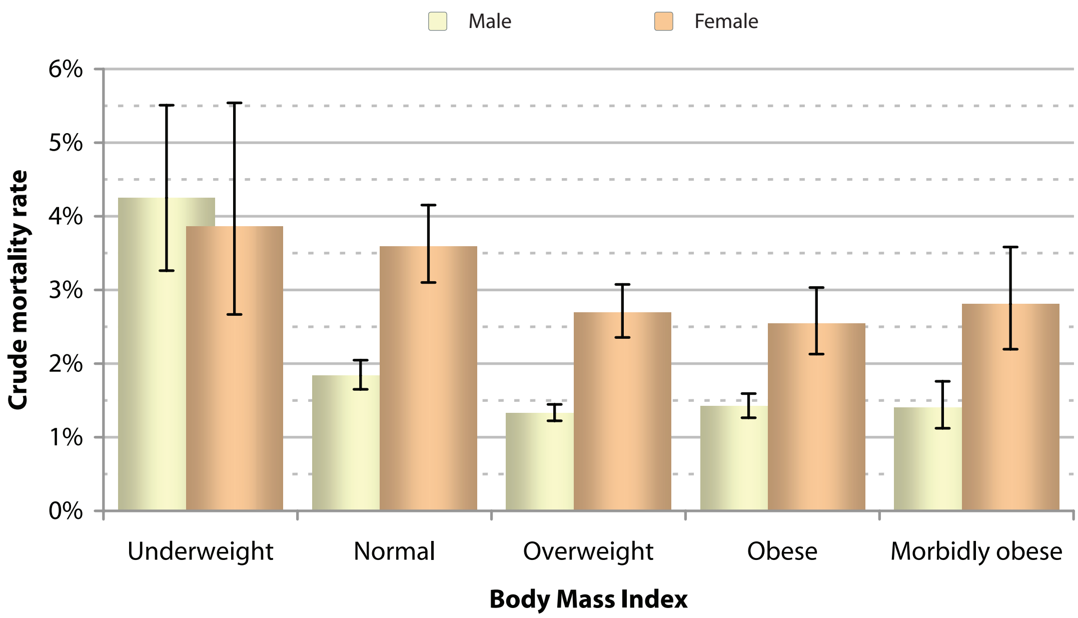
Mortality and BMI

The in-hospital mortality rate for patients who are underweight is higher than the average, at 4.1% and, unusually, is the same for males and female patients. However, obesity and morbid obesity are not associated with an increased risk of operative mortality.

Mortality, BMI and gender; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

Body mass index		Gender: Male	Female	Unspecified	All
Underweight	<20.0	4.3% 1,341	3.9% 776	0.0% 2	**4.1%** **2,119**
Normal	20.0-24.9	1.8% 18,228	3.6% 5,013	0.0% 3	**2.2%** **23,244**
Overweight	25.0-29.9	1.3% 41,568	2.7% 8,060	0.0% 7	**1.6%** **49,635**
Obese	30.0-34.9	1.4% 20,636	2.5% 4,916	0.0% 6	**1.6%** **25,558**
Morbidly obese	>34.9	1.4% 5,617	2.8% 2,349	0.0% 2	**1.8%** **7,968**
Unspecified		1.8% 4,652	2.8% 1,054	2.9% 70	**2.0%** **5,776**
All		**1.5%** **92,042**	**2.9%** **22,168**	**2.2%** **90**	**1.8%** **114,300**

Isolated CABG: Crude mortality, body mass index and gender; financial years 2004-2008 (n=108,504)



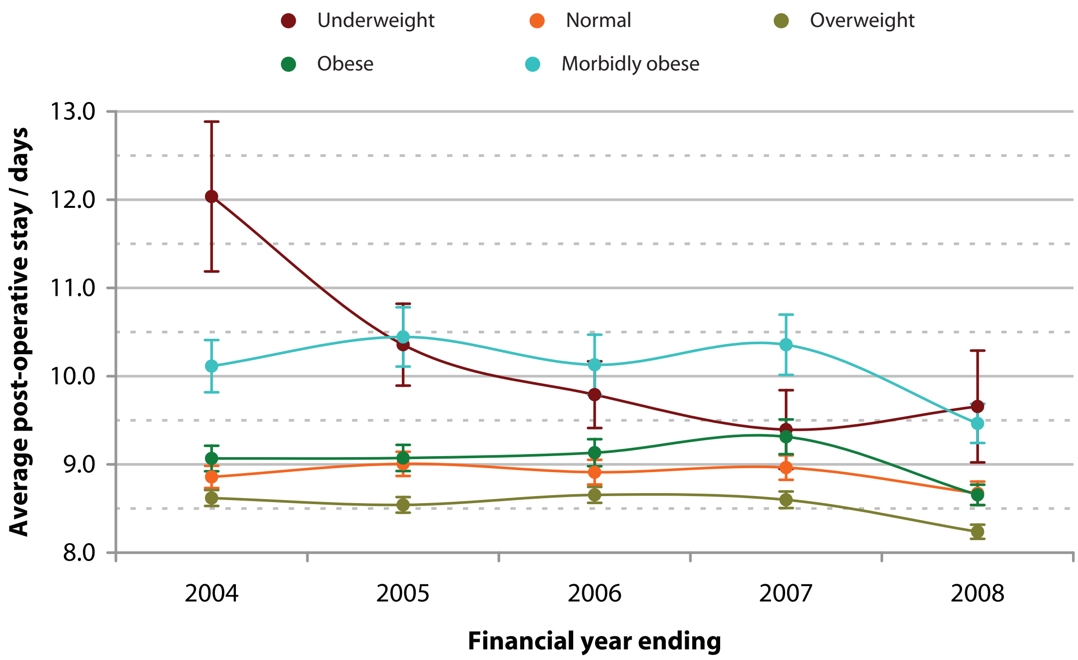
Post-operative stay and BMI

Patients who are underweight or morbidly obese have a greater length of post-operative stay than other patients.

Post-operative stay, BMI and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

Body mass index	Financial year 2004	2005	2006	2007	2008
Underweight	12.0 306	10.4 499	9.8 592	9.4 360	9.7 314
Normal	8.9 4,521	9.0 4,940	8.9 4,390	9.0 3,987	8.7 4,574
Overweight	8.6 9,798	8.5 10,627	8.7 9,239	8.6 8,544	8.2 9,945
Obese	9.1 5,060	9.1 5,137	9.1 4,494	9.3 4,622	8.7 5,590
Morbidly obese	10.1 1,462	10.4 1,567	10.1 1,458	10.4 1,458	9.5 1,821
Unspecified	8.5 2,141	9.2 923	10.8 431	8.8 247	9.2 268

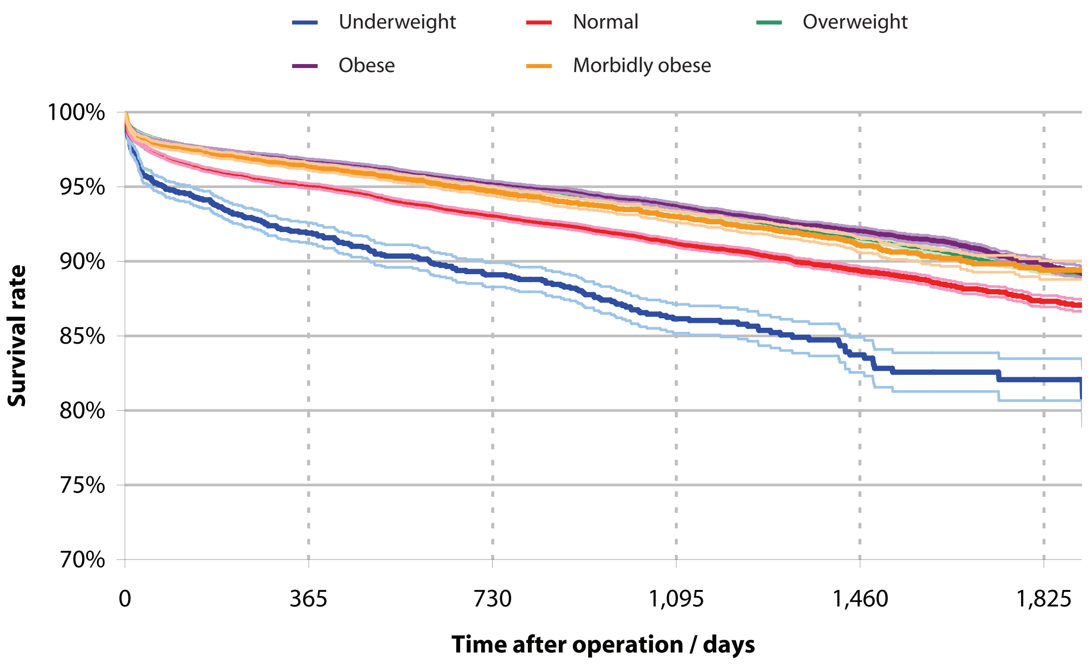
Isolated CABG: Post-operative stay and BMI; bars denote standard errors (n=105,305)

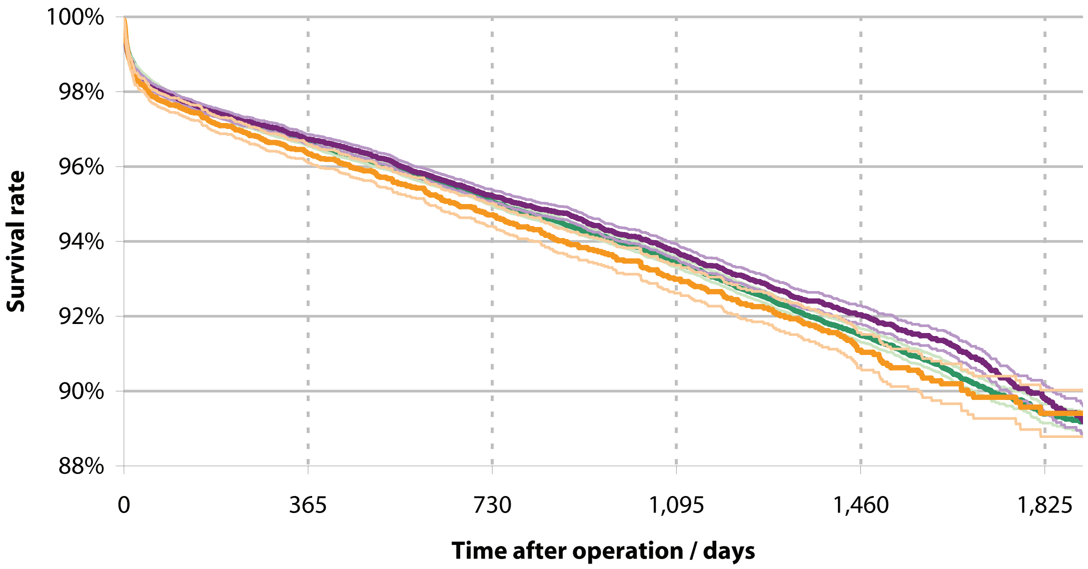


Survival and BMI

Patients who are underweight have a worse medium-term survival than other patients. Of interest, morbid obesity does not seem to be associated with a worse medium-term survival than being of normal weight.

Isolated CABG: Medium-term survival and BMI; financial years 2004-2008 (n=84,470)





Operative priority

Key points from operative priority analyses

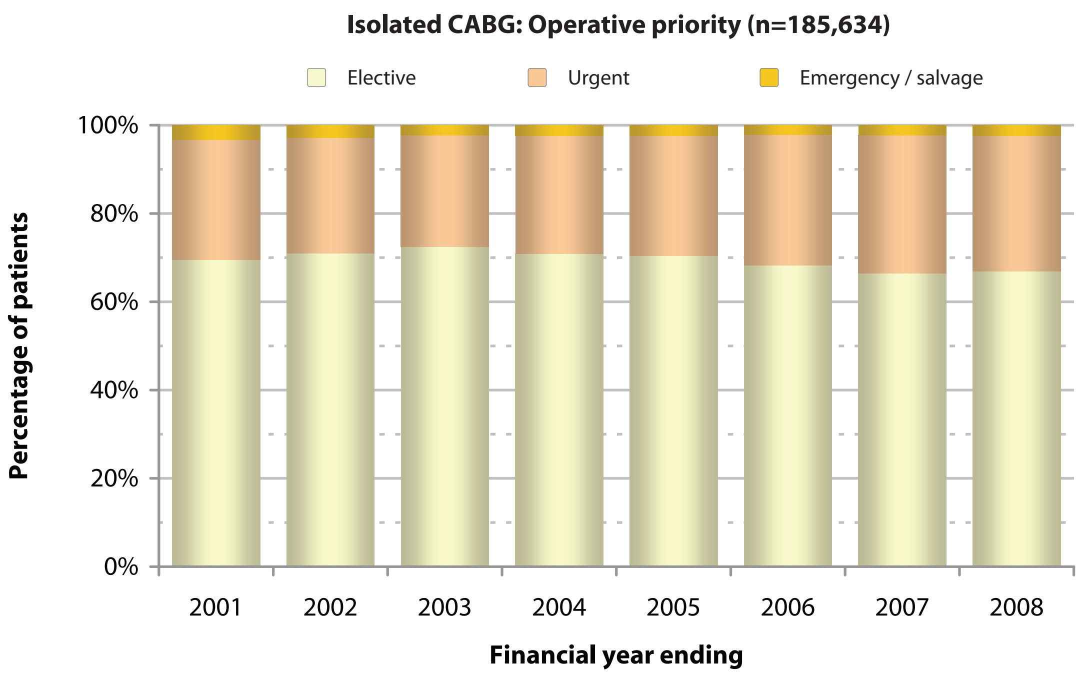
- There has been a small decrease in the proportion of elective patients over time. The number of patients who undergo CABG as emergency or salvage cases remains small.
- The in-hospital mortality rate for elective cases is low, and in the most recent year, up to March 2008, was less than 1.0%.
- Priority remains an important predictor of operative mortality with urgent and emergency cases having mortality rates of 2.2% & 8.3% respectively in the year ending March 2008.
- Urgent & emergency patients consistently stay in hospital longer than elective patients.
- Priority of surgery has a marked association with medium-term survival; emergency patients do worse than urgent patients, who, in turn, do worse than elective patients.

Operative priority distributions

The definition of priority used in the SCTS database is that patients admitted from home for surgery are regarded as *elective* cases, those who need to stay in hospital for surgery are *urgent*, those for whom operative care is provided immediately are *emergency* and those who require resuscitation into the operating theatre are designated as *salvage* cases. There has been a small decrease in the proportion of elective patients over time. The number of emergency and salvage cases performed each year is small.

Operative priority over time

		Financial year							
		2001	2002	2003	2004	2005	2006	2007	2008
Priority	Elective	15,260	16,521	18,919	17,235	17,222	15,165	13,625	15,277
	Urgent	5,958	6,096	6,582	6,477	6,653	6,562	6,389	6,994
	Emergency	611	581	503	545	545	448	448	520
	Salvage	116	86	90	45	44	45	32	40
	Unspecified	93	119	144	129	72	31	18	15



Mortality and operative priority

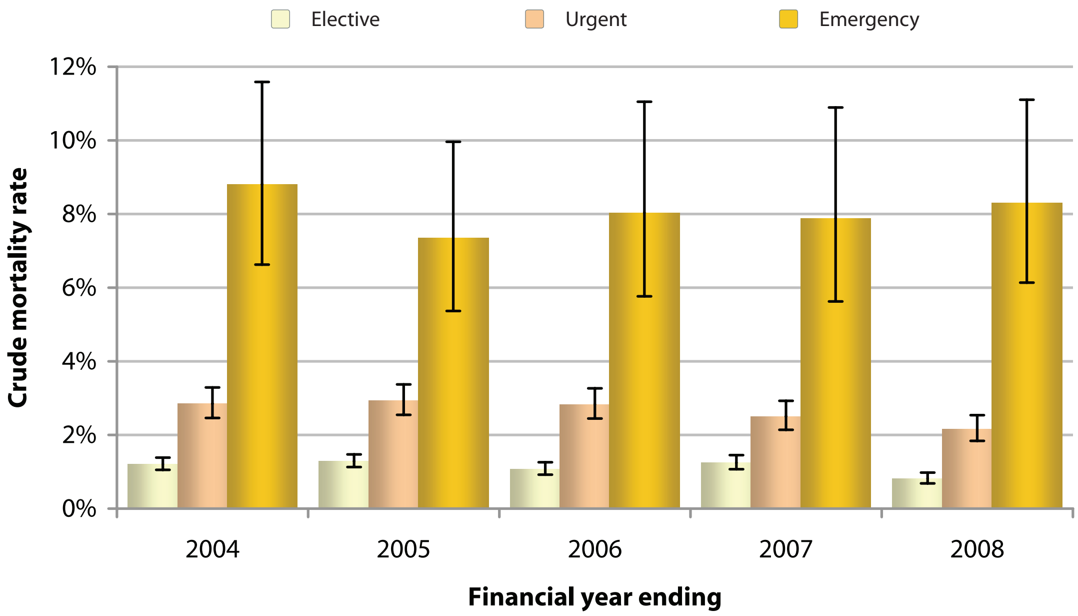
Operative mortality is strongly associated with operative priority. The mortality rate for elective cases is very low, but urgent, emergency and salvage cases have a progressively higher risk.

The in-hospital mortality rates for elective and urgent cases have both fallen over time ($\chi2$ test for trends p=0.002 and p=0.003 respectively), but there has been no change in the mortality rates for emergency and salvage cases.

Mortality, operative priority and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	**All**
Priority	Elective	1.2% 17,221	1.3% 17,213	1.1% 15,125	1.2% 13,555	0.8% 15,253	**1.1%** **78,367**
	Urgent	2.8% 6,460	2.9% 6,651	2.8% 6,543	2.5% 6,349	2.2% 6,987	**2.6%** **32,990**
	Emergency	8.8% 545	7.4% 544	8.0% 448	7.9% 444	8.3% 518	**8.1%** **2,499**
	Salvage	50.0% 44	29.5% 44	33.3% 45	35.5% 31	40.0% 40	**37.7%** **204**
	Unspecified	2.7% 111	5.6% 71	3.3% 30	0.0% 18	10.0% 10	**3.8%** **240**
	All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**

Isolated CABG: Crude mortality and operative priority (n=114,060)



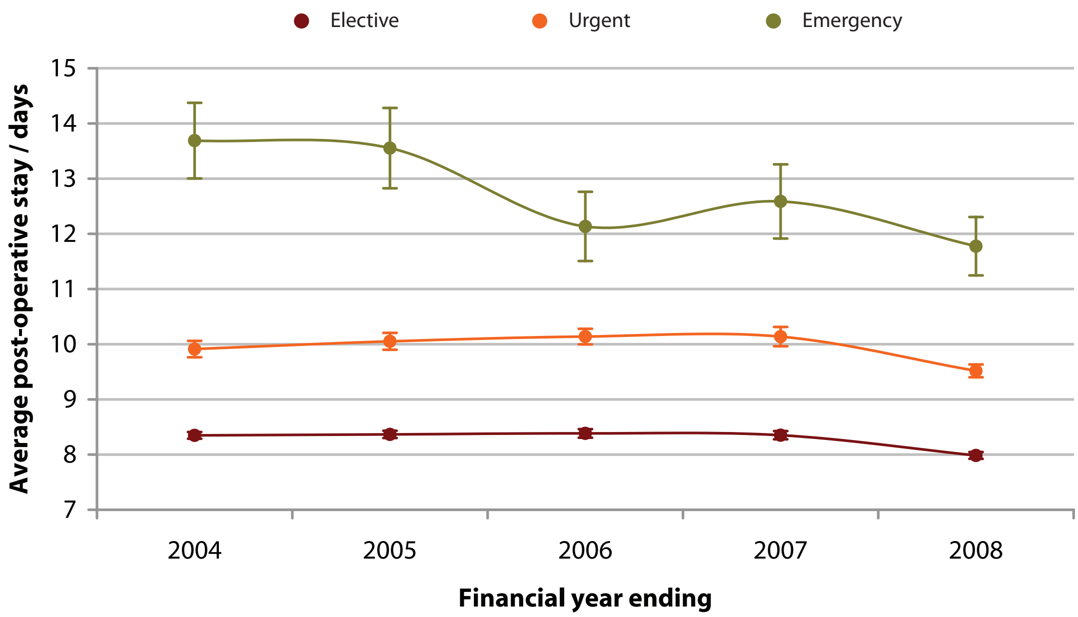
Post-operative stay and operative priority

Post-operative stay is strongly associated with priority, with emergency patients staying the longest. Of interest, the increase in number of urgent patients associated with implementing routine interventional strategies for managing acute coronary syndromes does not seem to have had an effect in reducing the difference in length-of-stay between elective and urgent cases.

Post-operative stay, priority and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

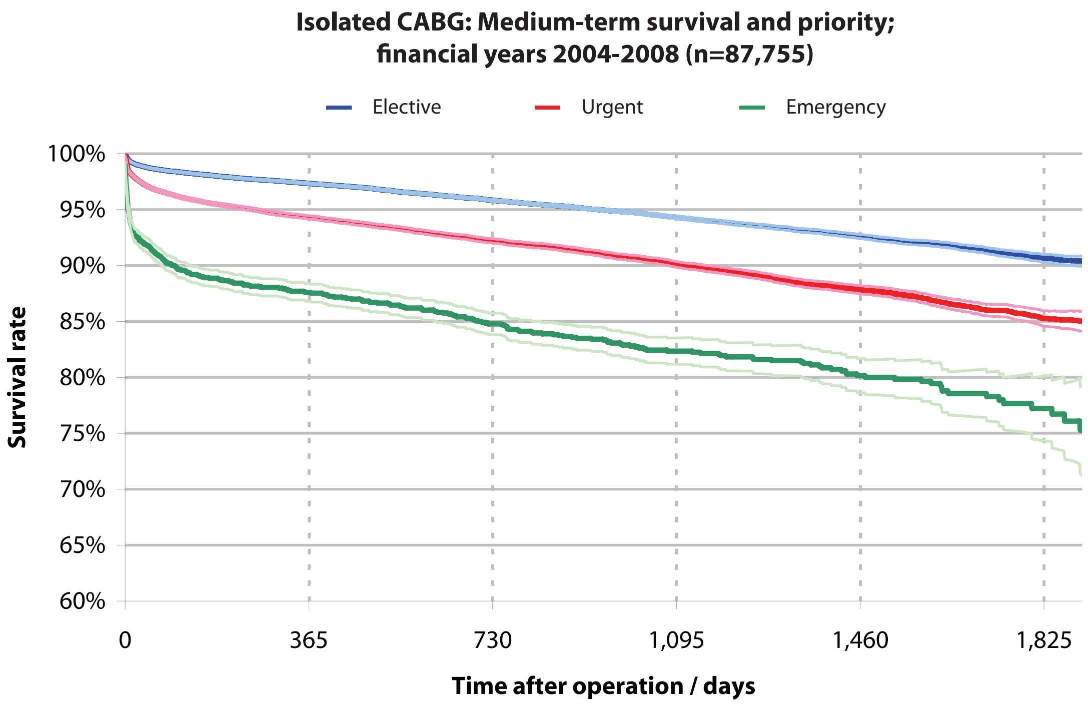
		Financial year				
		2004	2005	2006	2007	2008
Priority	Elective	8.3 16,556	8.4 16,722	8.4 14,059	8.4 12,846	8.0 15,098
	Urgent	9.9 6,120	10.1 6,371	10.1 6,071	10.1 5,935	9.5 6,853
	Emergency	13.7 524	13.6 497	12.1 410	12.6 402	11.8 508
	Salvage	13.9 41	13.3 41	15.4 43	11. 31	21.5 38
	Unspecified	10.9 47	10.3 62	13.6 21	7.8 4	7.3 15

Isolated CABG: Post-operative stay and priority; bars denote standard errors (n=108,972)



Survival and operative priority

Priority is strongly associated with medium-term survival: the Kaplan-Meier survival rate at 5 years is excellent for elective patients at 90%, but is lower for both urgent and emergency patients, as might be expected.



Ejection fraction

Key points from ejection fraction analyses

- Ejection fraction describes the proportion of blood that is pumped out each time the heart contracts, and is an important index of cardiac function. It is classified as good, fair or poor.
- There has been little change in the proportion of patients with the different categories of ejection fraction over time.
- Impaired ejection fraction remains strongly associated with increased mortality.
- As well as being strongly associated with increased in-hospital mortality, impaired ejection fraction is also associated with increased length-of-stay.
- Medium-term survival is strongly associated with ejection fraction: for patients with good function it is 90% at 5 years, but for those with poor function it is just over 70%.

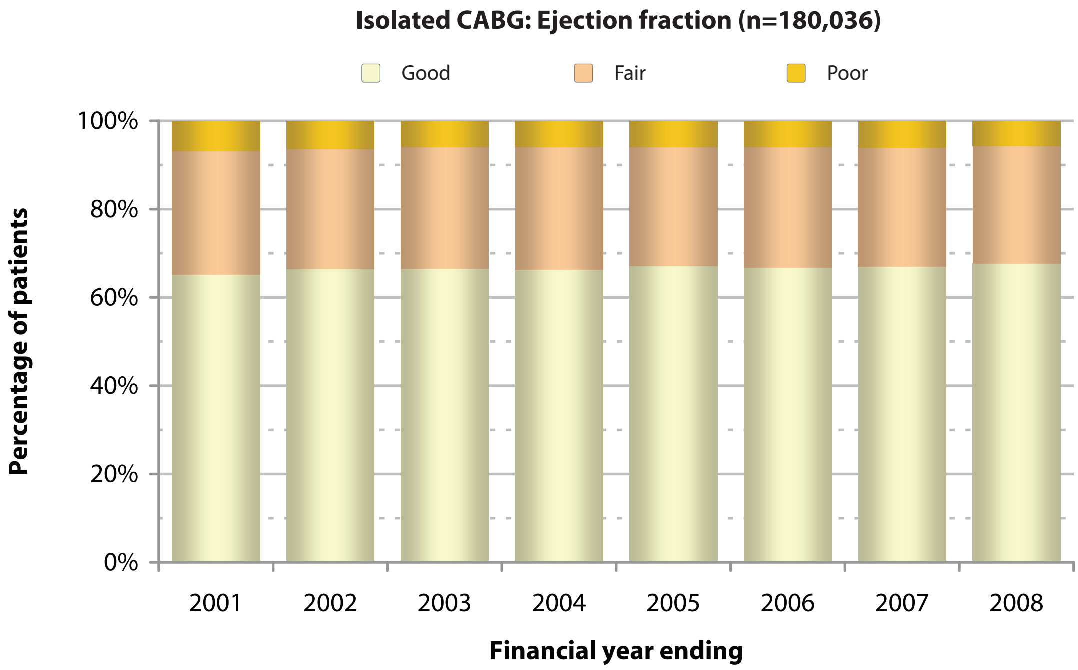
Ejection fraction distribution

Ejection fraction is an index of how much blood the heart ejects each time it pumps. The normal heart has an ejection fraction of about 65%. For the purposes of the SCTS database any ejection fraction of greater than 50% is regarded at *good,* 30% to 50% is regarded as *moderate* or *fair* and less than 30% is classified as *poor.*

There has been no real change in the proportion of patients with impaired ejection fraction over time. About two-thirds of patients undergoing isolated CABG have an ejection fraction over 50%.

Ejection fraction distributions over time

		Financial year							
		2001	2002	2003	2004	2005	2006	2007	2008
Ejection fraction	Good	13,958	14,741	16,480	15,729	16,022	14,360	13,572	15,062
	Fair	6,016	6,032	6,793	6,593	6,450	5,887	5,474	5,925
	Poor	1,459	1,422	1,474	1,396	1,417	1,273	1,227	1,274
	Unspecified	605	1208	1491	713	647	731	239	585



Mortality and ejection fraction

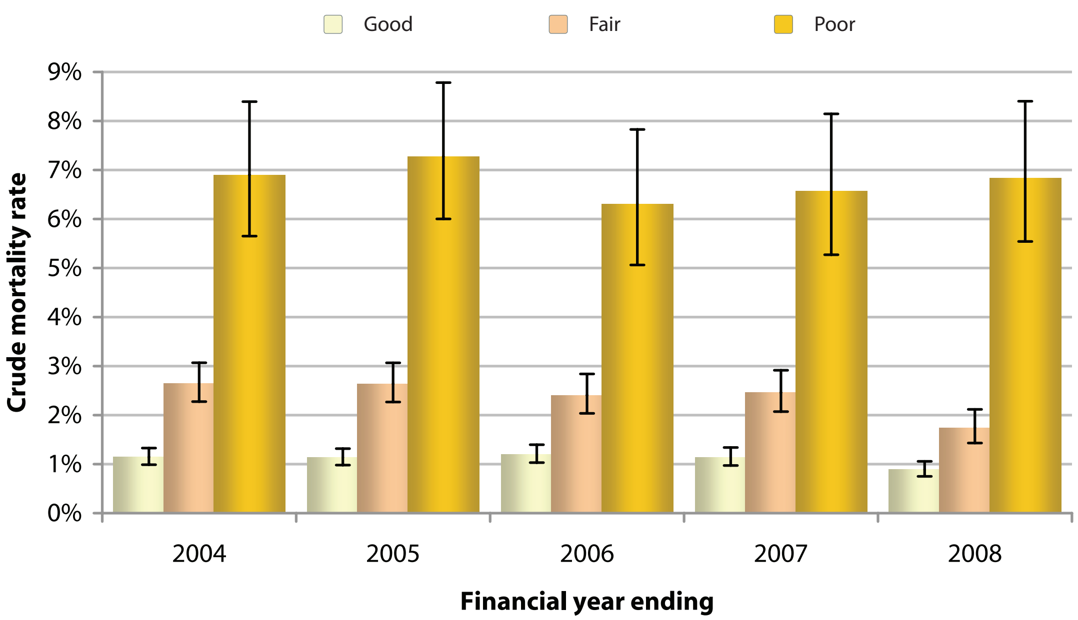
Ejection fraction remains strongly associated with in-hospital mortality. Patients with good left ventricular function had a mortality rate of 0.9% in 2008; for those with poor function it was 6.8%.

The mortality rate for patients with good and moderate left ventricular function has reduced over time, but it has remained constant for those with poor function (χ^2 test for trends p=0.057, p=0.001 and p=0.695 respectively).

Mortality, ejection fraction and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	**All**
Ejection fraction	Good	1.1% 15,713	1.1% 16,016	1.2% 14,332	1.1% 13,493	0.9% 15,042	**1.1%** **74,596**
	Fair	2.6% 6,583	2.6% 6,444	2.4% 5,862	2.5% 5,449	1.7% 5,915	**2.4%** **30,253**
	Poor	6.9% 1,391	7.3% 1,416	6.3% 1,268	6.6% 1,218	6.8% 1,272	**6.8%** **6,565**
	Unspecified	2.2% 694	2.9% 647	1.0% 729	2.5% 237	2.1% 579	**2.0%** **2,886**
	All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**

Isolated CABG: Crude mortality and ejection fraction (n=111,414)



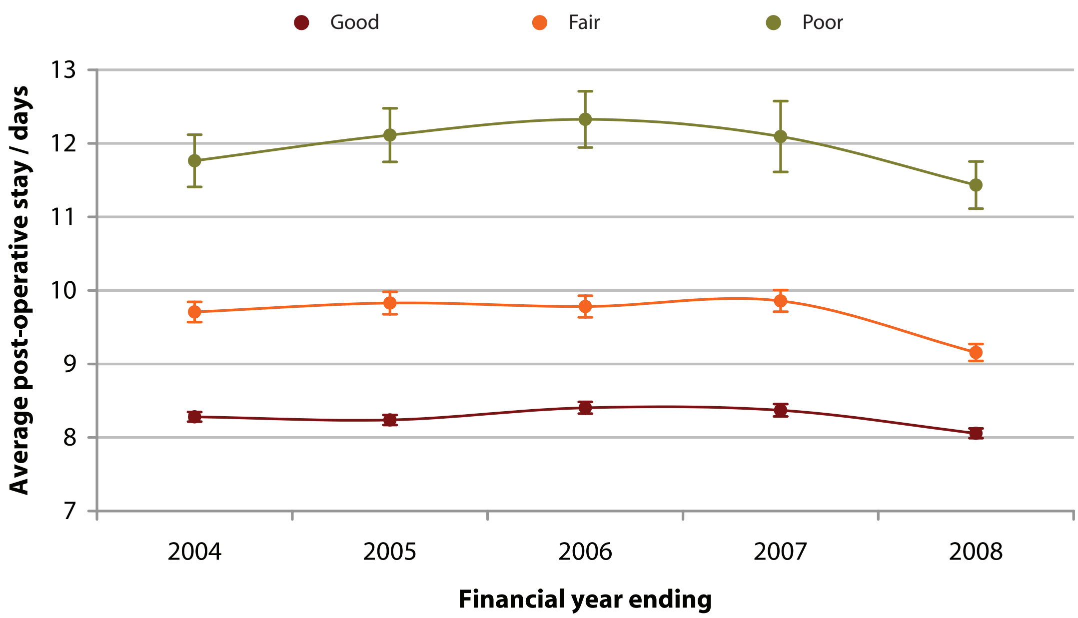
Post-operative stay and ejection fraction

Post-operative stay is strongly associated with ejection fraction, with patients with *poor* ejection fraction having an average stay of 11.4 days in 2008, some 3 days longer than for those with good left ventricular function. Impaired ejection fraction is therefore strongly associated with increased resource utilisation.

Post-operative stay, ejection fraction and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

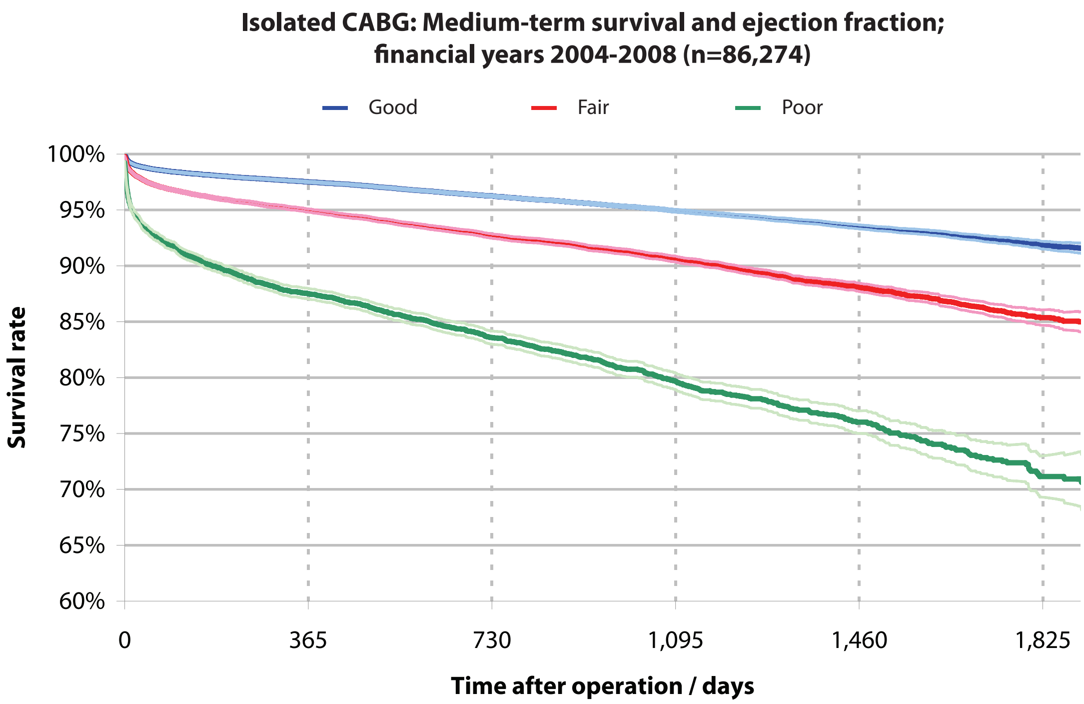
		Financial year				
		2004	2005	2006	2007	2008
Ejection fraction	Good	8.3 15,086	8.2 15,450	8.4 13,285	8.4 12,706	8.1 14,845
	Fair	9.7 6,259	9.8 6,236	9.8 5,441	9.9 5,147	9.2 5,838
	Poor	11.8 1,328	12.1 1,373	12.3 1,152	12.1 1,147	11.4 1,251
	Unspecified	9.5 615	10.5 634	8.6 726	8.9 218	9.2 578

Isolated CABG: Post-operative stay and ejection fraction; bars denote standard errors (n=106,544)



Survival and ejection fraction

Medium-term survival is strongly associated with left ventricular function at the time of surgery. For those with good left ventricular function it is better than 90% at 5 years, but it decreases as the left ventricular ejection fraction becomes increasingly impaired.



Number of previous myocardial infarctions

Key points from previous myocardial infarction analyses

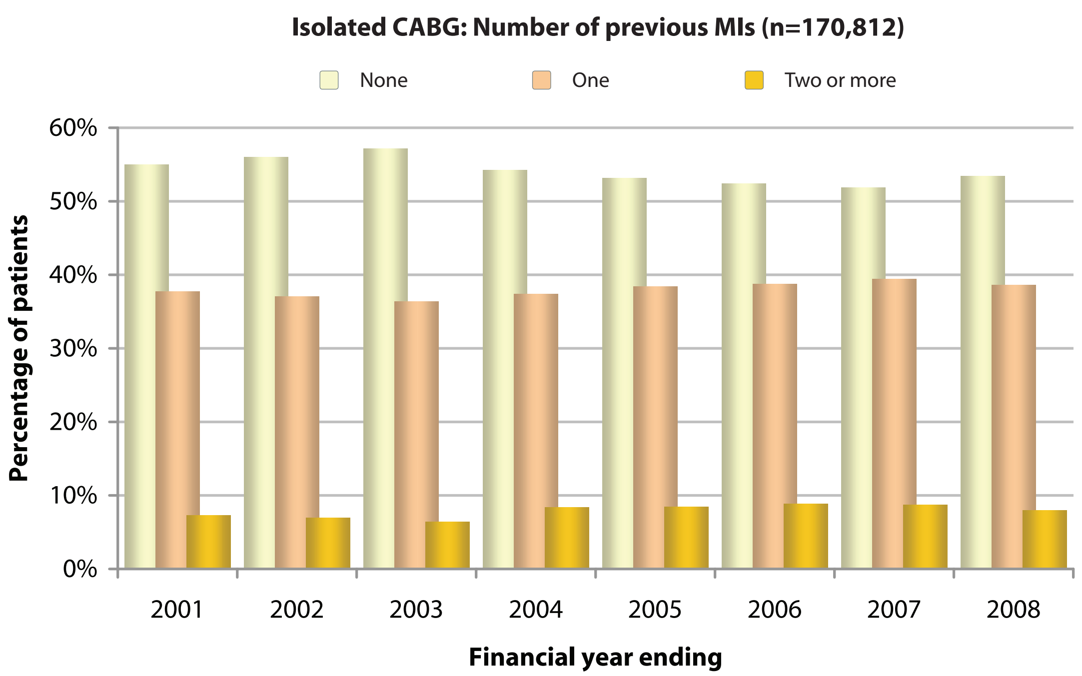
- Heart attacks (myocardial infarctions; MIs) occur when heart muscle dies. Any heart attack can cause muscle damage and decrease the *pumping ability* of the heart by decreasing the left ventricular ejection fraction, which is known to be associated with worse operative and medium-term survival rates, as described above. Increased numbers of prior MIs are also associated with worse survival rates.
- There has been little change in the proportion of patients undergoing isolated CABG who have had previous MIs over time.
- The mortality rate for patients undergoing CABG who have no history of previous MI in the year to March 2008 was 0.8%, for those who had 2 or more previous MIs it was 3.6%.

Previous MI distribution

There has been no real change over time in the proportion of patients undergoing isolated CABG who have suffered previous MIs; just over 50% of patients have no history of a heart attack. Under 10% of patients have suffered at least two previous MIs.

Previous MI distributions over time

		Financial year							
		2001	2002	2003	2004	2005	2006	2007	2008
Previous MIs	None	10,866	12,019	13,361	12,185	12,226	10,073	10,249	11,637
	One	7,457	7,960	8,503	8,403	8,826	7,447	7,796	8,402
	Two or more	1,435	1,486	1,497	1,883	1,942	1,696	1,723	1,740
	Unspecified	2,280	1,938	2,877	1,960	1,542	3,035	744	1,067
	All	**22,038**	**23,403**	**26,238**	**24,431**	**24,536**	**22,251**	**20,512**	**22,846**



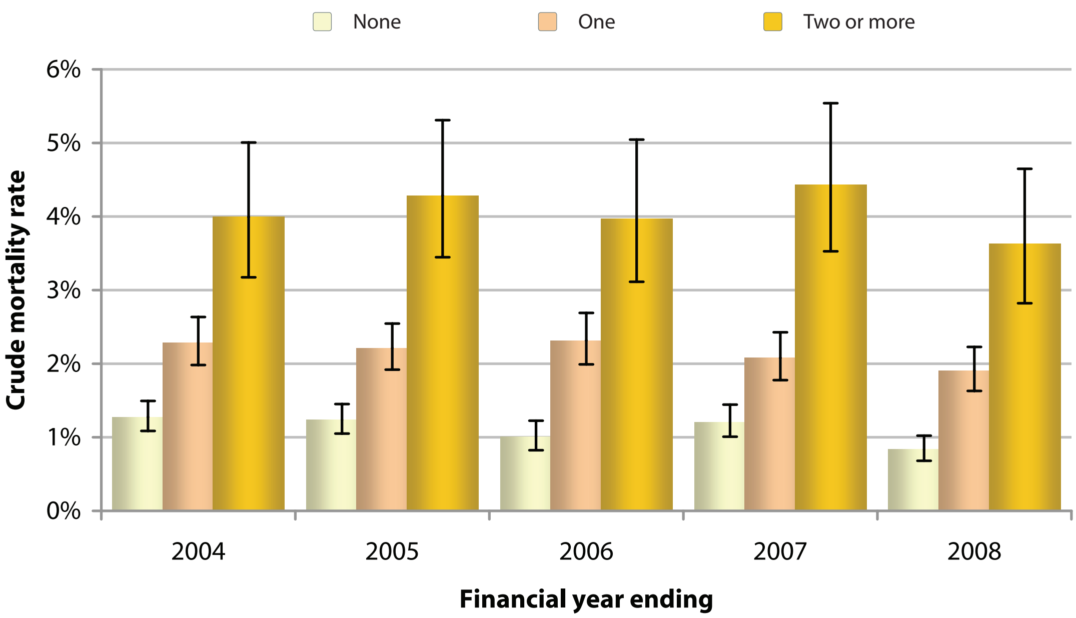
Mortality and number of previous MIs

In the same way that impaired ejection fraction is associated with a high in-hospital mortality rate, so is a history of previous myocardial infarction; the risk increases further when there has been more than one previous MI.

Mortality, number of previous MIs and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

Number of previous MIs	Financial year					
	2004	2005	2006	2007	2008	**All**
None	1.3% 12,161	1.2% 12,225	1.0% 10,043	1.2% 10,190	0.8% 11,623	**1.1%** **56,242**
One	2.3% 8,397	2.2% 8,819	2.3% 7,429	2.1% 7,749	1.9% 8,392	**2.2%** **40,786**
Two or more	4.0% 1,878	4.3% 1,937	4.0% 1,687	4.4% 1,716	3.6% 1,736	**4.1%** **8,954**
Unspecified	2.2% 1,945	2.9% 1,542	2.0% 3,032	1.9% 742	1.5% 1,057	**2.1%** **8,318**
All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**

Isolated CABG: Crude mortality and number of previous MIs (n=105,982)

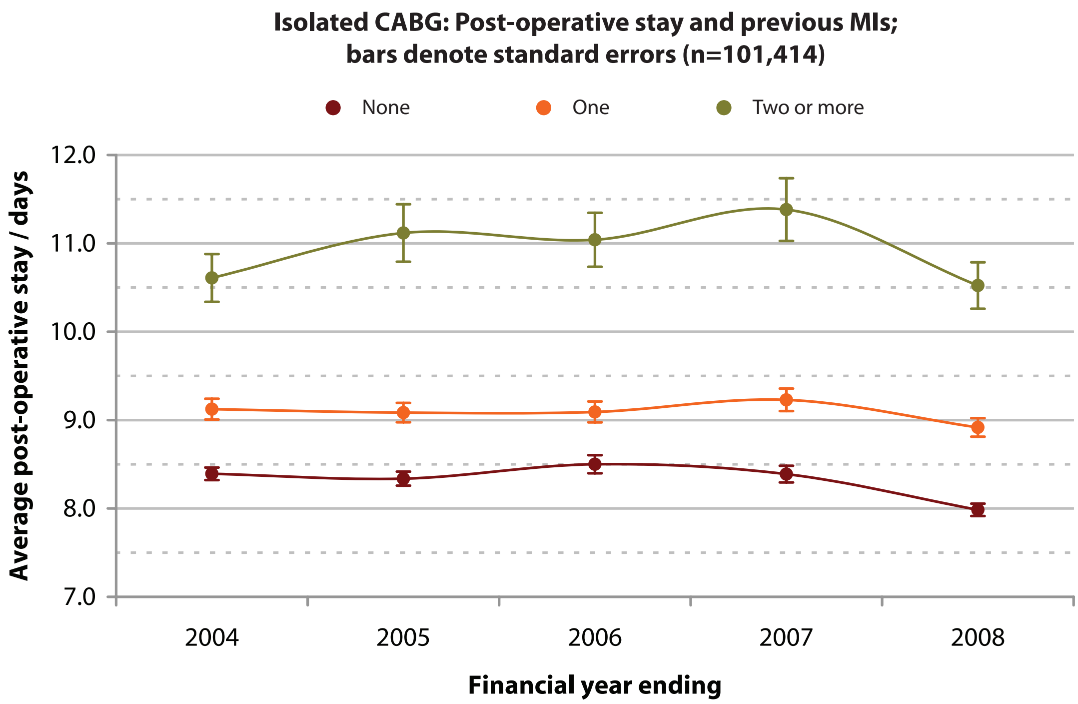


Post-operative stay and previous MIs

Length of post-operative stay is strongly associated with the number of previous MIs; for those with no MI the average was 8.0 days in 2008, for those with one and two or more it was 8.9 and 10.5 days respectively.

Post-operative stay, previous MIs and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

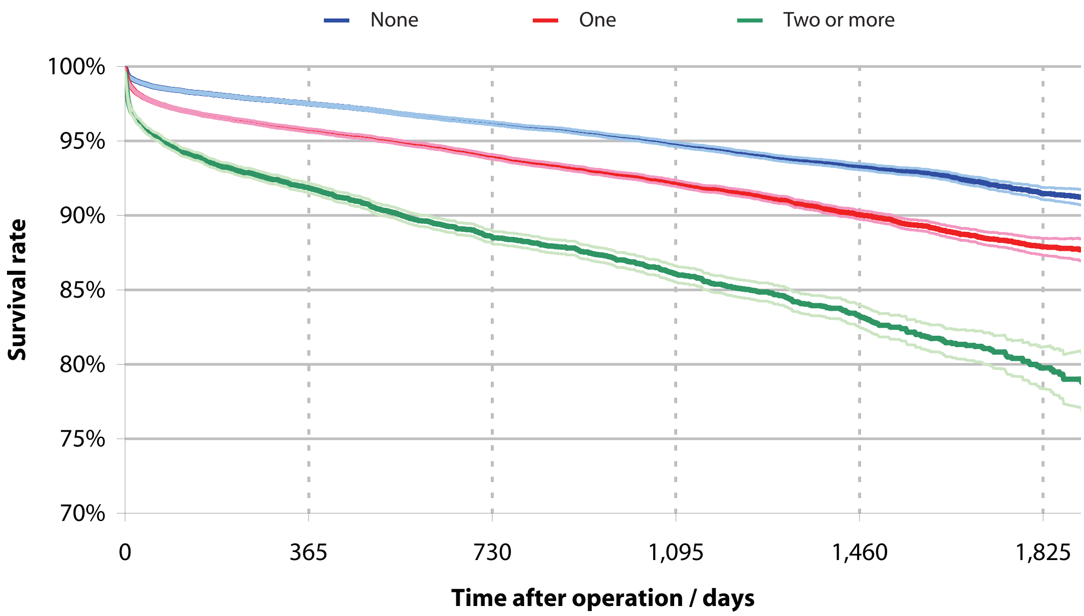
		Financial year				
		2004	2005	2006	2007	2008
Previous MIs	None	8.4 11,573	8.3 11,653	8.5 9,218	8.4 9,509	8.0 11,344
	One	9.1 8,092	9.1 8,614	9.1 6,979	9.2 7,401	8.9 8,381
	Two or more	10.6 1,797	11.1 1,892	11.0 1,605	11.4 1,624	10.5 1,732
	Unspecified	9.4 1,826	10.0 1,534	9.2 2,802	9.3 684	8.7 1,055



Survival and previous MIs

Medium-term survival is strongly associated with previous MIs. Those with no previous MI had a Kaplan-Meier survival rate over 90% at 5 years post-surgery, for those with one and two or more MIs the survival rates at 5 years were 88% and 80% respectively.

Isolated CABG: Medium-term survival and previous MIs; financial years 2004-2008 (n=82,601)

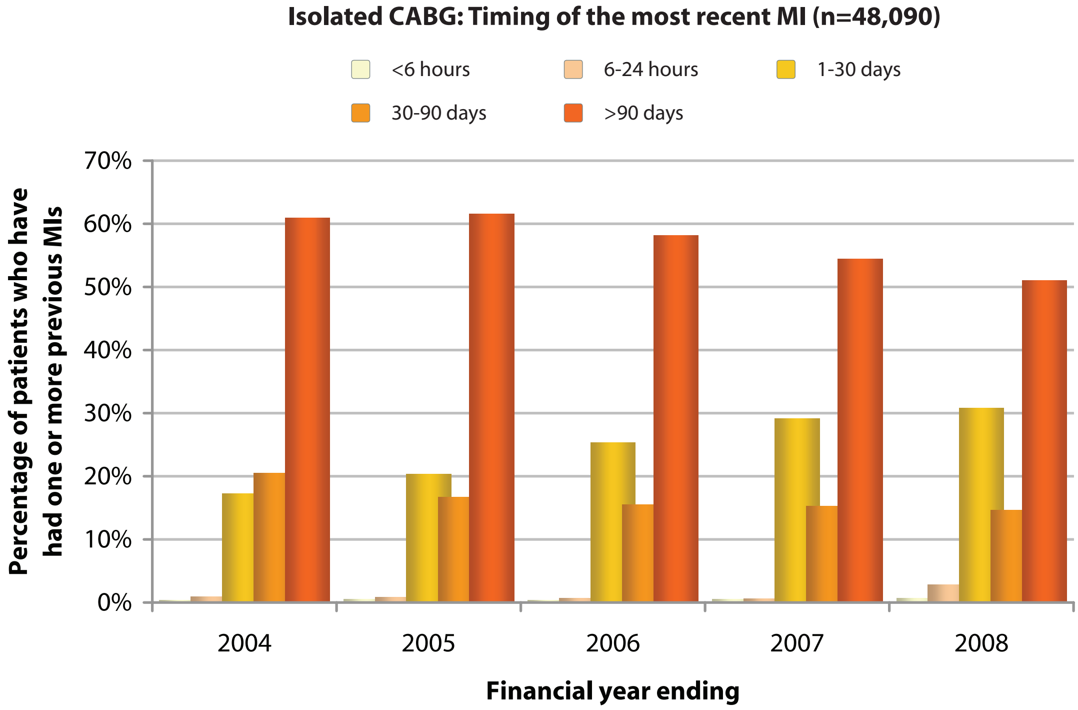


Timing of the most recent MI

Key points from timing of previous MI analyses

- About half the patients undergoing isolated CABG surgery have had a previous MI. Over recent years the way in which MIs are diagnosed has changed, and this may have confounded some of our analyses; however, the proportion of patients who have suffered a heart attack within the previous 30 days has gone up from under 19% in 2004 to over 34% in 2008. This probably reflects a more widespread implementation of a routine invasive interventional strategy for patients with acute coronary syndromes.
- The in-hospital mortality rate is inversely related to the time from the previous MI; in the small number of cases when surgery was undertaken within 6 hours of an MI the mortality rate was elevated at 18.4%; when there has been more than 90 days from the heart attack, the mortality rate reduced to 1.7%.
- There has been a small increase in the number of patients undergoing coronary artery bypass surgery within 24 hours of an MI over time. This may be related to implementation of primary angioplasty programs for heart attacks.

Timing of most recent MI distribution



Mortality and timing of the most recent MI

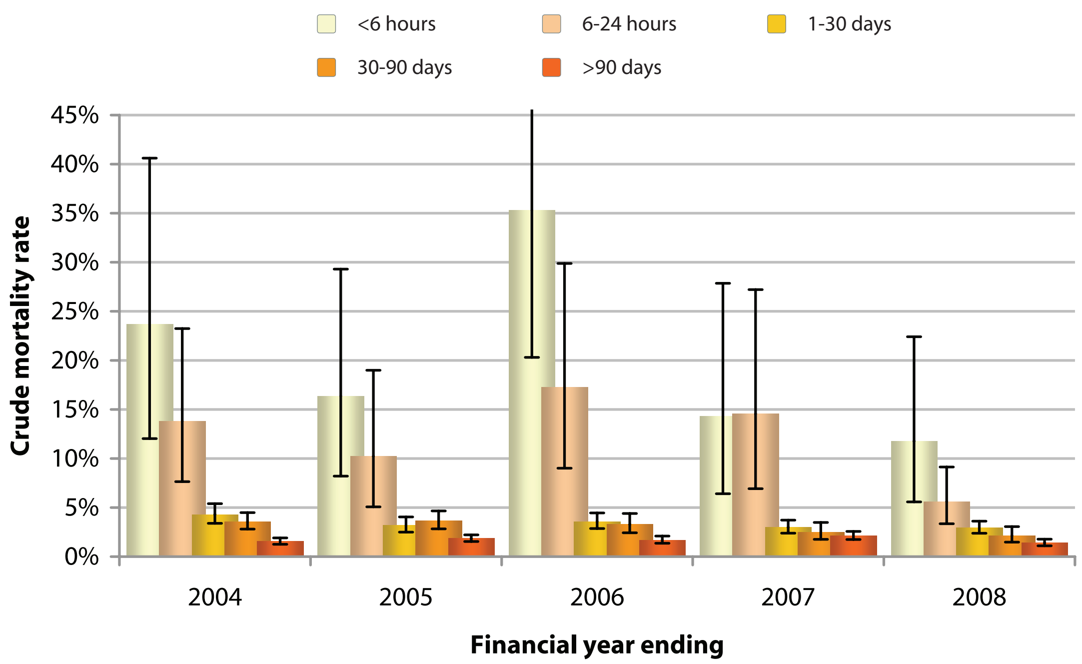
Surgery is rarely undertaken within 24 hours of an MI. There has, however, been a small increase in the number of these patients over the most recent year of study, which may be related to implementation of primary angioplasty services for acute MI, with a small number of these patients going ahead to emergency surgery.

Mortality rates are lowest when there has been at least 90 days between an MI and CABG, and the mortality rate increases the closer surgery is undertaken to the heart attack.

Mortality, timing of the most recent MI and financial year; for entries where the number of previous MIs is recorded as either *One* or *Two or more*; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

Timing of most recent MI	Financial year					
	2004	2005	2006	2007	2008	**All**
<6 hours	23.7% 38	16.4% 55	35.3% 34	14.3% 49	11.8% 68	**18.4%** **244**
6-24 hours	13.8% 87	10.3% 87	17.2% 58	14.8% 54	5.6% 285	**9.6%** **571**
1-30 days	4.3% 1,677	3.2% 2,102	3.6% 2,234	3.0% 2,664	2.9% 3,060	**3.3%** **11,737**
30-90 days	3.6% 2,000	3.6% 1,732	3.3% 1,368	2.5% 1,400	2.1% 1,448	**3.1%** **7,948**
>90 days	1.6% 5,927	1.8% 6,383	1.7% 5,130	2.1% 4,984	1.4% 5,062	**1.7%** **27,486**
Unspecified	2.0% 546	3.0% 397	1.7% 292	0.3% 314	3.4% 205	**2.1%** **1,754**
All patients	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**

Isolated CABG: Crude mortality and timing of the most recent MI (n=47,986)



Percutaneous coronary intervention

Key points from percutaneous coronary intervention analyses

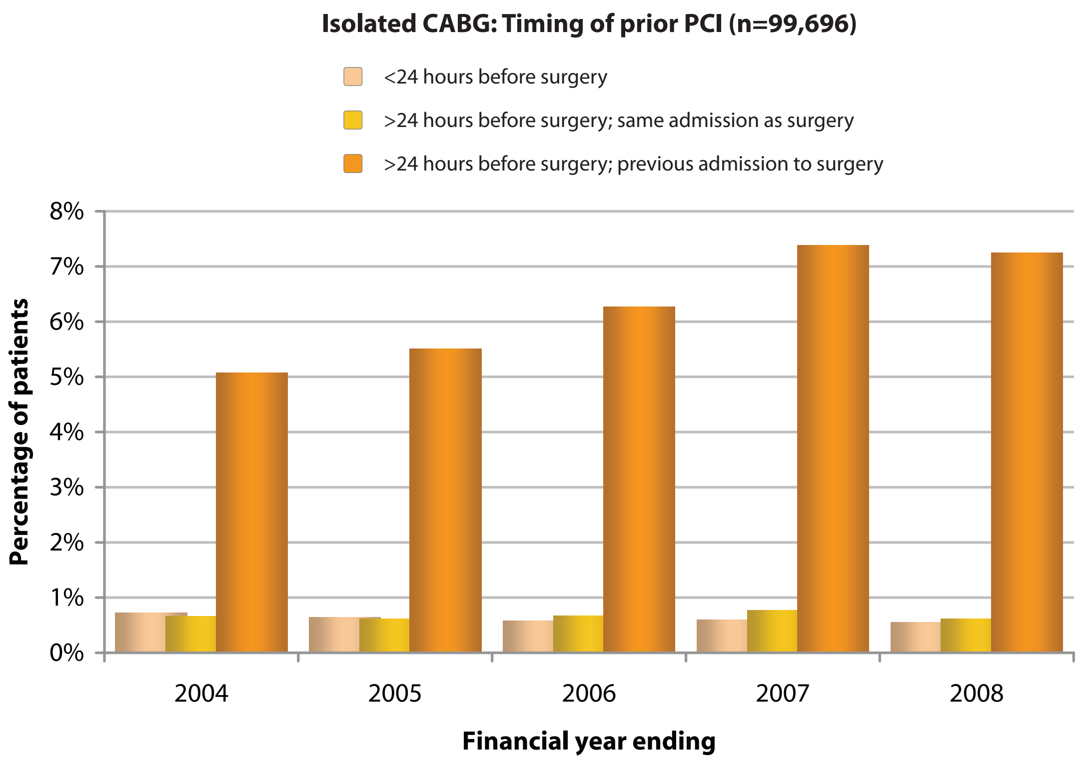
- The proportion of patients who have had a percutaneous coronary intervention (PCI) prior to their CABG has gone up with time, and now represents just over 8%, with the vast majority having undergone PCI during a previous hospital admission.
- There were only a small number of patients undergoing isolated CABG within 24 hours of a PCI, with an overall mortality rate in this group of 7.9%
- Having CABG surgery within 24 hours of a PCI was associated with significantly worse medium-term survival. Patients who had a PCI during a previous hospital admission had a similar medium-term survival to those who had no prior PCI.

Distribution of timing of prior PCI

There has been a rise in the number of patients undergoing percutaneous coronary interventions (angioplasty) over time. Until about 1998, more patients were treated by CABG than PCI. Since then PCI has been the predominant type of treatment for patients with angina. These issues are explored in more detail in Prof. David Taggart's section on *CABG: the best treatment for multi-vessel coronary artery disease* on page 48.

The major *Achilles' heel* of PCI as a treatment strategy is a high recurrence of angina. Some of these patients will then come to coronary artery bypass surgery. The SCTS dataset collects data on prior PCI as: previous PCI within 24 hours of surgery; prior PCI in the same hospital admission; or prior PCI in a previous hospital admission. When CABG follows PCI in the same admission it will almost always be due to complications or acute failure of the PCI. When the prior PCI was during a subsequent admission it will usually be due to a failure of the previous PCI resulting from in-stent re-stenosis, or development of further disease in the other coronary arteries.

In line with the increase in overall PCI numbers over time, the proportion of patients coming to CABG who have had previous PCI has gone up over time, to just over 8% in 2008. Of these the vast majority had the PCI during a previous admission.



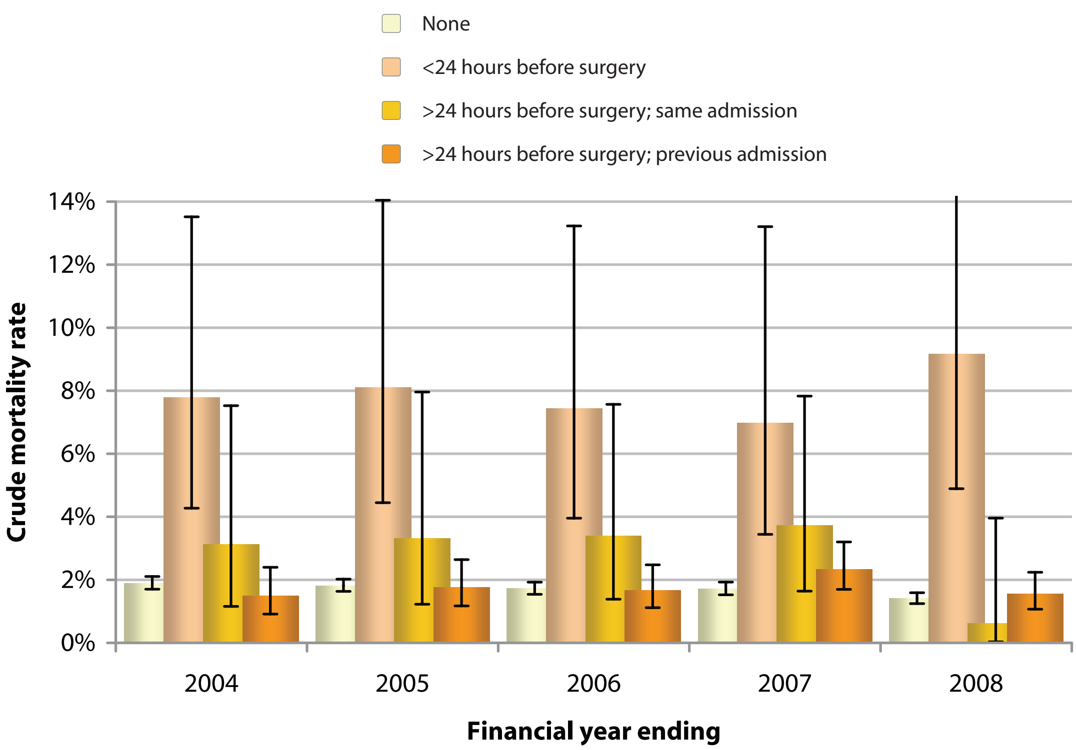
Mortality and timing of prior PCI

Only a small volume of patients had a PCI within the same admission, but this was associated with a higher mortality rate. There is no evidence here that prior PCI in a previous hospital admission is associated with a higher in-hospital mortality rate.

Mortality, previous PCI and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

Timing of previous PCI		Financial year					
		2004	2005	2006	2007	2008	**All**
	None	1.9% 18,271	1.8% 18,869	1.7% 17,997	1.7% 16,504	1.4% 18,471	**1.7% 90,112**
	<24 hours before surgery	7.8% 154	8.1% 148	7.4% 148	7.0% 129	9.2% 120	**7.9% 699**
	>24 hours before surgery; same admission	3.1% 160	3.3% 151	3.4% 177	3.7% 188	0.6% 160	**2.9% 836**
	>24 hours before surgery; previous admission	1.5% 1,206	1.8% 1,413	1.7% 1,555	2.3% 1,710	1.6% 1,931	**1.8% 7,815**
	Unspecified	1.8% 4,590	2.3% 3,942	2.0% 2,314	1.9% 1,866	1.6% 2,126	**1.9% 14,838**
	All	**1.9% 24,381**	**1.9% 24,523**	**1.8% 22,191**	**1.8% 20,397**	**1.5% 22,808**	**1.8% 114,300**

Isolated CABG: Crude mortality and timing of prior PCI (n=99,462)

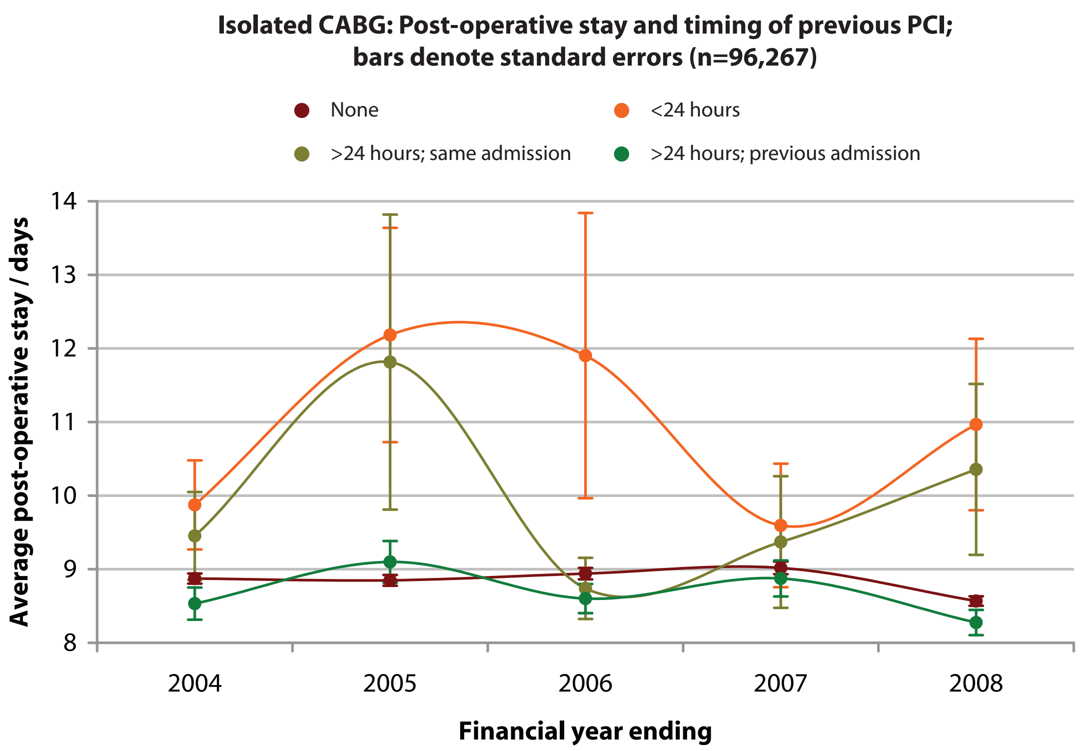


Post-operative stay and timing of previous PCIs

There has been some variation in this measure over time, but patients with PCIs during the same hospital admission generally had a greater length-of-stay than those who did not. There is no difference between the length-of-stay for those who had a PCI during a previous hospital admission and those who had no prior PCI.

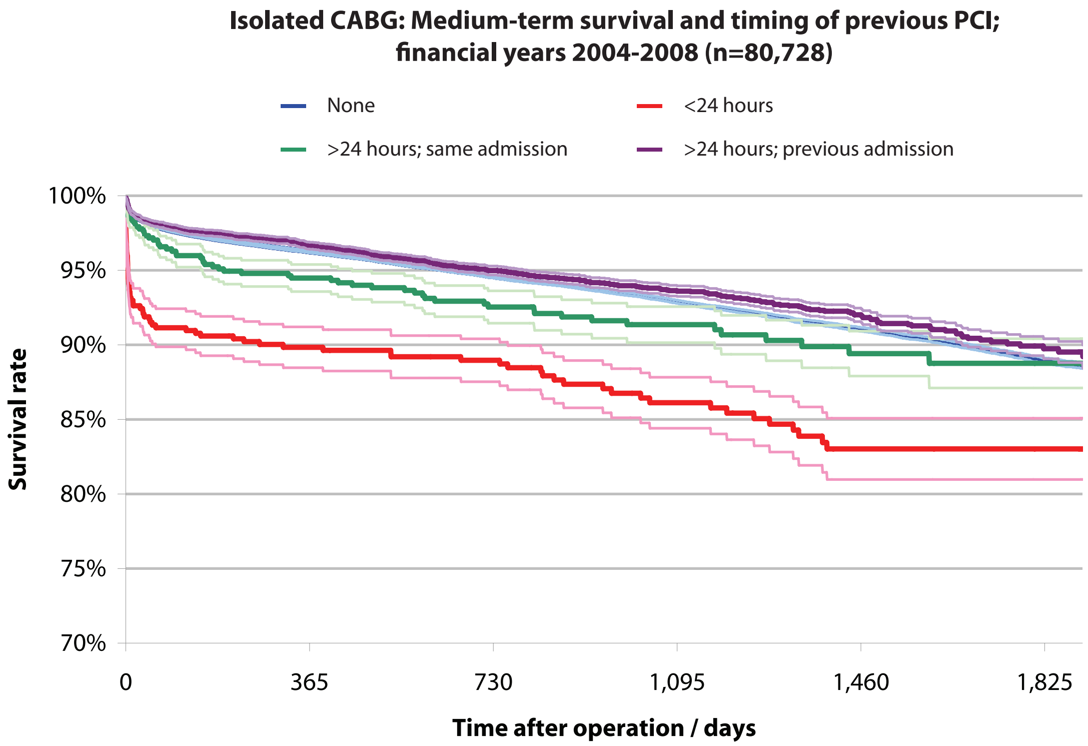
Post-operative stay, timing of previous PCIs and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

		Financial year				
		2004	2005	2006	2007	2008
Timing of previous PCI	None	8.9 17,687	8.8 18,407	8.9 16,847	9.0 15,758	8.6 18,445
	<24 hours	9.9 151	12.2 142	11.9 144	9.6 126	11.0 119
	>24 hours; same admission	9.5 157	11.8 151	8.7 165	9.4 184	10.4 160
	>24 hours; previous admission	8.5 1,188	9.1 1,397	8.6 1,474	8.9 1,638	8.3 1,927
	Unspecified	9.0 4,105	9.1 3,596	9.6 1,974	8.8 1,512	8.5 1,861



Survival and timing of previous PCIs

Patients who underwent CABG within 24 hours of a PCI had a medium-term survival rate significantly worse than other patients. There was little difference between the other groups, and in particular there was no difference in survival between those patients who had a PCI in a previous hospital admission and those who had no prior PCI.



Left main stem disease

Key points from left main stem disease analyses

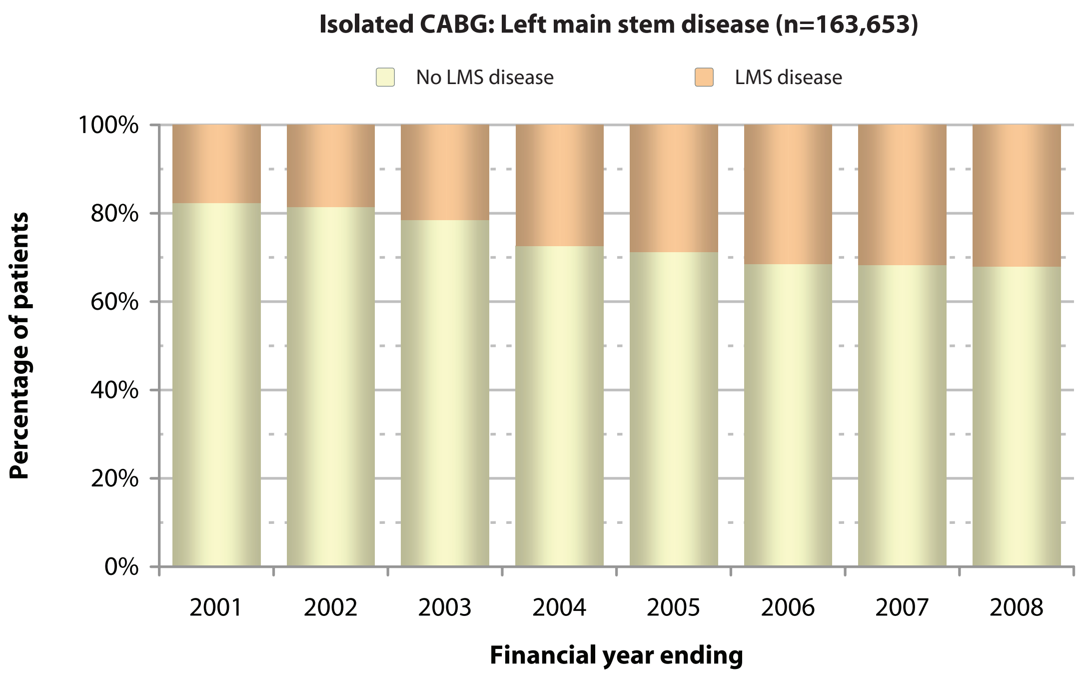
- Associated with the increase in PCI activity for other patterns of disease, there had been an increase in the proportion of patients with left main stem (LMS) disease between 2001 and 2006. This now seems to have stabilised at about 30% of the total population undergoing isolated CABG.
- The mortality rate for patients with LMS disease remains higher than those without.
- Patients with LMS stenosis had a significantly greater length of in-hospital stay and a worse medium-term survival.

LMS disease distribution

The proportion of patients with LMS disease has increased over time from 18% in 2001 to 32% in 2006. This proportion has since remained stable.

Left main stem disease distributions over time

		Financial year							
		2001	2002	2003	2004	2005	2006	2007	2008
LMS disease	No LMS disease	16,164	17,004	17,990	14,971	15,010	13,414	12,473	14,074
	LMS disease	3,461	3,867	4,923	5,645	6,052	6,163	5,802	6,640
	Unspecified	2,413	2,532	3,325	3,815	3,474	2,674	2,237	2,132
	All	**22,038**	**23,403**	**26,238**	**24,431**	**24,536**	**22,251**	**20,512**	**22,846**

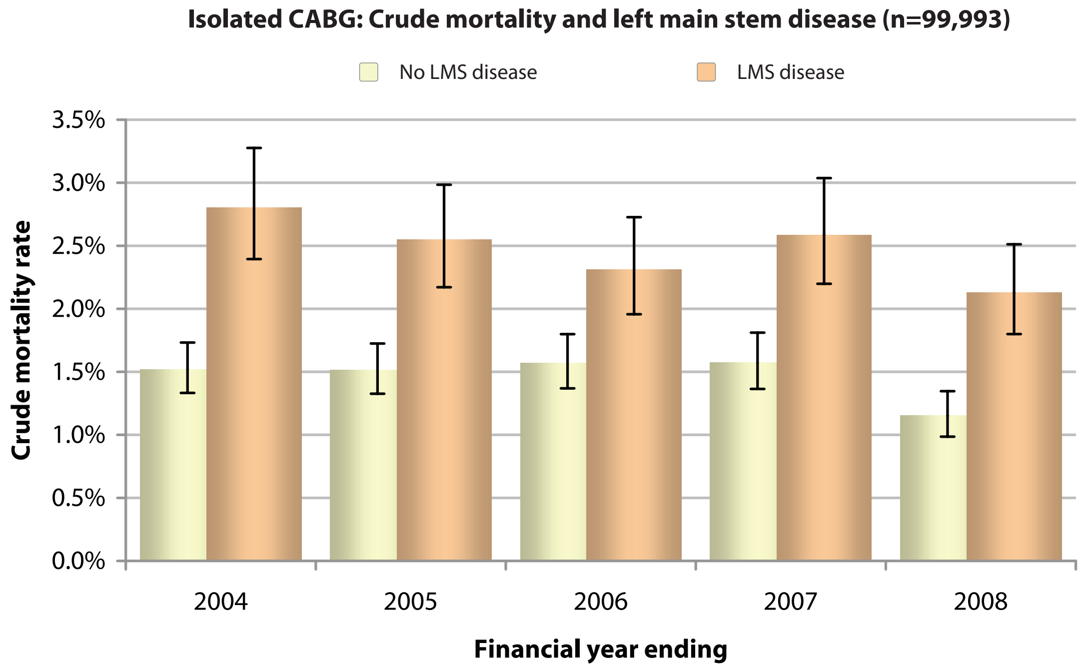


Mortality and LMS disease

The in-hospital mortality rate for patients with LMS disease remains higher than those without. There has been a significant reduction in the mortality rate for those with LMS disease over time (χ^2 test for trends $p<0.035$).

Mortality, left main stem disease and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	**All**
LMS disease	No LMS disease	1.5% 14,937	1.5% 15,004	1.6% 13,378	1.6% 12,402	1.2% 14,054	**1.5%** **69,775**
	LMS disease	2.8% 5,638	2.5% 6,046	2.3% 6,143	2.6% 5,763	2.1% 6,628	**2.5%** **30,218**
	Unspecified	2.1% 3,806	2.7% 3,473	1.8% 2,670	1.3% 2,232	1.6% 2,126	**2.0%** **14,307**
	All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**



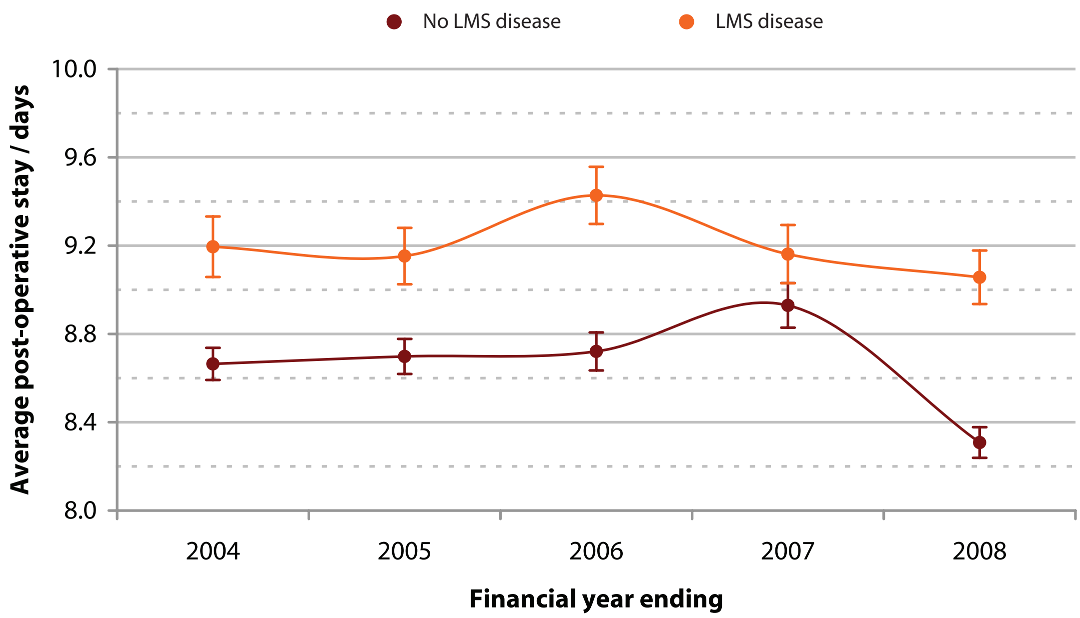
Post-operative stay and LMS disease

Patients with LMS disease have a greater post-operative length-of-stay than those without.

Post-operative stay, LMS disease and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

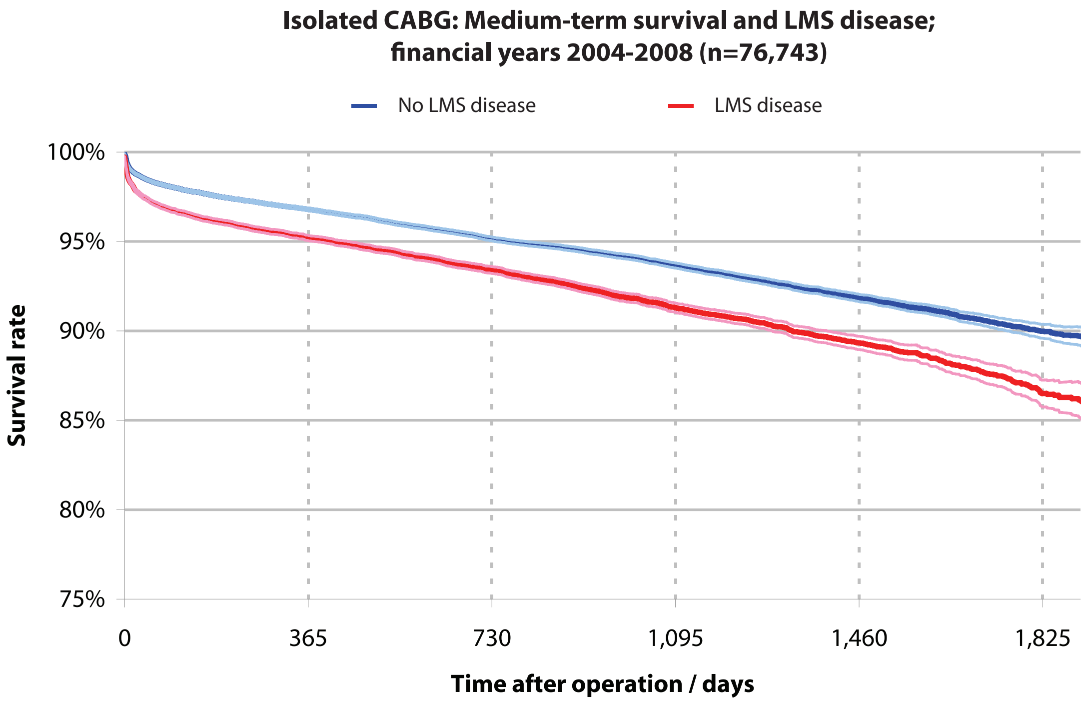
		Financial year				
		2004	2005	2006	2007	2008
LMS disease	No LMS disease	8.7 14,414	8.7 14,729	8.7 12,715	8.9 11,922	8.3 13,865
	LMS disease	9.2 5,442	9.2 5,877	9.4 5,728	9.2 5,356	9.1 6,525
	Unspecified	9.4 3,432	9.7 3,087	9.5 2,161	9.0 1,940	8.7 2,122

Isolated CABG: Post-operative stay and LMS disease; bars denote standard errors (n=96,573)



Survival and LMS disease

Patients with LMS disease have a worse medium-term survival rate than those without. This may be related to a higher incidence of non-cardiac co-morbidities amongst patients with LMS disease (there is a reported association between LMS and carotid stenosis for example) or may represent a higher overall burden of coronary artery disease in patients with LMS stenosis, which subsequently adversely affects survival.



Previous cardiac surgery

Key points from previous surgery analyses

- The proportion of patients who have had previous cardiac surgery has continued to fall year on year, from just over 3% in 2001 to around 1.5% in 2008.
- The mortality associated with redo surgery is nearly four times that of first-time surgery.
- Patients undergoing redo cardiac surgery have an average post-operative length-of-stay that is significantly greater than for patients undergoing first-time surgery.
- Medium-term survival following redo surgery is worse than for first-time surgery with a Kaplan-Meier survival rate at 5 years of only 80%.
- The median length of time between first and redo coronary operations has increased from 8-9 years for those undergoing surgery before 1999 to 12-13 years for those undergoing surgery between 2004 and 2008, suggesting better graft survival in recent years.

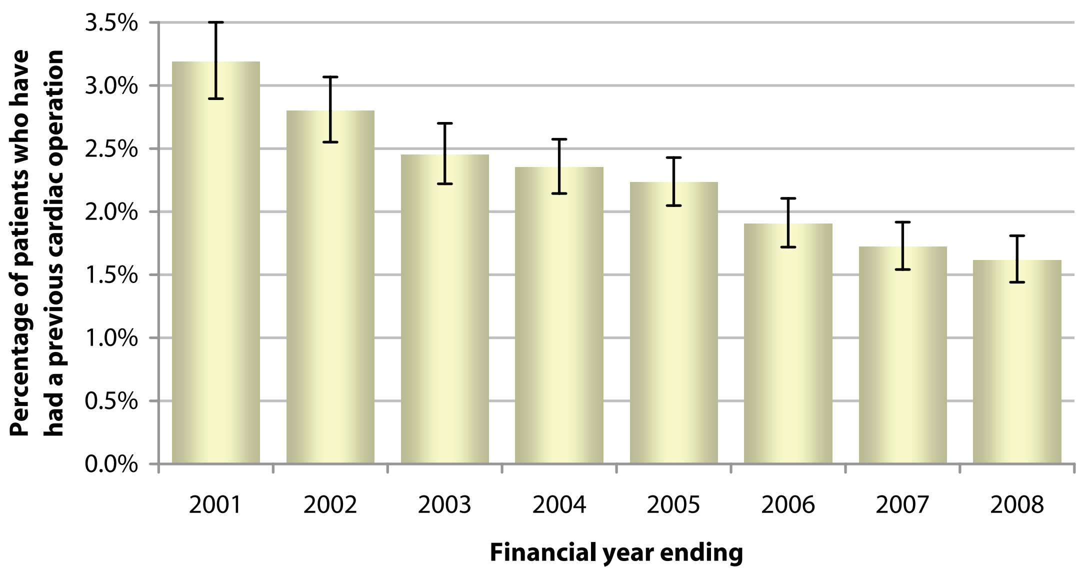
Distribution of previous cardiac surgery

With increasing use of PCI, many patients with previous cardiac surgery who then require further treatment may now more frequently undergo PCI rather than surgery. The proportion of patients who undergo CABG surgery who are *redos* has now fallen to just over 1.5%.

Previous cardiac surgery over time

		Financial year							
		2001	2002	2003	2004	2005	2006	2007	2008
Previous surgery	No previous surgery	20,383	22,496	25,267	23,634	23,794	21,325	20,038	22,343
	Previous surgery	671	648	635	569	543	414	351	367
	Unspecified	984	259	336	228	199	512	123	136
	All	**22,038**	**23,403**	**26,238**	**24,431**	**24,536**	**22,251**	**20,512**	**22,846**

Isolated CABG: Previous cardiac surgery (n=183,478)

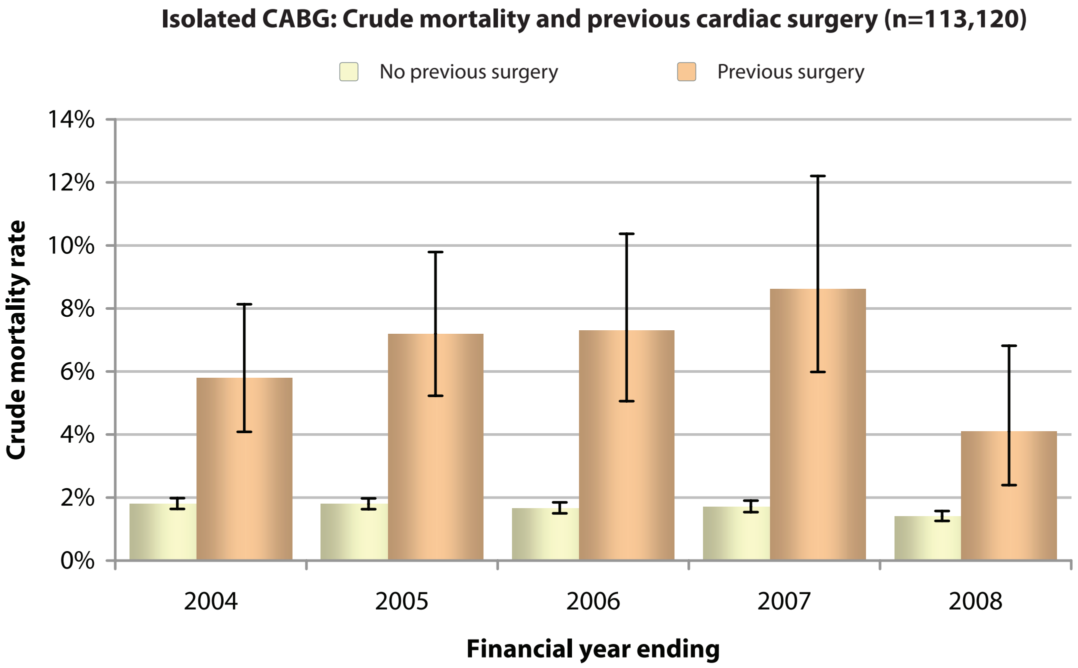


Mortality and previous cardiac surgery

In general, redo cardiac surgery is more tricky than a first-time operation; the coronaries may be of poor quality and the availability of conduits may be restricted. Associated with this, the overall mortality rate for redo CABG surgery during the 5-year period 2004 to 2008 is 6.6% compared to 1.7% for first-time procedures.

Mortality, previous cardiac surgery and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	**All**
Previous surgery	No previous surgery	1.8% 23,586	1.8% 23,783	1.7% 21,269	1.7% 19,935	1.4% 22,311	**1.7%** **110,884**
	Previous surgery	5.8% 569	7.2% 542	7.3% 411	8.6% 348	4.1% 366	**6.6%** **2,236**
	Unspecified	3.1% 226	4.0% 198	3.1% 511	2.6% 114	5.3% 131	**3.5%** **1,180**
	All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**



i. The rules for defining this variable are as follows: if both the *Previous surgery …* and *Number of previous heart operations* questions are *No* and *None* then the entry is designated *No previous surgery*; if any one of *CABG*, *valve*, *congenital cardiac* or *other cardiac* are recorded in the *Previous surgery …* and a value >0 is entered in the *Number of previous heart operations* then the entry is designated *Previous surgery*; other combinations (blank data, *None* in combination with any positive response option in the *Previous surgery …* question recording previous cardiac surgery OR any combination of the aortic / thoracic / vascular options in the *Previous surgery …* question in conjunction with non-zero response in the *Number of previous heart operations* question) are treated as *Unspecified.*

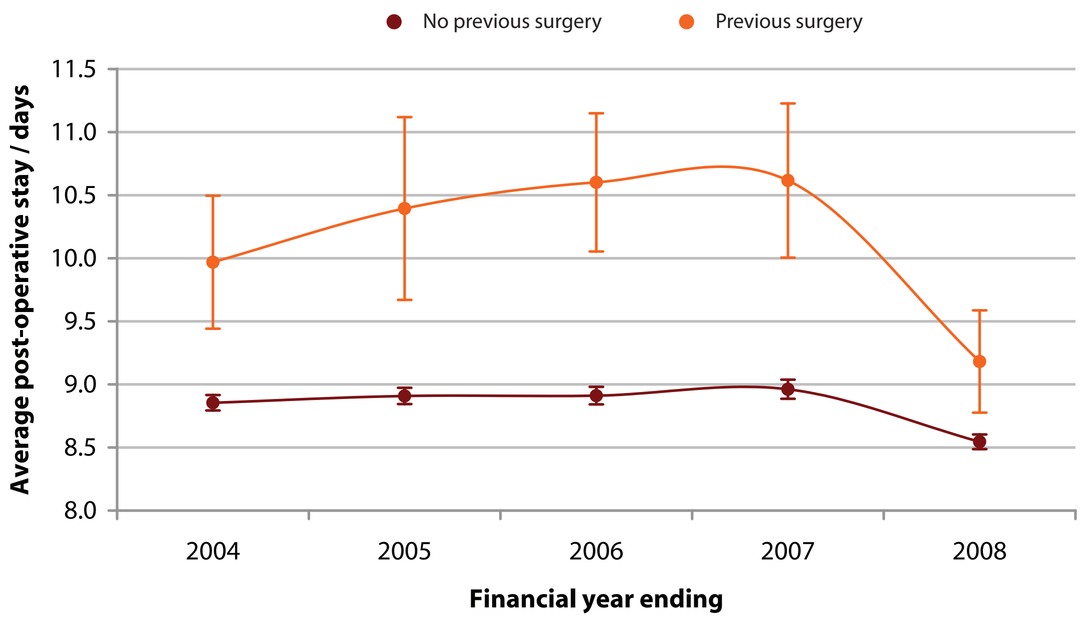
Post-operative stay and previous surgery

Redo surgery is consistently associated with an increase in average length of post-operative stay.

Post-operative stay, previous surgery and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

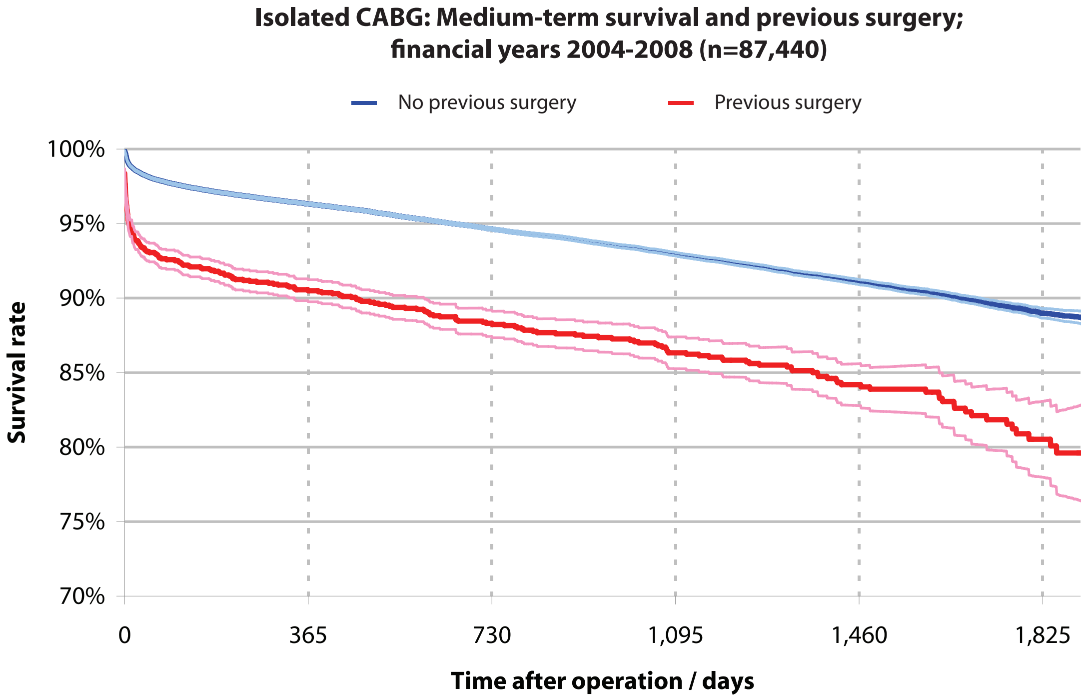
		Financial year				
		2004	2005	2006	2007	2008
Previous surgery	No previous surgery	8.9 22,591	8.9 22,977	8.9 19,716	9.0 18,773	8.5 22,019
	Previous surgery	10.0 543	10.4 522	10.6 389	10.6 331	9.2 363
	Unspecified	11.0 154	9.0 194	11.1 499	10.1 114	9.2 130

Isolated CABG: Post-operative stay and previous surgery; bars denote standard errors (n=108,224)



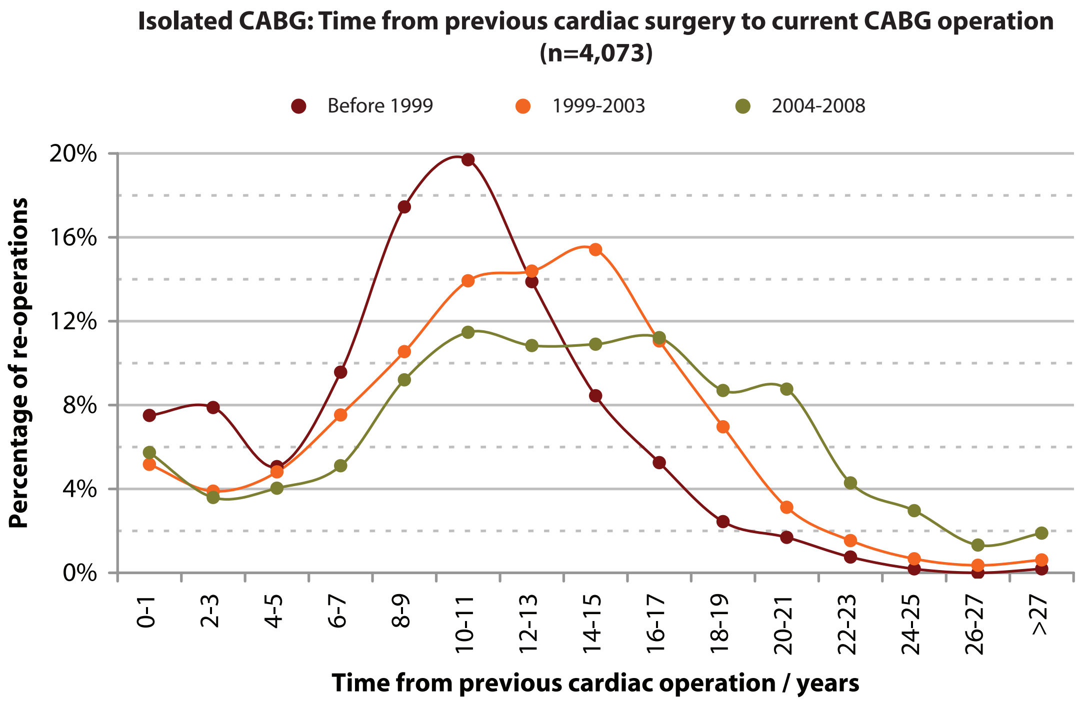
Survival and previous surgery

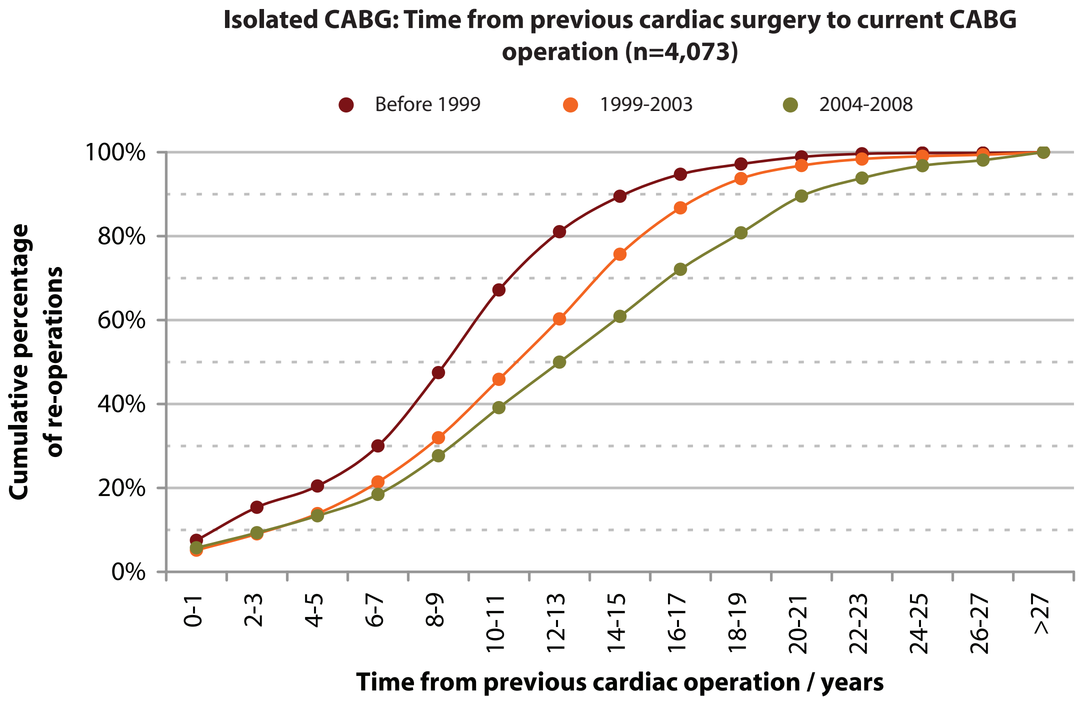
Redo CABG surgery is associated with a worse medium-term survival rate than first-time surgery, but this seems to be largely due to the early mortality. For those who survive 1 year after redo surgery, the slope of the survival curve is similar to those undergoing first-time operations.



Timing of previous cardiac surgery

This shows the time elapsed between previous cardiac surgery and current CABG for patients having their redo operations in 3 different time-periods. The median time interval prior to 1999 was 8-9 years and this has increased to 12-13 years between 2004 and 2008. This suggests better graft survival in recent years and may be due to the use of more arterial grafts (see page 125), better use of antiplatelet medication, statins and ACE inhibitors, or, more probably, a combination of all these factors. This should be seen in conjunction with the *quality* descriptions described on pages 435 (*good practice* example 3) and 448 (*quality accounts*).





Diabetes

Key points from diabetes analyses

- Between 2001 and 2008 there has been a 33% increase in the proportion of patients who are diabetic.
- The mortality for diabetics remains higher than for non-diabetic patients.
- Diabetics have a longer length-of-stay than non-diabetics.
- Diabetics have a medium-term survival rate of 85% compared to non-diabetics of 90%.

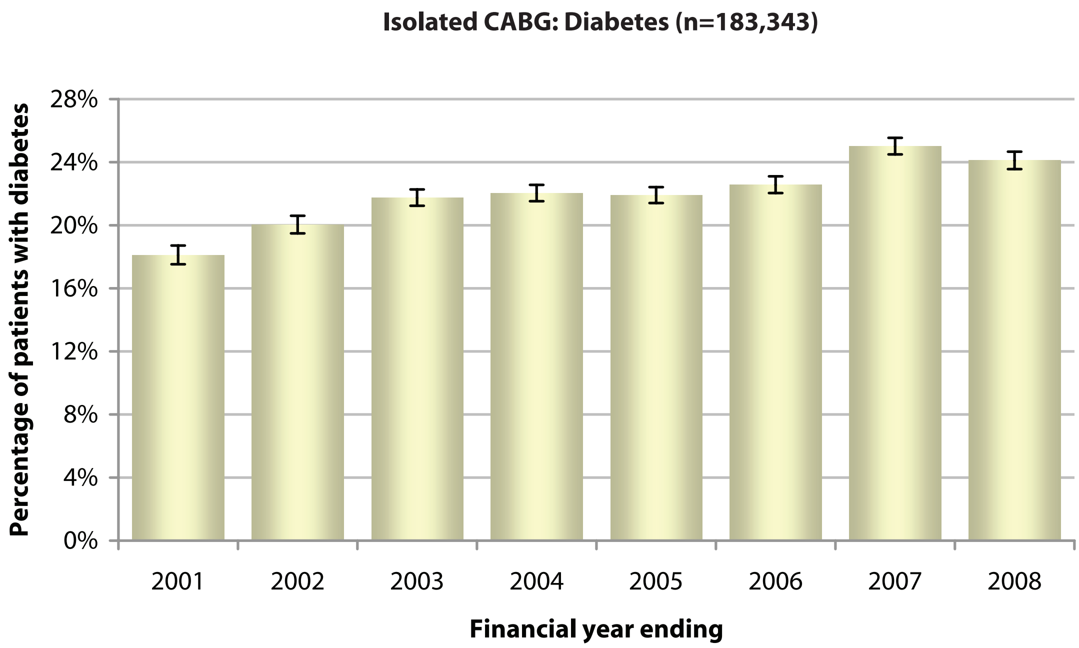
Diabetes distribution

Diabetes is a serious condition in which the body does not utilise glucose efficiently. Diabetes is becoming increasingly common in developed countries and is associated with many illnesses, including disease right throughout the vascular system. Diabetics are more prone to heart attacks, strokes, renal disease and intermittent claudication.

The proportion of patients undergoing isolated CABG who have a diagnosis of diabetes has risen by 33% from about 18% in 2001 to 24% in 2008 (χ^2 test for trends: $p<0.001$)

Diabetes distributions over time

		Financial year							
		2001	2002	2003	2004	2005	2006	2007	2008
Diabetes	No diabetes	17,539	18,569	20,277	18,392	18,742	17,097	15,269	17,271
	Diabetes	3,879	4,653	5,635	5,199	5,258	4,983	5,094	5,486
	Unspecified	620	181	326	840	536	171	149	89
	All	**22,038**	**23,403**	**26,238**	**24,431**	**24,536**	**22,251**	**20,512**	**22,846**



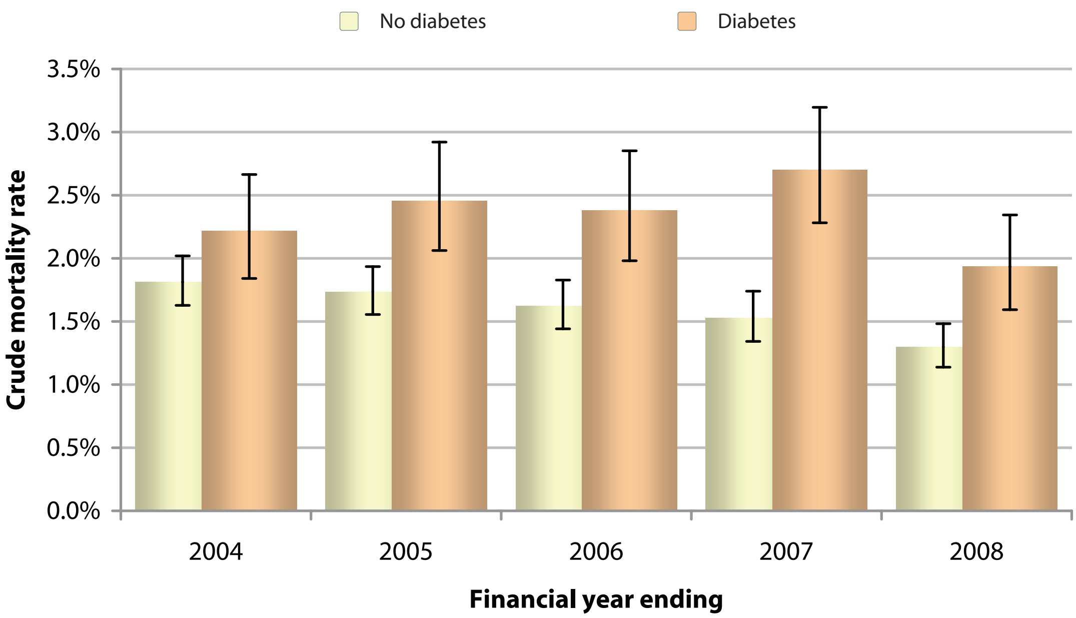
Mortality and diabetes

The post-operative mortality rate for diabetic patients remains significantly higher than for non-diabetic patients, but it has decreased over time, in particular for non-diabetics (χ^2 test for trends: mortality for non-diabetic patients decreases over time, p<0.001; for diabetic patients there is no such indication, p=0.578).

Mortality, diabetes and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	**All**
Diabetes	No diabetes	1.8% 18,365	1.7% 18,734	1.6% 17,059	1.5% 15,179	1.3% 17,246	**1.6%** **86,583**
	Diabetes	2.2% 5,189	2.5% 5,253	2.4% 4,961	2.7% 5,070	1.9% 5,481	**11%** **25,954**
	Unspecified	2.1% 827	3.7% 536	2.9% 171	3.4% 148	7.4% 81	**3.0%** **1,763**
	All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**

Isolated CABG: Crude mortality and diabetes (n=112,537)



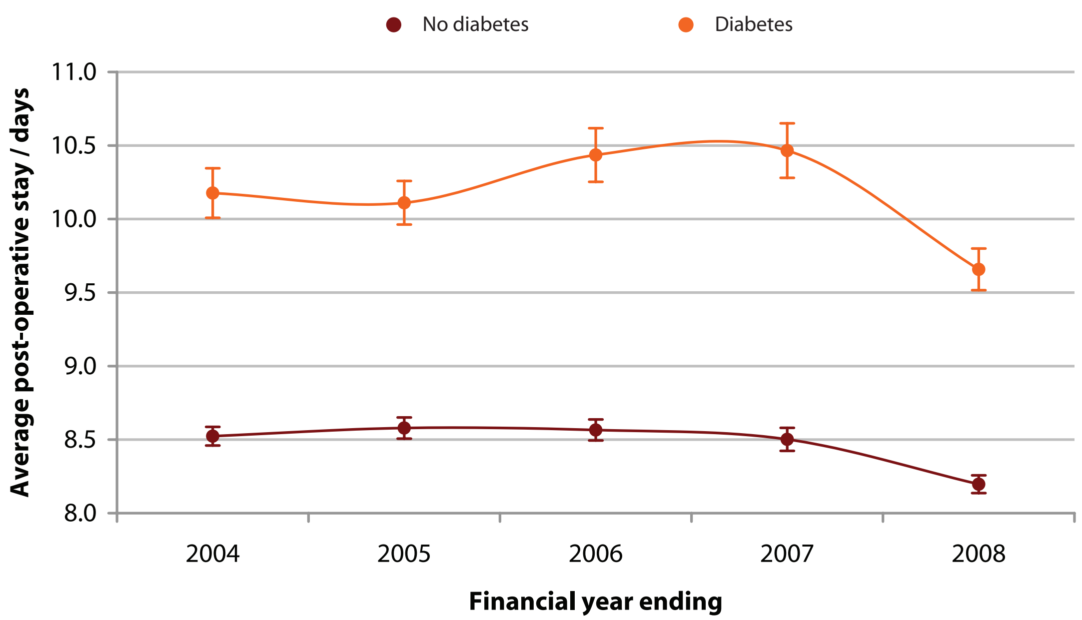
Post-operative stay and diabetes

Diabetic patients stay in hospital consistently longer than non-diabetic patients, but the length-of-stay for both groups of patients has decreased in 2008.

Post-operative stay, diabetes and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

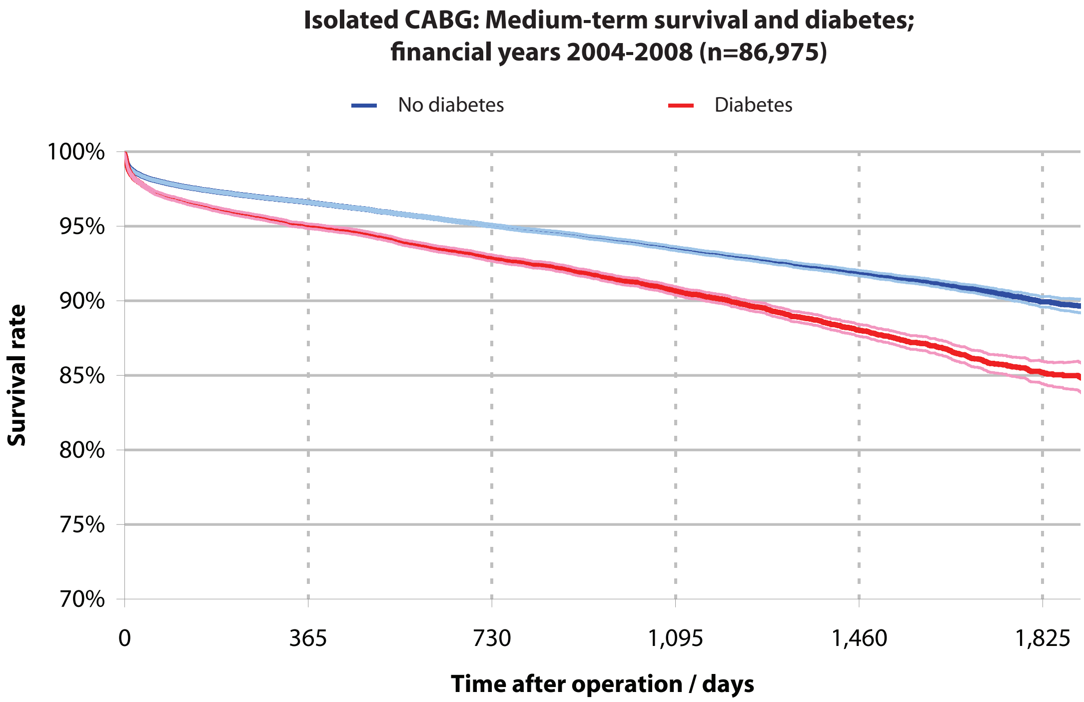
		Financial year				
		2004	2004	2006	2007	2008
Diabetes	No diabetes	8.5 17,616	8.6 18,132	8.6 15,897	8.5 14,330	8.2 17,021
	Diabetes	10.2 4,982	10.1 5,119	10.4 4,613	10.5 4,819	9.7 5,413
	Unspecified	9.1 690	10.3 442	11.1 94	9.3 69	11.4 78

Isolated CABG: Post-operative stay and diabetes; bars denote standard errors (n=107,942)



Survival and diabetes

Medium-term survival is worse for diabetics. Not only is there is a small increase in early mortality for diabetic patients, but the curve continues to diverge from the non-diabetic patients over the 5 years of follow-up.



Hypertension

Key points from hypertension analyses

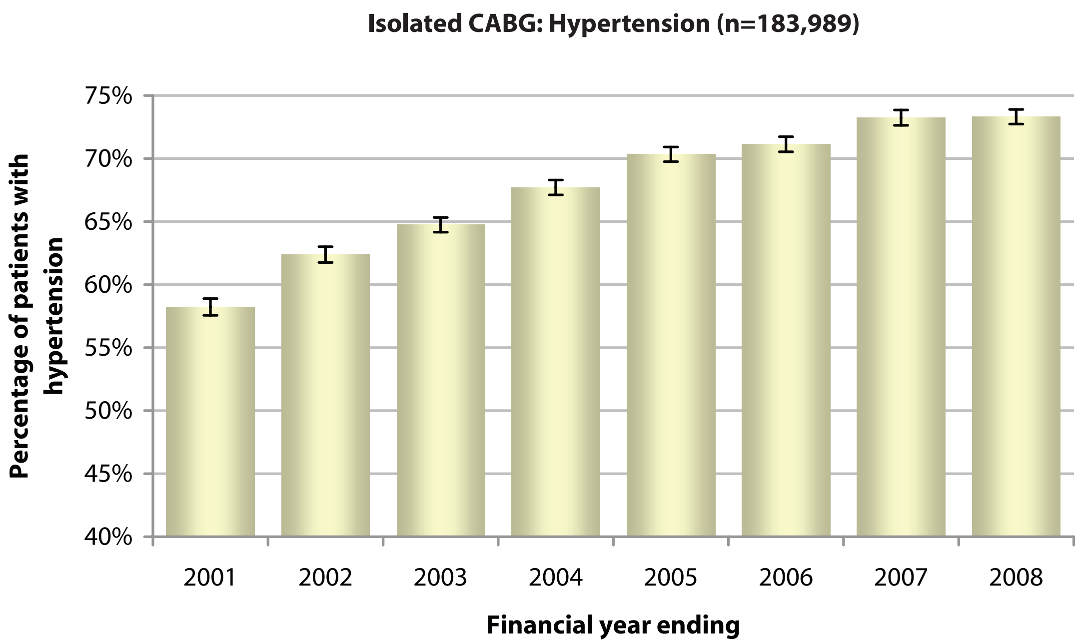
- The proportion of patients with a diagnosis of hypertension has continued to increase from just under 60% in 2001 to just under 75% in 2008.
- In the most recent year of study there is no significant increase in operative mortality in patients with hypertension.
- Hypertension remains associated with longer in-hospital stay & worse medium-term survival rate.

Hypertension distribution

There has been a marked increase in the incidence of hypertension, this may indicate that the disease is becoming more common, or may reflect the more elderly population now coming to surgery and the implementation of better systems for diagnosis of hypertension in primary and secondary care.

Hypertension distributions over time

		Financial year							
		2001	2002	2003	2004	2005	2006	2007	2008
Hypertension	No hypertension	8,992	8,747	9,114	7,793	7,164	6,362	5,449	6,046
	Hypertension	12,534	14,505	16,738	16,341	16,988	15,682	14,919	16,615
	Unspecified	512	151	386	297	384	207	144	185
	All	**22,038**	**23,403**	**26,238**	**24,431**	**24,536**	**22,251**	**20,512**	**22,846**

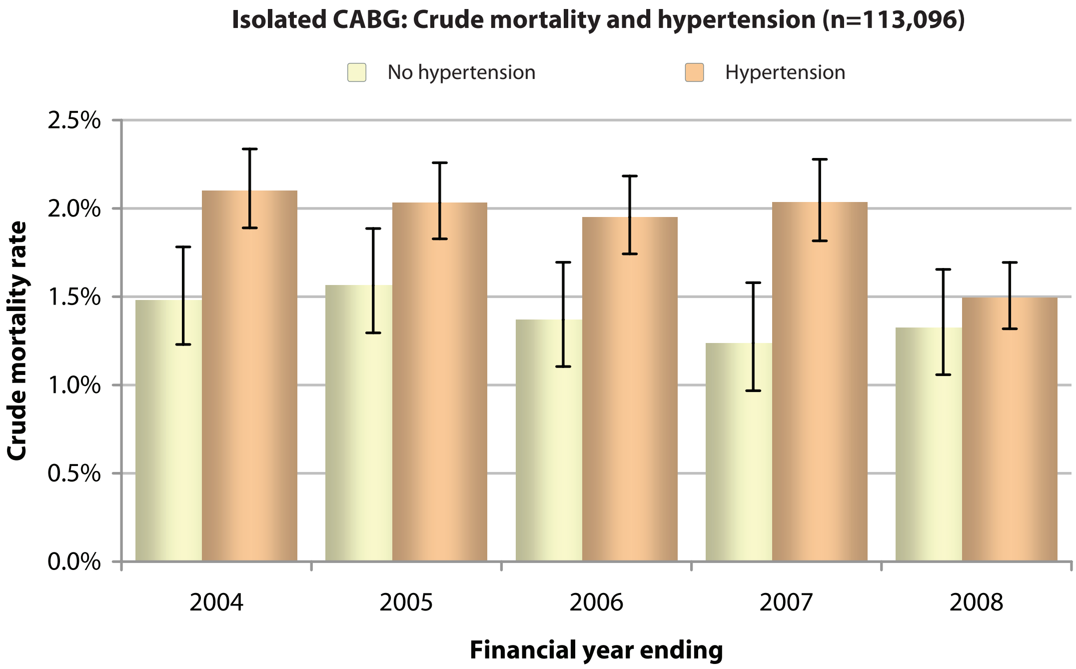


Mortality and hypertension

There is a small increase in mortality rate associated with a diagnosis of hypertension. In the most recent year of study this difference is no longer significant.

Mortality, hypertension and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	All
Hypertension	No hypertension	1.5% 7,764	1.6% 7,161	1.4% 6,352	1.2% 5,412	1.3% 6,040	**1.4%** **32,729**
	Hypertension	2.1% 16,322	2.0% 16,978	2.0% 15,633	2.0% 14,843	1.5% 16,591	**1.9%** **80,367**
	Unspecified	2.4% 295	4.4% 384	3.9% 206	3.5% 142	4.5% 177	**3.7%** **1,204**
	All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**



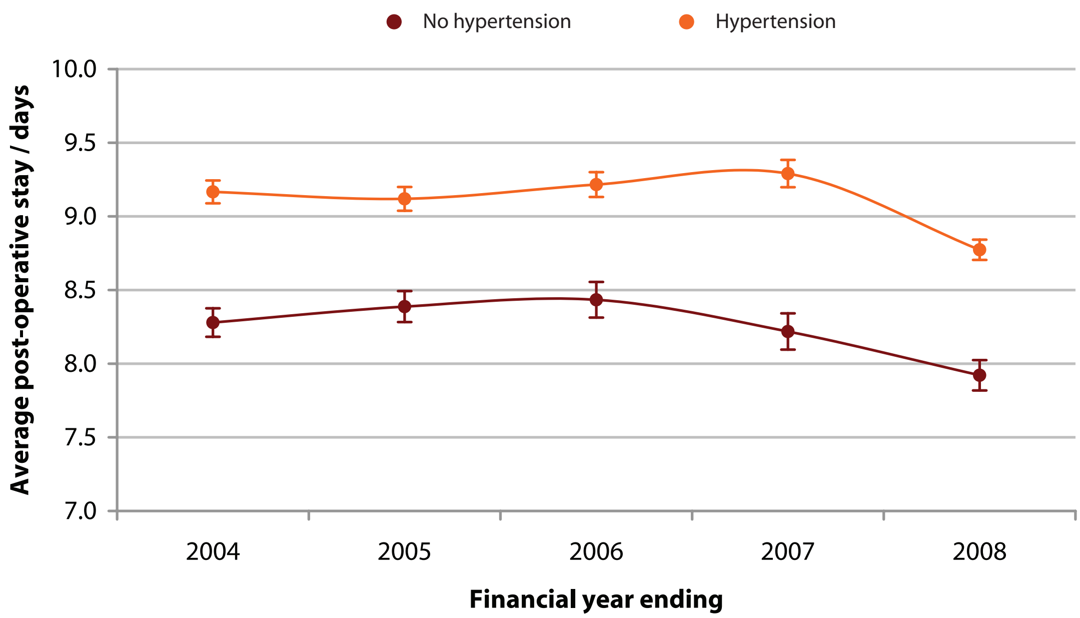
Post-operative stay and hypertension

Hypertensive patients have a consistently greater average length-of-stay.

Post-operative stay, hypertension and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

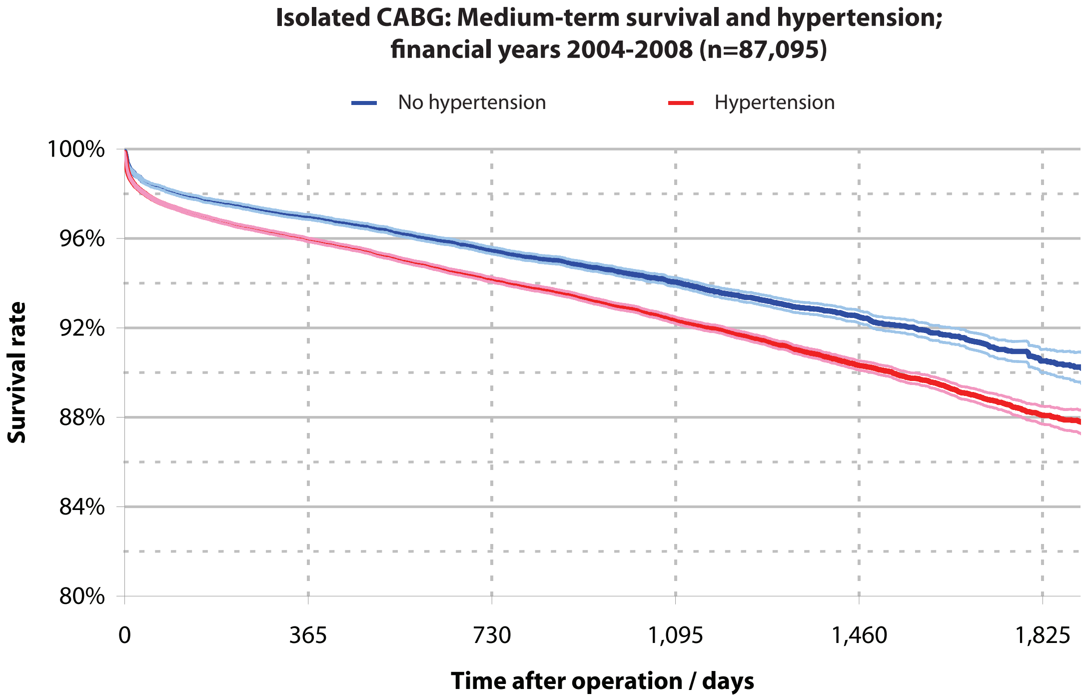
		Financial year				
		2004	2004	2006	2007	2008
Hypertension	No hypertension	8.3 7,463	8.4 6,913	8.4 6,009	8.2 5,138	7.9 5,915
	Hypertension	9.2 15,599	9.1 16,403	9.2 14,391	9.3 13,946	8.8 16,426
	Unspecified	10.4 226	11.4 377	10.0 204	8.3 134	10.1 171

Isolated CABG: Post-operative stay and hypertension; bars denote standard errors (n=108,203)



Survival and hypertension

Hypertensive patients have a worse medium-term survival rate. This may simply be because hypertensive patients are likely to be older and have other co-morbidities, but it may be because hypertension remains a risk factor for mortality, despite the emphasis on better diagnosis and treatment of hypertension in the community.



Extra-cardiac arteriopathy

Key points from extra-cardiac arteriopathy analyses

- There has been a small increase in the proportion of patients undergoing CABG who have extra-cardiac arteriopathy (ECA). This is important as it remains a major risk factor for increased in-hospital mortality.
- ECA is associated with a longer in-hospital stay and a much worse medium-term survival rate.

ECA distribution

Extra-cardiac arteriopathy is defined as:

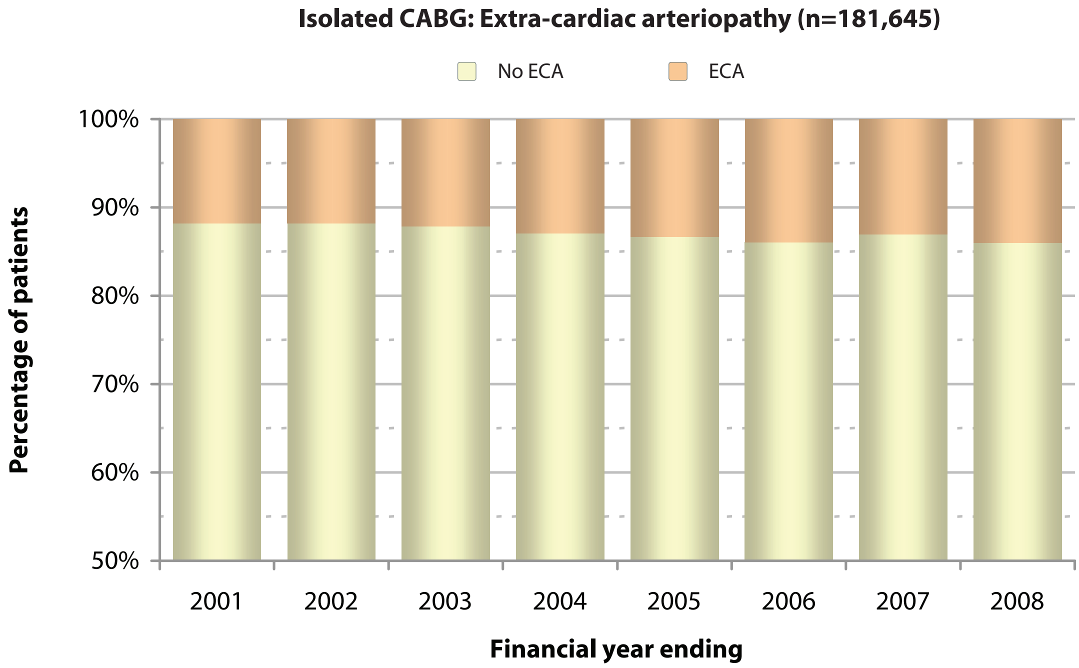
Any one of the following: claudication, carotid occlusion or >50% stenosis, previous or planned surgery on the abdominal aorta, limb arteries or carotids.

The risk factors for developing ECA are the same as those causing coronary artery disease, and so it not surprising that a significant proportion of patients undergoing CABG have a diagnosis of ECA.

The incidence of ECA has increased over time; this increase has been small but is important, and ECA remains a major risk factor for in-hospital mortality.

Extra-cardiac arteriopathy distributions over time

		Financial year							
		2001	2002	2003	2004	2005	2006	2007	2008
Extra-cardiac arteriopathy	No ECA	18,125	20,012	22,637	20,262	20,988	19,036	17,685	19,523
	ECA	2,420	2,679	3,122	3,007	3,230	3,080	2,654	3,185
	Unspecified	1,493	712	479	1,162	318	135	173	138
	All	**22,038**	**23,403**	**26,238**	**24,431**	**24,536**	**22,251**	**20,512**	**22,846**



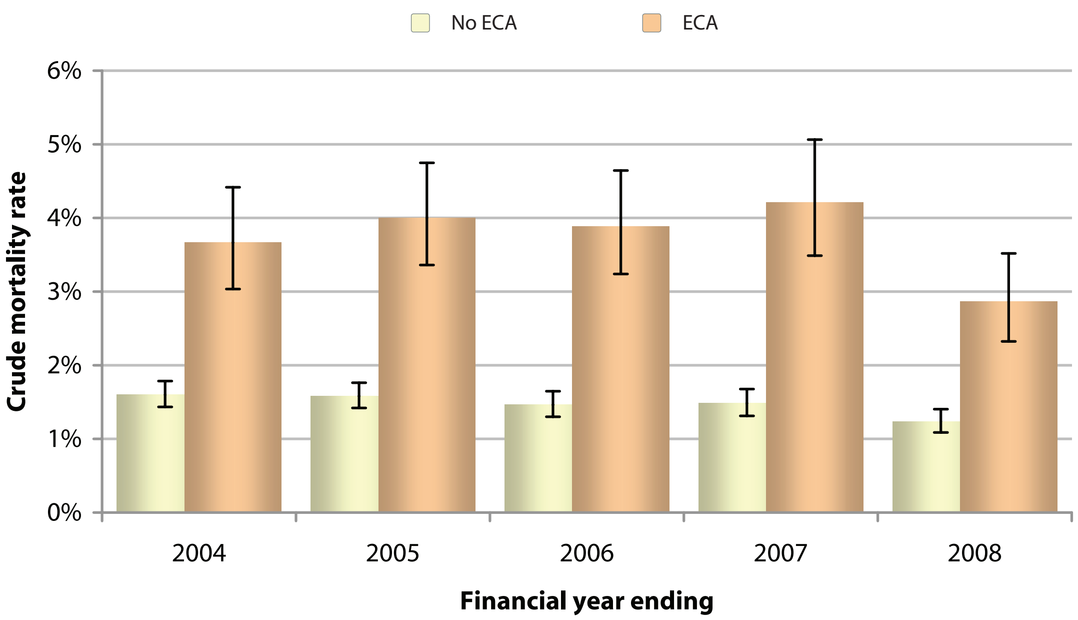
Mortality and ECA

The mortality rate for patients undergoing CABG who have a diagnosis of ECA remains significantly higher (more than double) than those in whom the risk factor is absent.

Mortality, extra-cardiac arteriopathy and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	**All**
Extra-cardiac arteriopathy	No ECA	1.6% 20,238	1.6% 20,979	1.5% 18,991	1.5% 17,587	1.2% 19,498	**1.5% 97,293**
	ECA	3.7% 3,001	4.0% 3,226	3.9% 3,065	4.2% 2,638	2.9% 3,179	**3.7% 15,109**
	Unspecified	2.7% 1,142	4.1% 318	2.2% 135	1.2% 172	3.1% 131	**2.8% 1,898**
	All	**1.9% 24,381**	**1.9% 24,523**	**1.8% 22,191**	**1.8% 20,397**	**1.5% 22,808**	**1.8% 114,300**

Isolated CABG: Crude mortality and extra-cardiac arteriopathy (n=112,402)



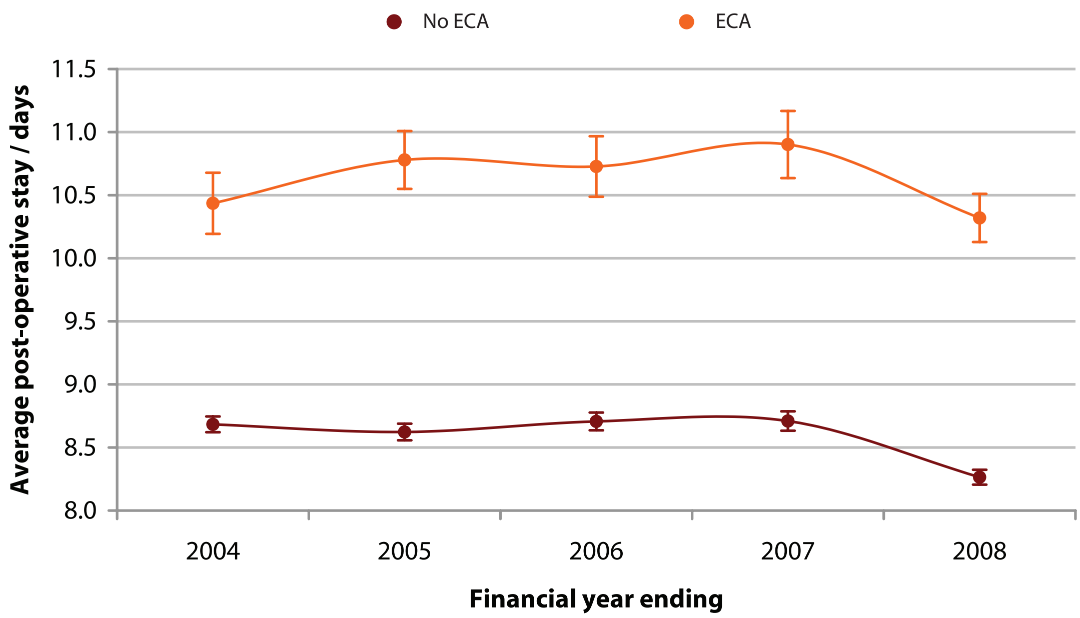
Post-operative stay and ECA

Patients with extra-cardiac arteriopathy tend to require an extra 2 days in hospital after their operation.

Post-operative stay, extra-cardiac arteriopathy and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

		Financial year				
		2004	2004	2006	2007	2008
ECA	No ECA	8.7 19,354	8.6 20,262	8.7 17,590	8.7 16,534	8.3 19,219
	ECA	10.4 2,875	10.8 3,120	10.7 2,884	10.9 2,523	10.3 3,165
	Unspecified	8.6 1,059	11.3 311	9.7 130	8.7 161	9.3 128

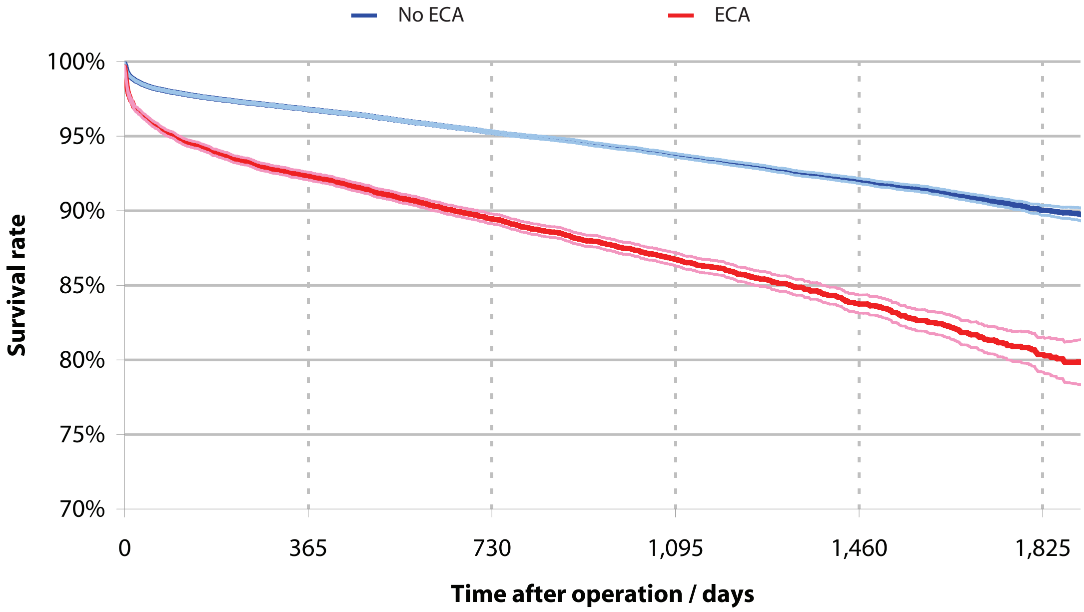
Isolated CABG: Post-operative stay and extra-cardiac arteriopathy; bars denote standard errors (n=107,526)



Survival and ECA

Extra-cardiac arteriopathy is strongly associated with a worse medium-term survival rate. Not only is there a large increase in early mortality, but the survival curves continue to diverge over the period of follow-up, and for patients with ECA the Kaplan-Meier survival rate at 5 years is 80%.

Isolated CABG: Medium-term survival and extra-cardiac arteriopathy; financial years 2004-2008 (n=86,808)



Renal disease

Key points from renal disease analyses

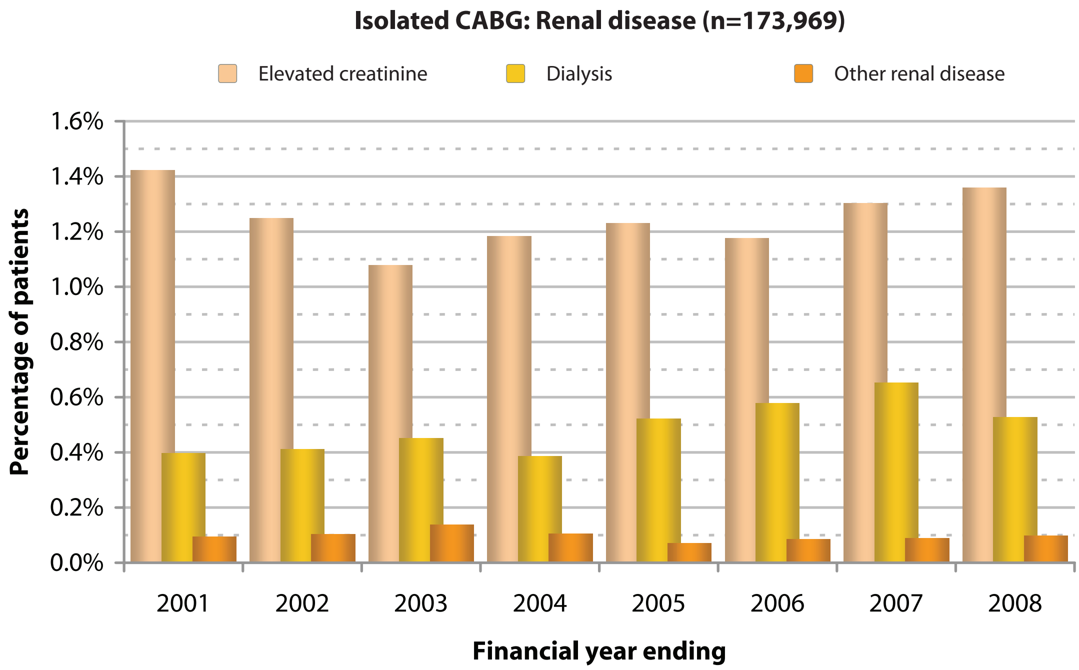
- There has been a small increase in the proportion of patients who have dialysis-dependent renal failure before surgery.
- Any degree of renal disease is associated with a marked increase in length-of-stay.
- Renal disease is a powerful predictor of poor post-operative survival: for patients on dialysis the medium-term survival rate at 5 years after surgery is only 50% compared to 90% for those without renal disease.

Renal disease distribution

The kidneys are responsible for excreting waste products from the body, and also have some other important functions. Normally creatinine levels within the blood are taken as an indicator of renal function, and a value of up to 120 μmol l^{-1}, is considered normal, but levels this high in small elderly patients can often indicate important problems with renal function. For the purposes of the SCTS database a level of greater than 200 μmol l^{-1}, is taken to indicate renal disease, but it now accepted than any impairment of renal function is associated with increased mortality in patients undergoing CABG. Renal disease (as currently defined) is rare in patients undergoing CABG, with an incidence of less than 2%. Additionally, around 0.5% of patients are on renal dialysis therapy.

Renal disease distributions over time

Renal disease	Financial year							
	2001	2002	2003	2004	2005	2006	2007	2008
No renal disease	18,825	20,784	22,699	22,619	23,367	20,866	19,686	21,933
Elevated creatinine	273	264	249	272	293	250	262	304
Dialysis	76	87	104	89	124	123	131	118
Other renal disease	18	22	32	24	17	18	18	22
Unspecified	2,846	2,246	3,154	1,427	735	994	415	469



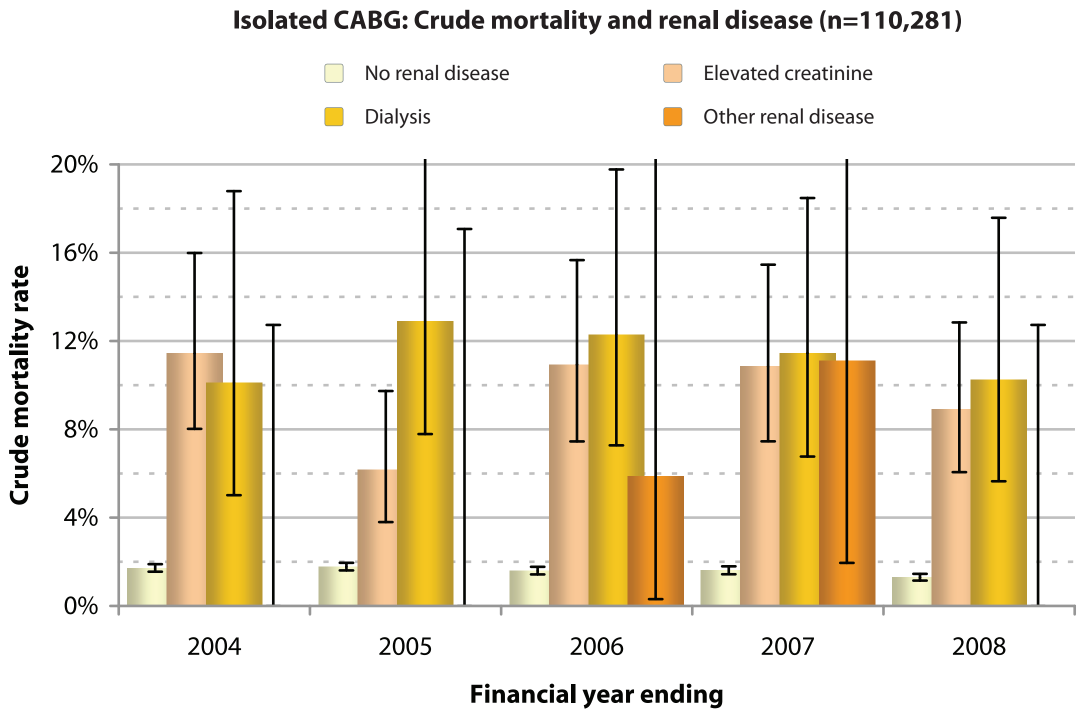
i Howell NJ, Keogh BE, Bonser RS, Graham TR, Mascaro J, Rooney SJ, Wilson IC, Pagano D. Mild renal dysfunction predicts in-hospital mortality & post-discharge survival following cardiac surgery. *Eur J Cardiothorac Surg.* 2008; **34(2):** 390-5

Mortality and renal disease

The presence of renal disease is a very important risk factor for operative mortality; patients with an elevated creatinine have a 6-fold increase in mortality rate and for patients on dialysis it is even higher.

Mortality, renal disease and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

	Financial year					
	2004	2005	2006	2007	2008	**All**
No renal disease	1.7% 22,585	1.8% 23,356	1.6% 20,812	1.6% 19,576	1.3% 21,903	**1.6%** **108,232**
Elevated creatinine	11.4% 271	6.2% 292	10.9% 247	10.9% 258	8.9% 303	**9.6%** **1,371**
Dialysis	10.1% 89	12.9% 124	12.3% 122	11.5% 131	10.3% 117	**11.5%** **583**
Other renal disease	0.0% 22	0.0% 16	5.9% 17	11.1% 18	0.0% 22	**3.2%** **95**
Unspecified	2.7% 1,414	3.5% 735	2.6% 993	3.6% 414	3.0% 463	**3.0%** **4,019**
All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**



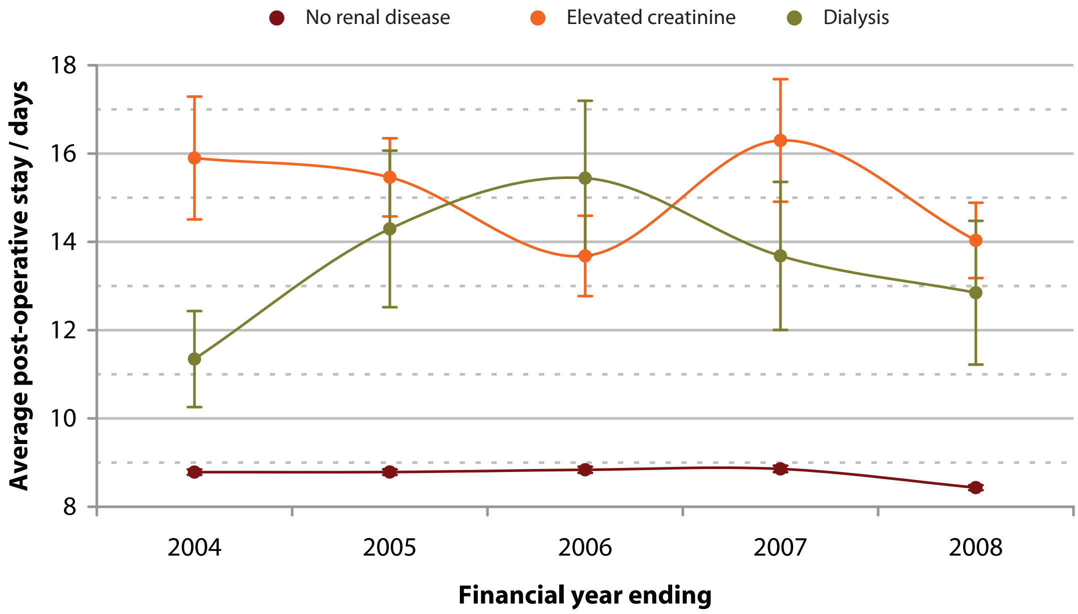
Post-operative stay and renal disease

Patients with renal disease tend to spend several days longer in hospital after their operation. This increased length-of-stay applies similarly to both those on dialysis and with a creatinine >200 μmol l^{-1}, and equates to about a 50% increase in length-of-stay.

Post-operative stay, renal disease and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

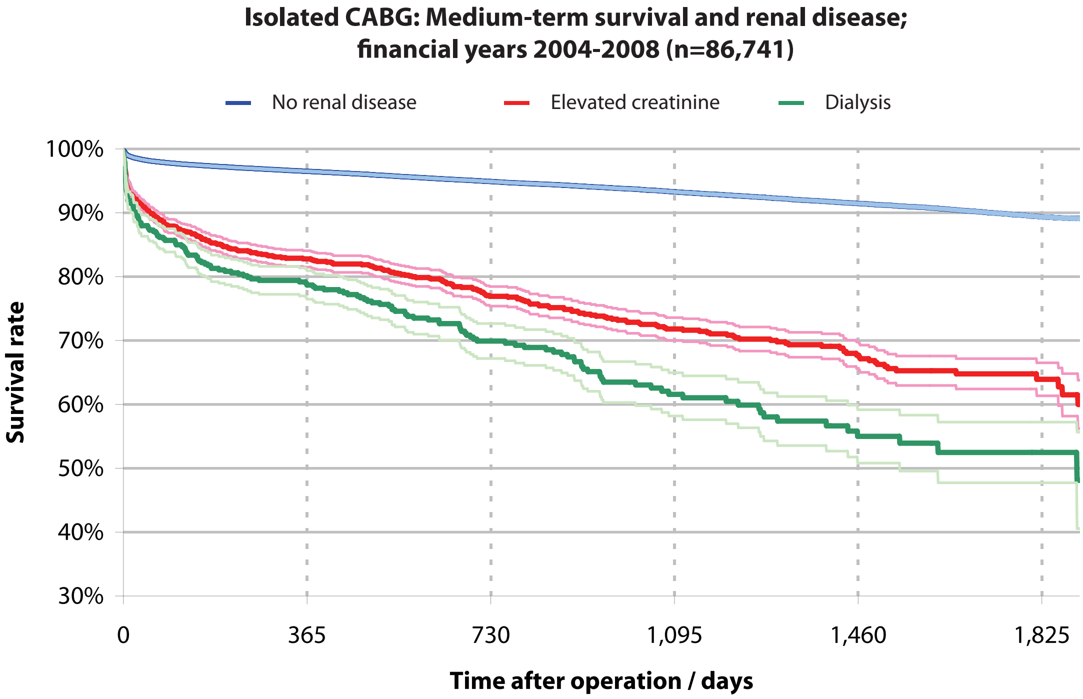
		Financial year				
		2004	2004	2006	2007	2008
Renal disease	No renal disease	8.8 21,936	8.8 22,843	8.8 19,562	8.9 18,749	8.4 21,882
	Elevated creatinine	15.9 256	15.5 276	13.7 226	16.3 236	14.0 303
	Dialysis	11.3 81	14.3 116	15.4 113	13.7 110	12.8 118
	Other renal disease	9.1 23	8.7 16	14.8 16	9.2 15	17.1 22
	Unspecified	9.3 992	11.5 442	10.8 687	12.5 108	10.8 187

Isolated CABG: Post-operative stay and renal disease; bars denote standard errors (n=106,899)



Survival and renal disease

The presence of renal disease is an important risk factor for medium-term survival; the survival rate for patients with a creatinine less than 200 µmol l^{-1} is around 90%, for those with elevated creatinine and dialysis dependent renal failure it is 65% and 52% respectively.



Angina

Key points from angina analyses

- The proportion of patients undergoing surgery who have severe angina has reduced over time.
- The presence of severe angina remains an important risk factor for operative mortality.
- There has been a small but significant increase in the proportion of patients undergoing CABG with no angina, in whom surgery is undertaken either for symptoms of shortness-of-breath, or solely to improve life-expectancy.

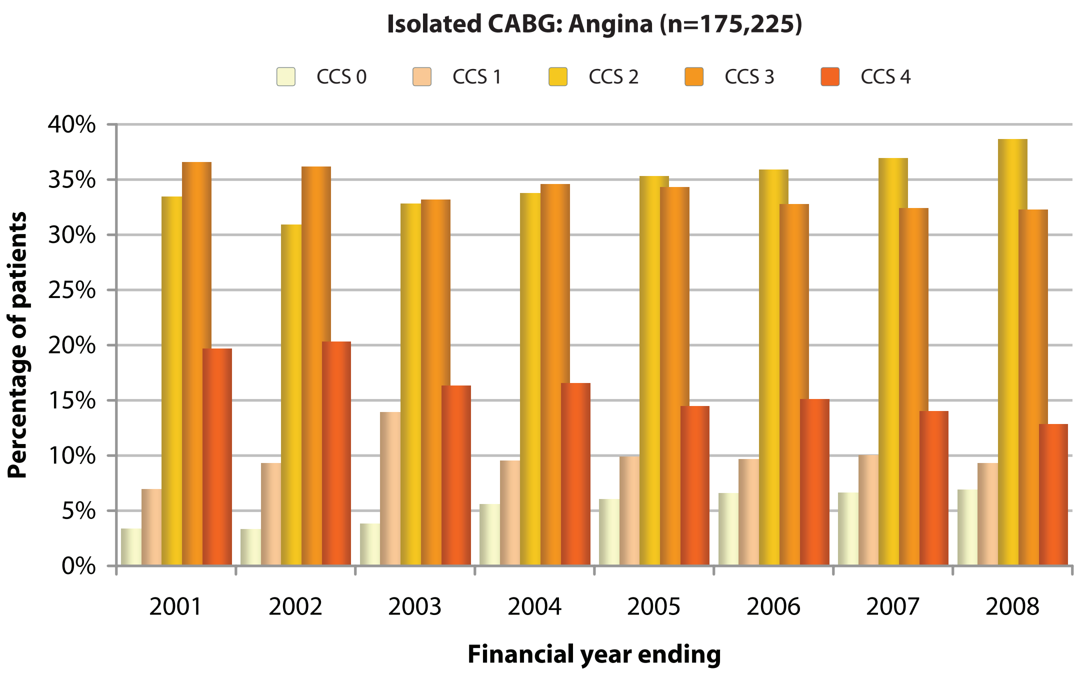
Angina distributions

Angina is graded according to the Canadian Cardiovascular Society (CCS) scale from 0 (no angina) to 4 (severe angina at rest or minimal activity). There has been a decrease in the proportion of patients who have class 4 symptoms.

There has been a small, but significant increase in the proportion of patients who have no angina, in whom surgery is undertaken either for symptoms of shortness-of-breath, or solely to improve life-expectancy, from 3% to 7% of the population (χ^2 test for trends: $p<0.001$).

Angina distributions over time

		Financial year							
		2001	2002	2003	2004	2005	2006	2007	2008
Angina	CCS 0	687	728	958	1,285	1,388	1,376	1,282	1,499
	CCS 1	1,412	2,028	3,481	2,202	2,272	2,022	1,943	2,024
	CCS 2	6,796	6,750	8,210	7,789	8,112	7,502	7,151	8,397
	CCS 3	7,437	7,894	8,301	7,977	7,880	6,848	6,273	7,007
	CCS 4	3,994	4,439	4,080	3,822	3,323	3,156	2,716	2,784
	Unspecified	1,712	1,564	1,208	1,356	1,561	1,347	1,147	1,135

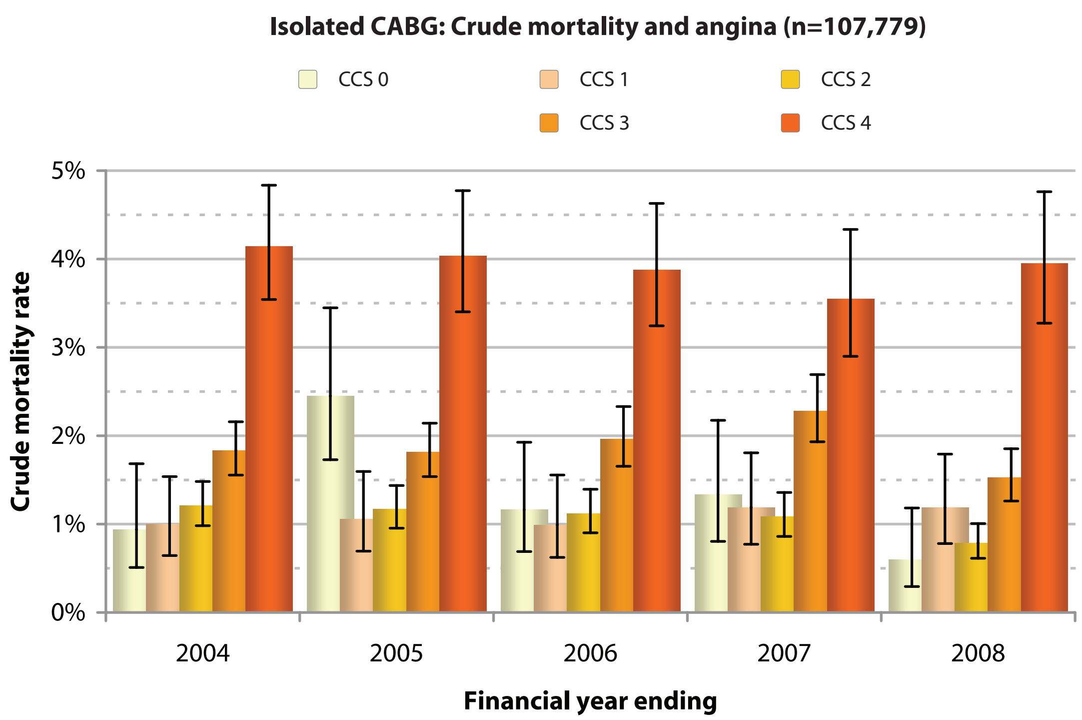


Mortality and angina

Severe angina (CCS class 4) is associated with a three-fold increase in-hospital mortality rate compared to those with mild symptoms.

Mortality, angina and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	**All**
Angina	CCS 0	0.9% 1,278	2.5% 1,387	1.2% 1,375	1.3% 1,274	0.6% 1,497	**1.3% 6,811**
	CCS 1	1.0% 2,198	1.1% 2,269	1.0% 2,018	1.2% 1,936	1.2% 2,019	**1.1% 10,440**
	CCS 2	1.2% 7,783	1.2% 8,108	1.1% 7,487	1.1% 7,114	0.8% 8,388	**1.1% 38,880**
	CCS 3	1.8% 7,965	1.8% 7,876	2.0% 6,820	2.3% 6,222	1.5% 6,995	**1.9% 35,878**
	CCS 4	4.1% 3,815	4.0% 3,322	3.9% 3,145	3.5% 2,705	4.0% 2,783	**3.9% 15,770**
	Unspecified	2.5% 1,342	2.8% 1,561	1.8% 1,346	1.7% 1,146	1.8% 1,126	**2.1% 6,521**
	All	**1.9% 24,381**	**1.9% 24,523**	**1.8% 22,191**	**1.8% 20,397**	**1.5% 22,808**	**1.8% 114,300**

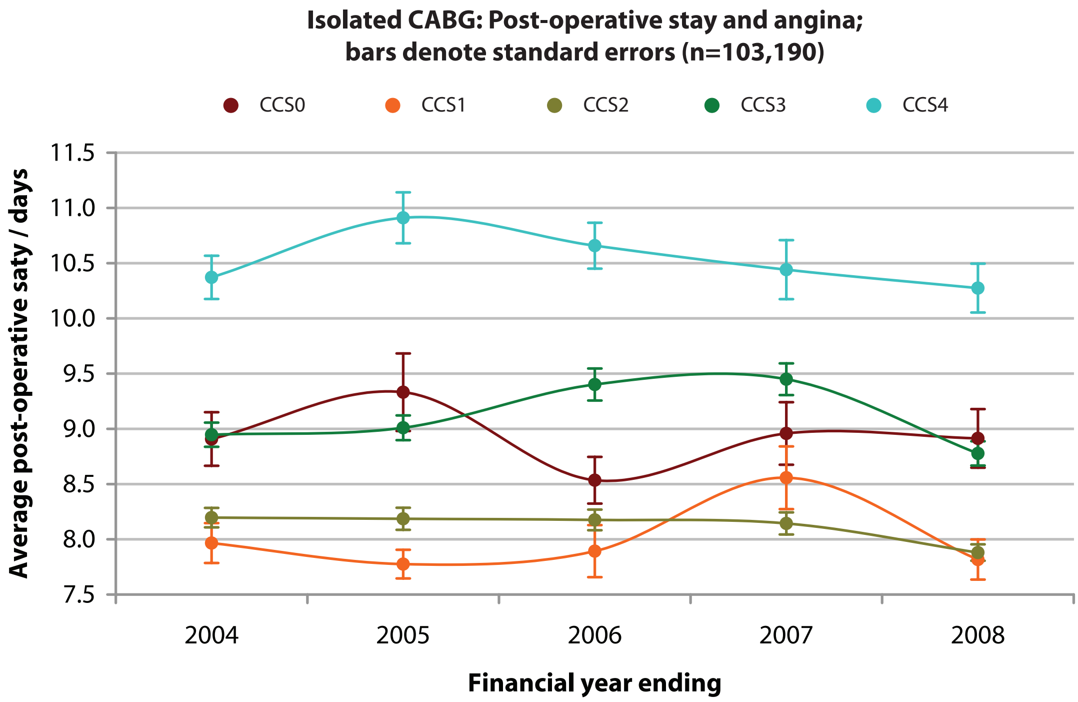


Post-operative stay and angina

Progressively severe angina is associated with progressively greater length-of-stay.

Post-operative stay, angina and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

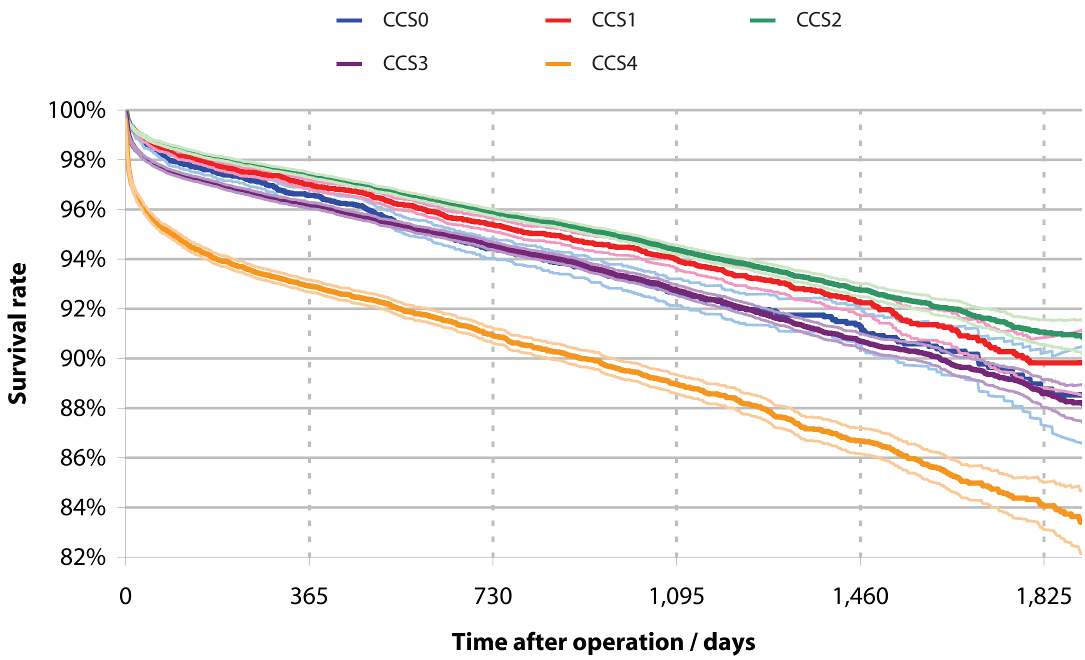
		Financial year				
		2004	2004	2006	2007	2008
Angina	CCS0	8.9 1,194	9.3 1,276	8.5 1,307	9.0 1,221	8.9 1,489
	CCS1	8.0 2,034	7.8 2,124	7.9 1,795	8.6 1,794	7.8 1,987
	CCS2	8.2 7,377	8.2 7,815	8.2 6,979	8.1 6,653	7.9 8,269
	CCS3	8.9 7,711	9.0 7,668	9.4 6,437	9.4 5,926	8.8 6,894
	CCS4	10.4 3,710	10.9 3,263	10.7 2,973	10.4 2,543	10.3 2,751
	Unspecified	9.8 1,262	9.6 1,547	9.7 1,113	9.1 1,081	8.9 1,122



Survival and angina

Severe angina before surgery is associated with a worse medium-term survival rate; this is due largely to an increase in early mortality, but the survival curve for these patients continues to diverge from those for patients with less severe symptoms.

Isolated CABG: Medium-term survival and angina; financial years 2004-2008 (n=88,804)



Dyspnoea

Key points from dyspnoea analyses

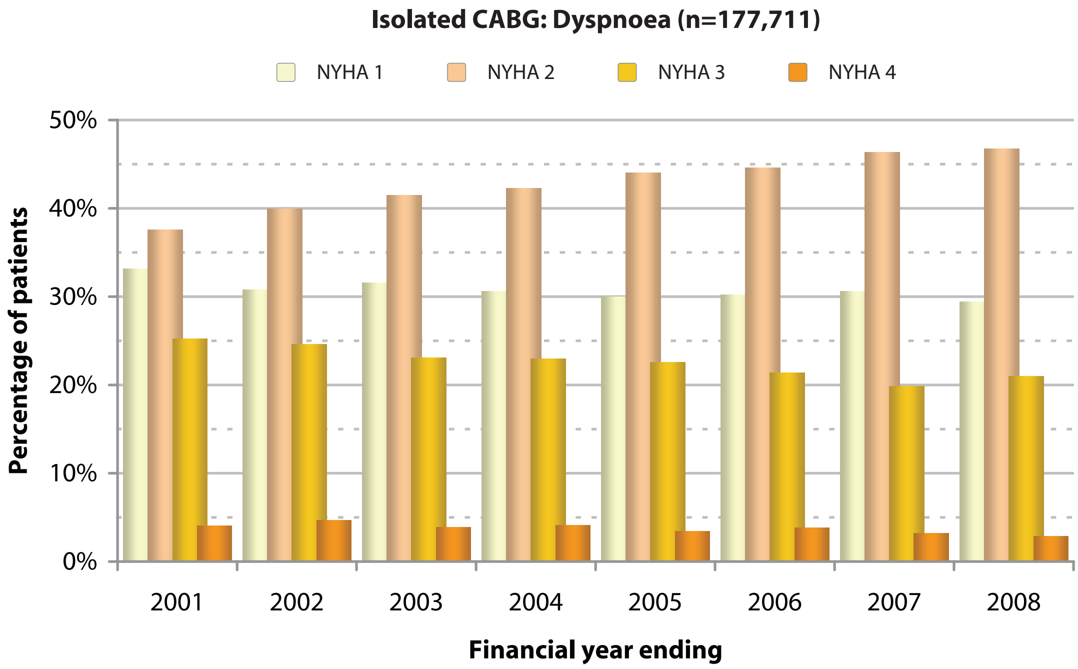
- There has been a decrease in the proportion of patients with moderate or severe dyspnoea over time.
- Moderate and severe dyspnoea are associated with an increased operative mortality.

Dyspnoea distribution

Dyspnoea (breathlessness) can be due to many causes which include cardiac dysfunction (sometimes dyspnoea may be one of the symptoms of angina) and respiratory difficulties. Dyspnoea is graded 1 to 4 according to the New York Heart Association (NYHA) grading, with higher grades indicating greater breathlessness. There has been an increase in the proportion of patients who are NYHA 2 over time.

Dyspnoea distributions over time

		Financial year							
		2001	2002	2003	2004	2005	2006	2007	2008
Dyspnoea	NYHA 1	6,771	6,636	7,523	7,209	7,132	6,532	6,195	6,674
	NYHA 2	7,671	8,618	9,889	9,946	10,472	9,636	9,389	10,611
	NYHA 3	5,150	5,311	5,500	5,402	5,375	4,617	4,015	4,764
	NYHA 4	831	1,008	927	973	810	827	649	648
	Unspecified	1,615	1,830	2,399	901	747	639	264	149
	All	**22,038**	**23,403**	**26,238**	**24,431**	**24,536**	**22,251**	**20,512**	**22,846**



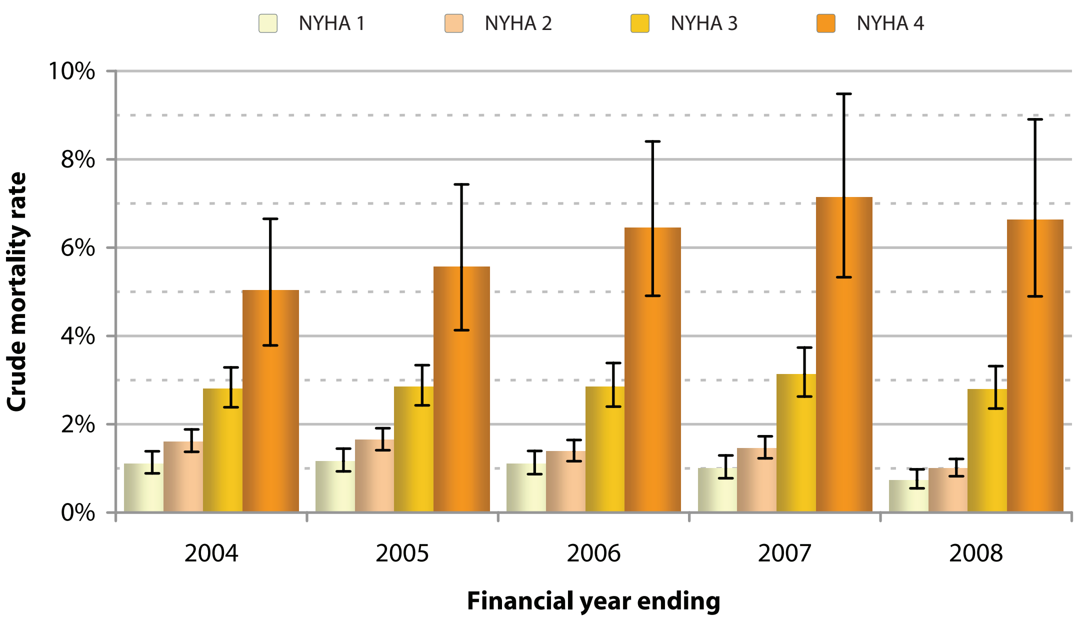
Mortality and dyspnoea

Grades 3 and grade 4 dyspnoea are associated with a three-fold and a six-fold increase in operative mortality rate respectively.

Mortality, diabetes and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	**All**
Dyspnoea	NYHA 1	1.1% 7,202	1.2% 7,128	1.1% 6,528	1.0% 6,173	0.7% 6,670	**1.0% 33,701**
	NYHA 2	1.6% 9,938	1.6% 10,469	1.4% 9,612	1.5% 9,331	1.0% 10,595	**1.4% 49,945**
	NYHA 3	2.8% 5,388	2.8% 5,370	2.9% 4,591	3.1% 3,986	2.8% 4,755	**2.9% 24,090**
	NYHA 4	5.0% 973	5.6% 809	6.4% 822	7.1% 644	6.6% 648	**6.1% 3,896**
	Unspecified	2.8% 880	2.8% 747	1.7% 638	1.9% 263	3.6% 140	**2.5% 2,668**
	All	**1.9% 24,381**	**1.9% 24,523**	**1.8% 22,191**	**1.8% 20,397**	**1.5% 22,808**	**1.8% 114,300**

Isolated CABG: Crude mortality and dyspnoea (n=111,632)



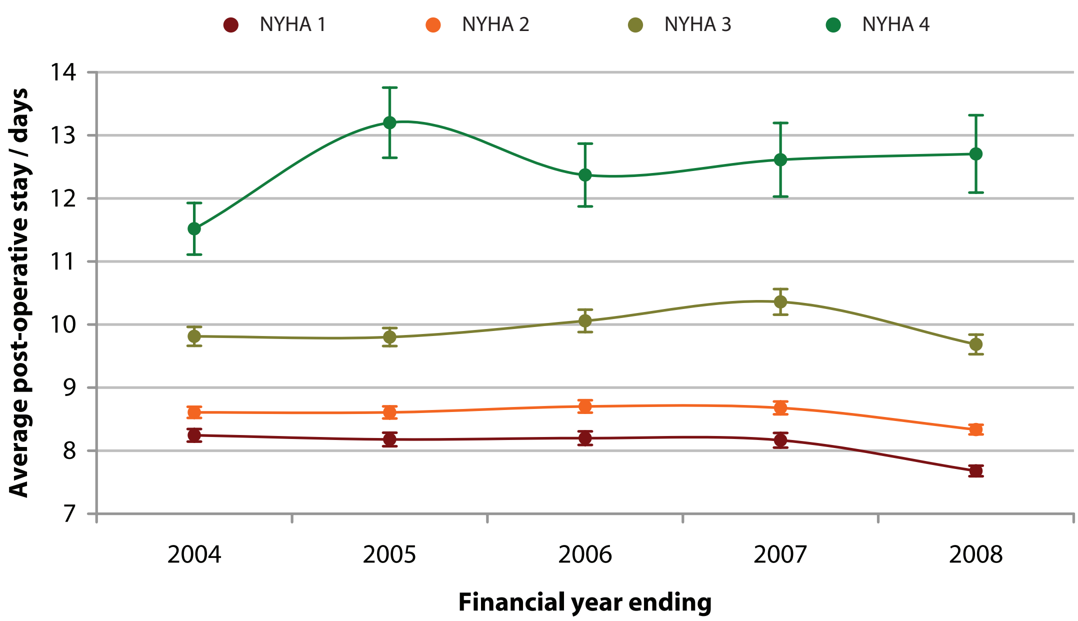
Post-operative stay and dyspnoea

On average, those who are the most breathless before surgery tend to spend an additional 4 days in hospital after their operation.

Post-operative stay, dyspnoea and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

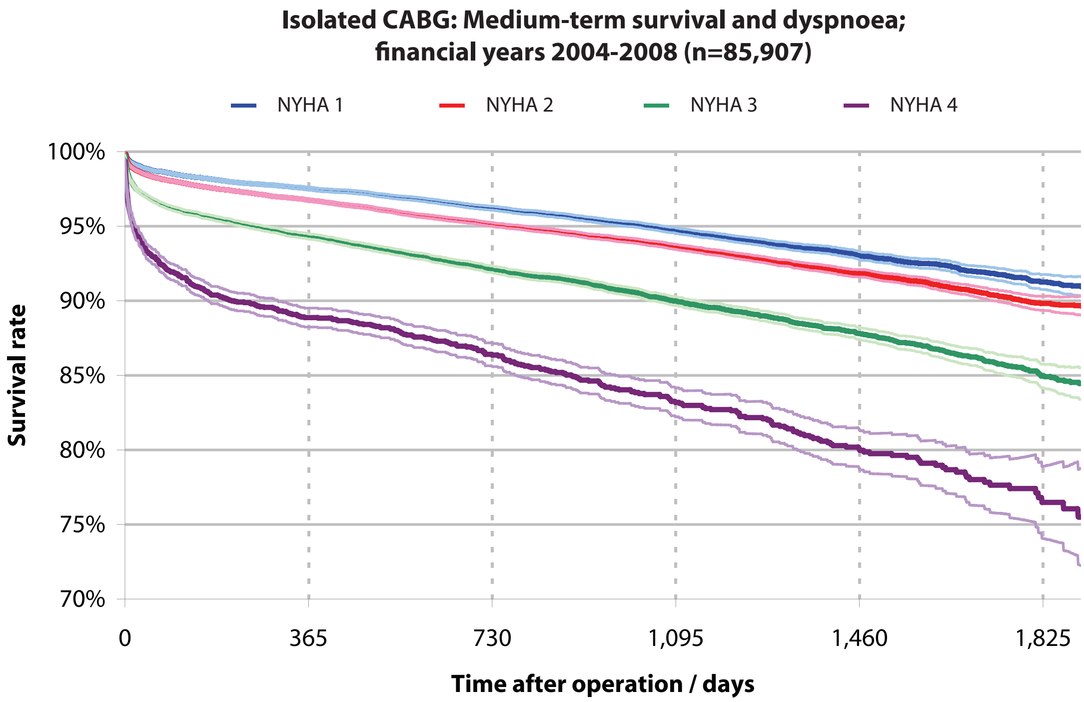
		Financial year				
		2004	2004	2006	2007	2008
Dyspnoea	NYHA 1	8.2 6,849	8.2 6,791	8.2 6,021	8.2 5,882	7.7 6,579
	NYHA 2	8.6 9,523	8.6 10,253	8.7 9,118	8.7 8,795	8.3 10,470
	NYHA 3	9.8 5,218	9.8 5,189	10.1 4,368	10.4 3,789	9.7 4,686
	NYHA 4	11.5 951	13.2 800	12.4 798	12.6 611	12.7 641
	Unspecified	8.8 747	10.1 660	9.5 299	11.3 141	10.2 136

Isolated CABG: Post-operative stay and dyspnoea; bars denote standard errors (n=107,332)



Survival and dyspnoea

Medium-term survival is strongly associated with increasing symptoms of dyspnoea. For those with class 4 symptoms the survival rate is only 75% at 5 years.

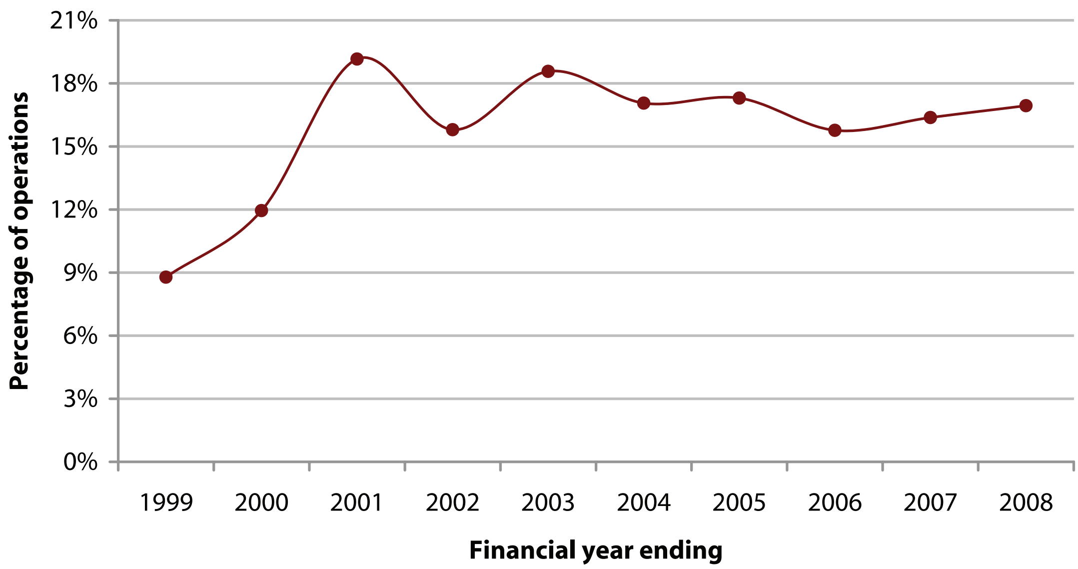


Protecting the heart during coronary surgery

There are really two distinctly different techniques used for coronary artery bypass surgery. The traditional way is to isolate the heart from the rest of the circulation and to support the rest of the body using cardiopulmonary bypass. The heart can then be protected whilst it receives no blood flow using cardioplegia solutions or a technique called cross-clamp fibrillation, and this gives a still and blood-less field on which to construct the bypass grafts. The other technique is to avoid cardiopulmonary bypass and use an *off-pump* technique in which the coronary artery is stabilised using a special device and surgery is undertaken on the beating heart. Advocates of off-pump surgery feel that benefits are derived from avoiding cardiopulmonary bypass; critics feel that the quality of the anastomoses may suffer and manipulation of the beating heart during surgery may lead to haemodynamic compromise, which may affect other organs of the body. Randomised studies comparing the techniques have shown that both are safe, and no real differences in outcomes have been seen. Some work from registry data has suggested that there may be some benefits from off-pump surgery in higher-risk patients.

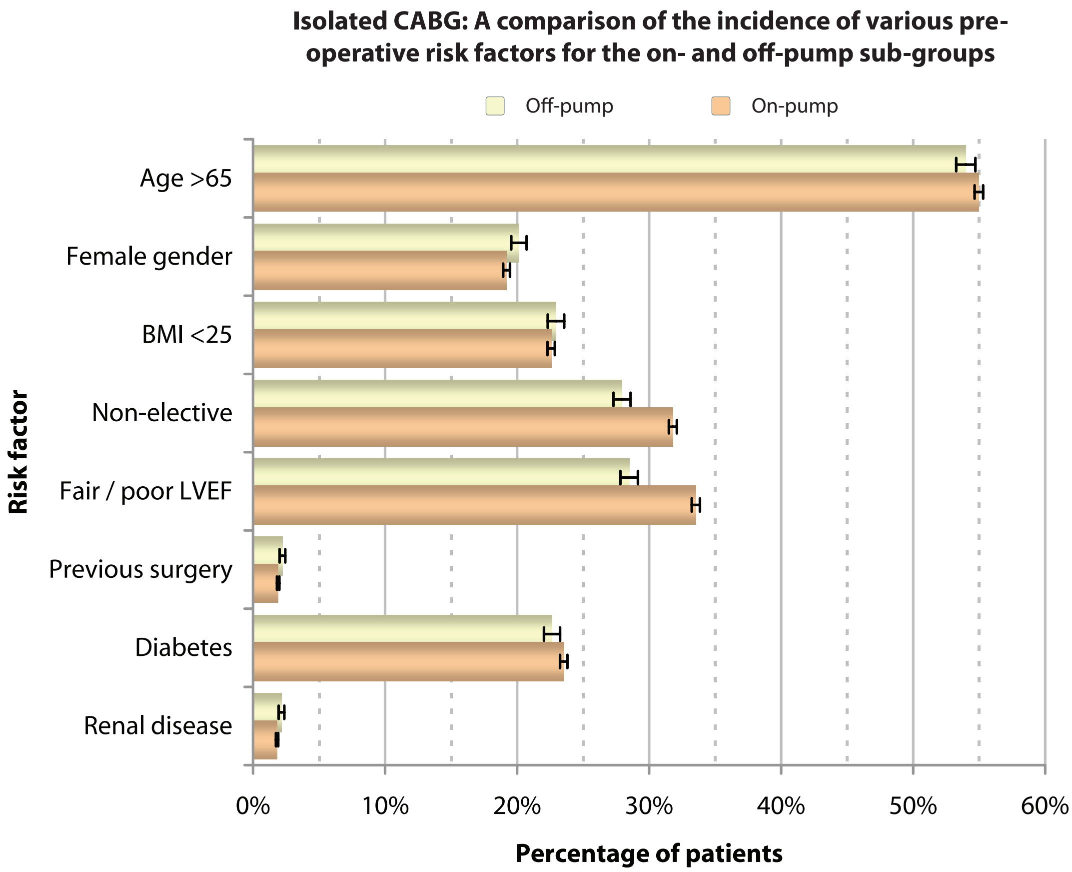
There was an increase in the proportion of patients undergoing off-pump surgery between 1999 and 2001. This increase has stabilised and over the last few years and in 2008 17% of patients had their coronary surgery performed off-pump. There is a major variation between surgeons; we know that some do almost all their cases *off-pump* and others do none.

Isolated CABG: Off-pump coronary surgery (n=208,166)



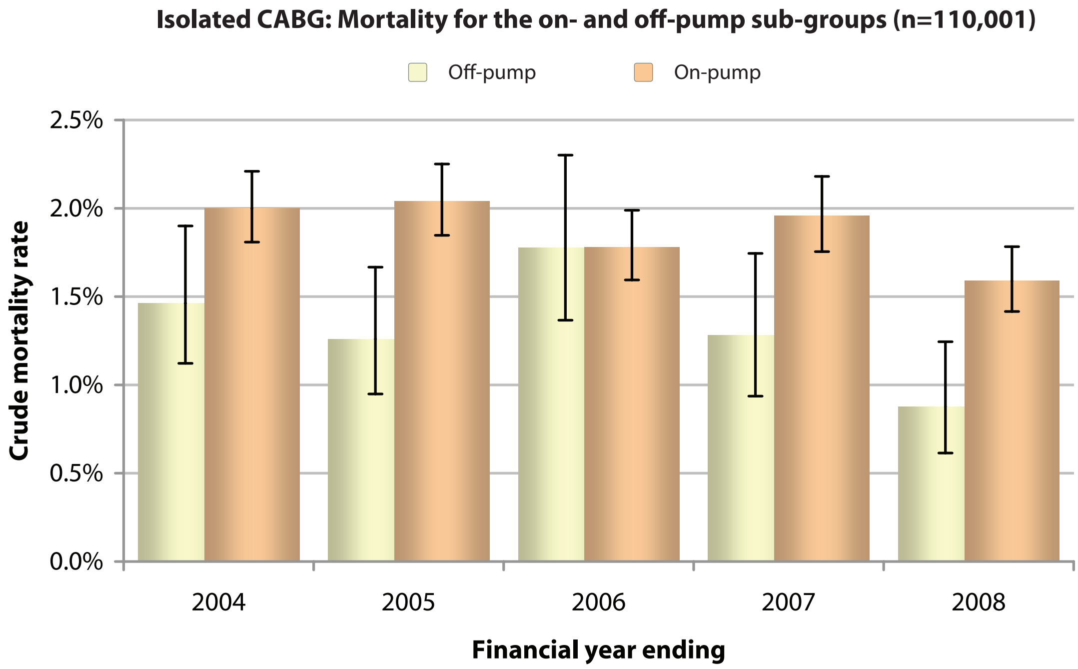
Risk factors and protection technique employed

The patient populations undergoing on-pump and off-pump surgery have some significant differences on univariate analysis. On-pump patients are more likely to be non-elective and have fair / poor left ventricular function, and both of these risk factors are known to be associated with worse in-hospital and medium-term survival rates (χ^2 on age >65, p=0.015; gender p=0.003). Conversely the off-pump patients are also more likely to have had previous surgery and have renal disease (χ^2 on previous surgery, p=0.005; renal disease, p=0.004), which are associated with higher mortality rates. We have adjusted for these factors in the analysis on page 120.



Mortality and protection technique

Overall the mortality for patients undergoing off-pump surgery is lower than those having surgery on-pump. This difference is significant. Because of the difference in risk factors between the groups shown above, we have adjusted for these differences in the analysis on page 120.



Survival and protection technique

This is an interesting graph. The early survival rate of the off-pump group is slightly better than for the on-pump group, but the lines cross over, with the medium-term survival being lower for the on-pump group 2 years after surgery. However, these differences are small, and do not display any statistical significance.

Isolated CABG: Medium-term survival and protection technique; financial years 2004-2008 (n=86,047)

On-pump *versus* off-pump surgery: regression modelling

Off-pump surgery is performed on a different patient population to conventional *on-pump* surgery as shown on page 117 and, overall, the in-hospital mortality rate is lower in the off-pump group. This may be because the patients undergoing off-pump surgery are lower risk or because the technique is safer. The available literature on this subject contains randomised studies and analysis of registries, and is not conclusive (see page 161). To analyse this in more detail we performed logistic regression modelling to adjust for differing casemix. We looked at all patients undergoing isolated coronary artery bypass surgery between April 2004 and March 2008 and inserted the following risk factors into the model:

- age (as a continuous variable)
- gender
- operative urgency (elective, urgent, emergency, salvage)
- previous cardiac surgery (no or yes)
- angina (0 to IV)
- dyspnoea (I to IV)
- diabetes (no or yes)
- hypertension (no or yes)
- previous MI (no or yes)
- renal disease (no or yes)
- pulmonary disease (no or yes)
- extra-cardiac arteriopathy (no or yes)
- ejection fraction (good, moderate, poor)
- heart rhythm (sinus rhythm or other)
- iv inotropes prior to anaesthetic (no or yes)
- ventilated pre-operatively (no or yes)
- cardiogenic shock pre-operatively (no or yes)
- BMI (<21, 21-25, 26-30, 31-35, >35 [i])

In addition we added the variable on-pump / off-pump surgery to the model and used in-hospital mortality as the outcome of interest. We ran 2 models:

- **Model 1:** we retained all risk factors in the model, even if they did not reach statistical significance (Harrell 2001). We included only patient-entries where all the above data fields were complete (*i.e.*, we have excluded any patient-entries with missing risk factor data).
- **Model 2:** we ran a model in which we removed non-significant variables using successive backwards elimination, to retain only variables with t-ratios greater than 3, again including only patients for whom all fields were complete.

The model parameters (*coefficients*) are given in the tables along with their uncertainties (standard deviations), and the odds ratios and their ranges, and the odds ratios are also shown graphically.

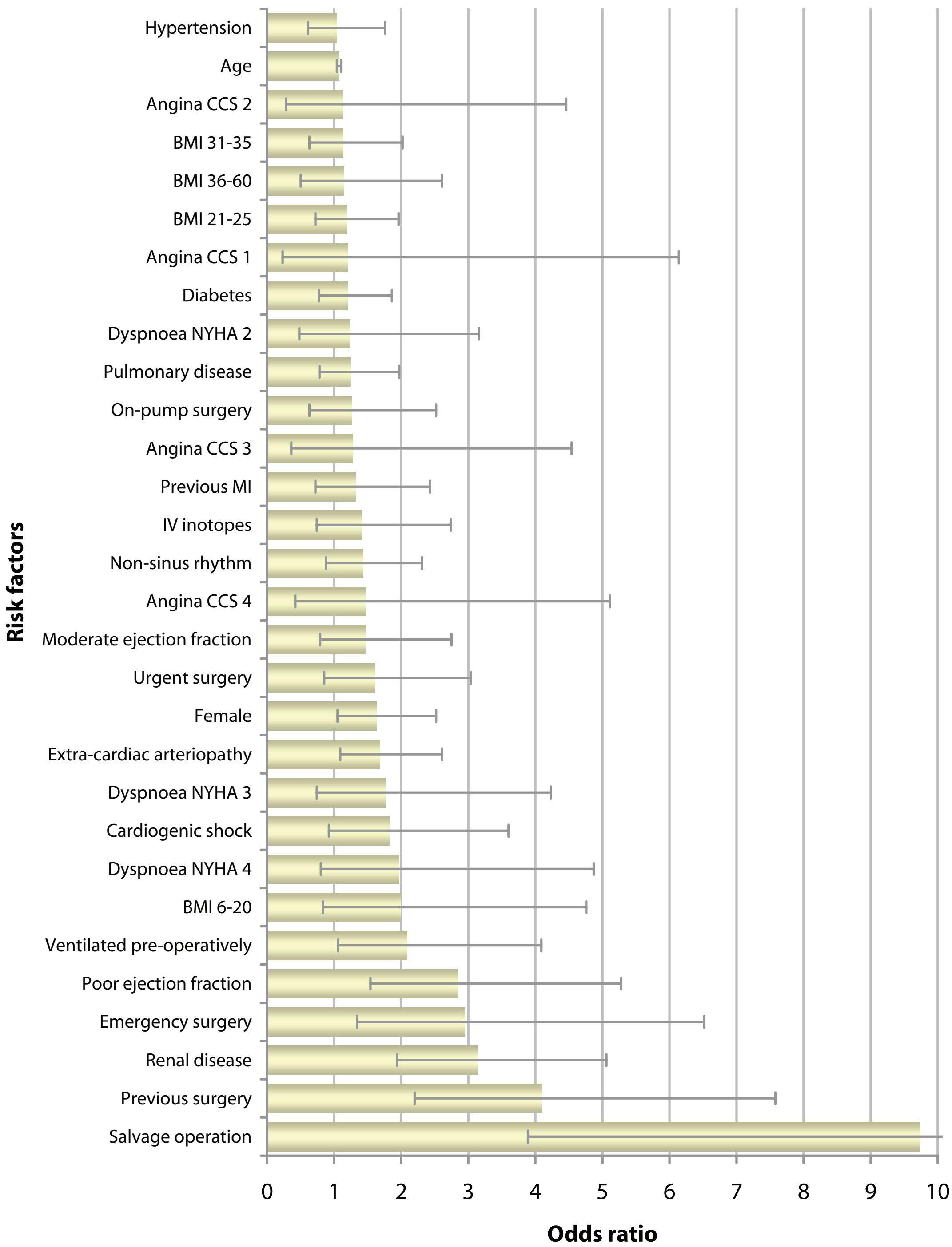
In the first model, the odds ratio of in-hospital mortality for on-pump surgery is 1.26, but the 95% confidence interval is from 0.63 to 2.52, and because the confidence intervals overlap 1 this finding is not statistically significant. So, in summary, whilst the odds ratio for in-hospital mortality in patients undergoing on-pump surgery is higher than 1 (after adjusting for all other risk factors), indicating it carries more risk than off-pump surgery, there is not sufficient evidence to state that this is a significant effect, using this logistic regression model.

i Patients with BMI <6 and BMI >60 were excluded.

Model 1. Model coefficients, standard deviations and odds ratios for risk factors for in-hospital mortality for patients undergoing isolated CABG surgery (n=69,206)

Risk factors		Coefficient	Standard deviation	Odds ratio	95% CI	
					Lower	Upper
Constant		-6.30	0.88			
On-pump	Yes	0.23	0.35	1.26	0.63	2.52
Age	Continuous	0.06	0.01	1.07	1.04	1.10
Gender	Female	0.49	0.22	1.63	1.05	2.52
Operative urgency	Urgent	0.47	0.33	1.60	0.85	3.04
	Emergency	1.08	0.40	2.95	1.34	6.52
	Salvage	2.28	0.47	9.74	3.89	24.38
Previous surgery	Yes	1.41	0.32	4.09	2.20	7.58
Angina	CCS 1	0.18	0.83	1.20	0.23	6.14
	CCS 2	0.11	0.70	1.12	0.28	4.46
	CCS 3	0.25	0.64	1.28	0.36	4.54
	CCS 4	0.39	0.64	1.47	0.42	5.11
Dyspnoea	NYHA 2	0.20	0.48	1.23	0.48	3.16
	NYHA 3	0.57	0.45	1.76	0.74	4.23
	NYHA 4	0.68	0.46	1.97	0.80	4.87
Diabetes	Yes	0.18	0.23	1.20	0.77	1.86
Hypertension	Yes	0.04	0.27	1.04	0.61	1.76
Previous MI	Yes	0.28	0.31	1.32	0.72	2.43
Renal disease	Yes	1.14	0.24	3.13	1.94	5.06
Pulmonary disease	Yes	0.21	0.24	1.24	0.78	1.97
Extra-cardiac arteriopathy	Yes	0.52	0.22	1.68	1.09	2.61
Ejection fraction	Fair	0.39	0.32	1.47	0.79	2.75
	Poor	1.05	0.32	2.85	1.54	5.28
Heart rhythm	Non-sinus	0.36	0.24	1.43	0.88	2.31
IV inotropes	Yes	0.35	0.33	1.42	0.74	2.74
Ventilated	Yes	0.73	0.34	2.09	1.06	4.09
Cardiogenic shock	Yes	0.60	0.35	1.82	0.92	3.60
BMI	6-20	0.69	0.44	1.99	0.83	4.76
	21-25	0.17	0.25	1.19	0.72	1.96
	31-35	0.12	0.30	1.13	0.63	2.02
	36-60	0.13	0.42	1.14	0.50	2.61

Isolated CABG: Odds ratios for coefficients in regression model 1; all risk factors retained; financial years 2004-2008 (n=69,206)



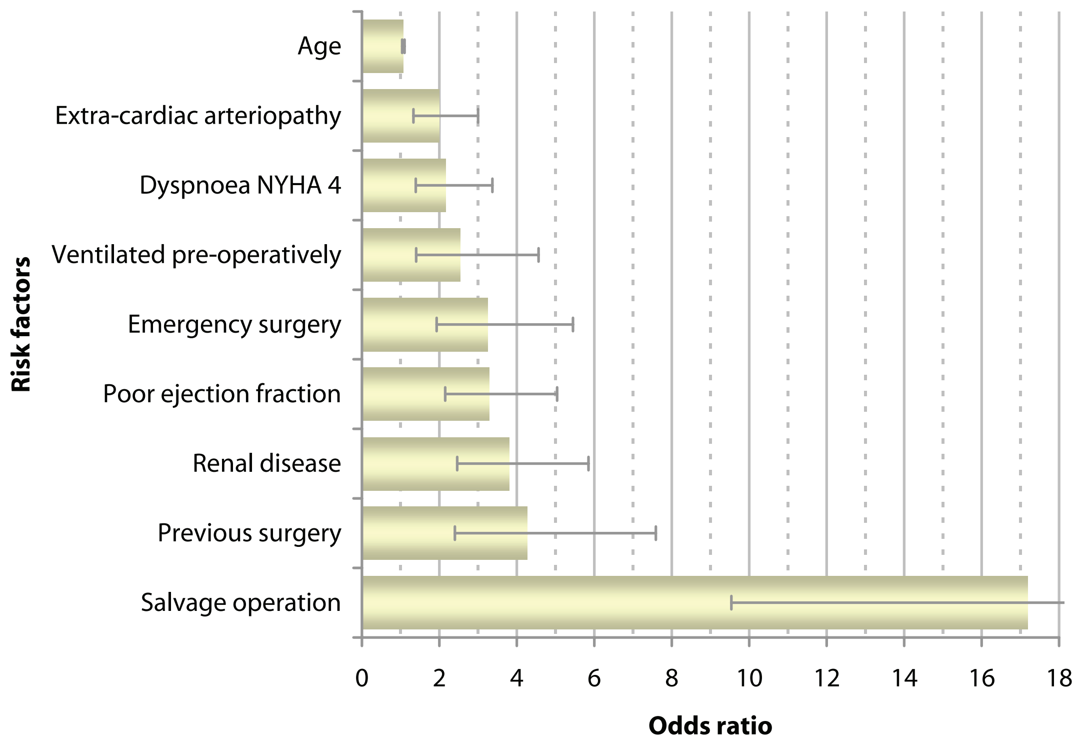
In second our model *on-pump* surgery was eliminated from the model, again giving indication that there is no evidence that on-pump surgery is associated with a high mortality. The significant variables left in the model are shown in the second table (the total number of patients remaining in the reduced model was higher than in the first model because, with a smaller number of risk factors, the total number of patients with complete risk factors was higher: n=78,741).

To explore these issues further would require a propensity-matched analysis, but it is still possible for this to be subject to bias from decision-making and selection factors that are not included in the SCTS database, such as quality of the target vessels. A definitive answer to whether on- or off-pump surgery is safer will only come from randomised clinical trial data.

Model 2. Model coefficients, standard deviations and odds ratios for risk factors for in-hospital mortality for a *reduced* on-pump model for patients undergoing isolated CABG surgery (n=78,741).

Risk factors		Coefficient	Standard deviation	Odds ratio	95% CI	
					Lower	Upper
Constant		-4.88	0.27			
Age	Continuous	0.07	0.01	1.07	1.04	1.10
Operative urgency	Emergency	1.18	0.27	3.24	1.93	5.45
	Salvage	2.84	0.30	17.19	9.54	30.99
Previous surgery	Yes	1.45	0.29	4.27	2.40	7.59
Dyspnoea	NYHA 4	0.77	0.23	2.16	1.39	3.37
Renal disease	Yes	1.33	0.22	3.80	2.46	5.85
Extra-cardiac arteriopathy	Yes	0.69	0.21	1.99	1.33	3.00
Ejection fraction	Poor	1.19	0.22	3.29	2.15	5.04
Ventilated	Yes	0.93	0.30	2.53	1.40	4.56

Isolated CABG: Odds ratios for coefficients in regression model 2; significant risk factors retained; financial years 2004-2008 (n=78,741)



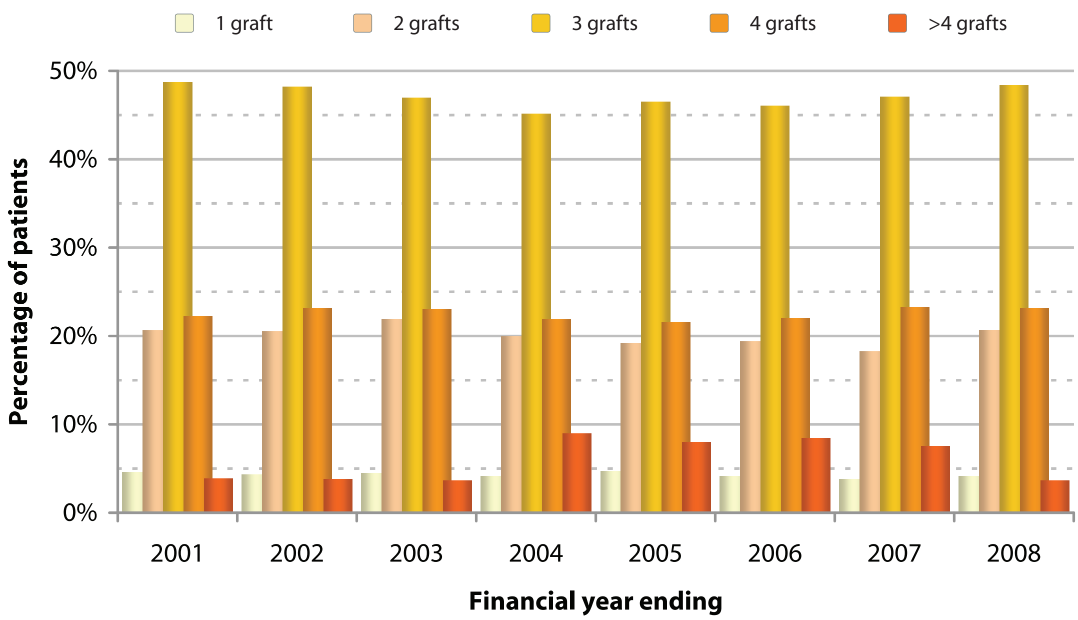
Aspects of coronary surgery practice

Number of bypass grafts

Key points from bypass graft analyses

- Just under 50% of patients receive 3 bypass grafts
- Just under 5% of patients receive only one bypass graft
- There has been no real change in the number of bypass grafts over time

Isolated CABG: Number of grafts used in isolated first-time CABG (n=163,417)



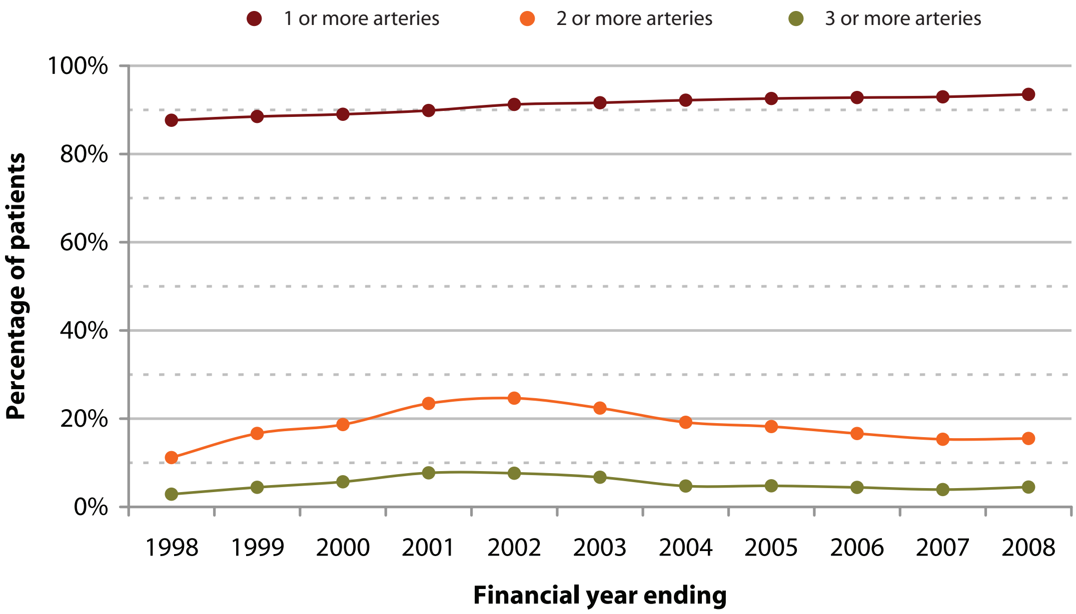
Arterial grafting

Use of the left internal mammary artery (LIMA) graft is known to be associated with better outcomes for patients, including better long-term survival and freedom from recurrent angina. The number of patients getting at least one arterial graft has increased year-on-year, and now stands at nearly 95%. Because of various factors including occlusive vascular disease it is unrealistic to expect that this will ever reach 100%.

Use of more than one arterial graft remains a little controversial; some enthusiasts believe that the better freedom from graft disease for arterial grafts means they should be used almost routinely, others believe that use of more than one arterial graft only adds small, if any, incremental benefit and does not justify the additional surgery and potential risk. Many surgeons just select the use of multiple arterial grafts for specific patients, including those at low risk or those who do not have satisfactory venous conduits.

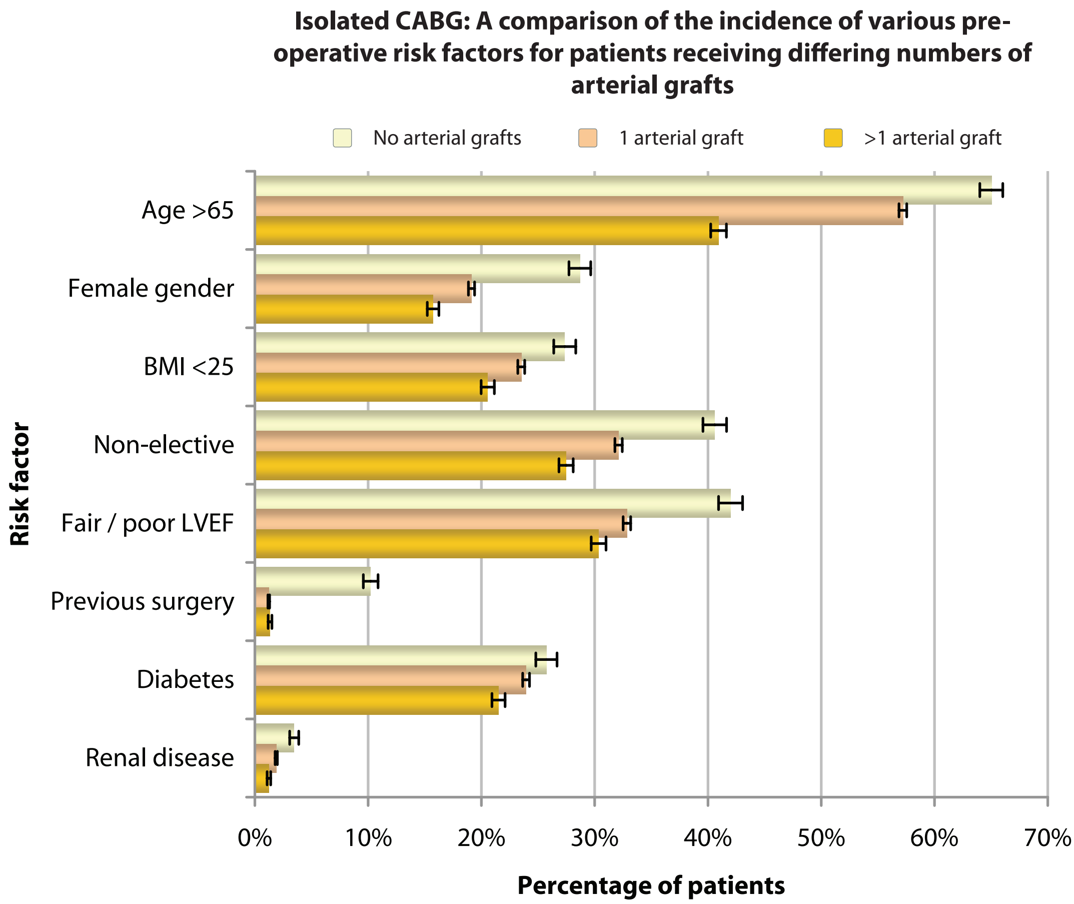
Whilst there has been a relentless increase in the proportion of patients who have one arterial graft, this has not been mirrored over time for multiple graft, which peaked in 2002 and has since levelled out with about 15% of patients receiving two and 5% getting three or more arterial grafts.

Isolated CABG: Arterial graft usage in first-time, isolated CABG procedures (n=195,671)



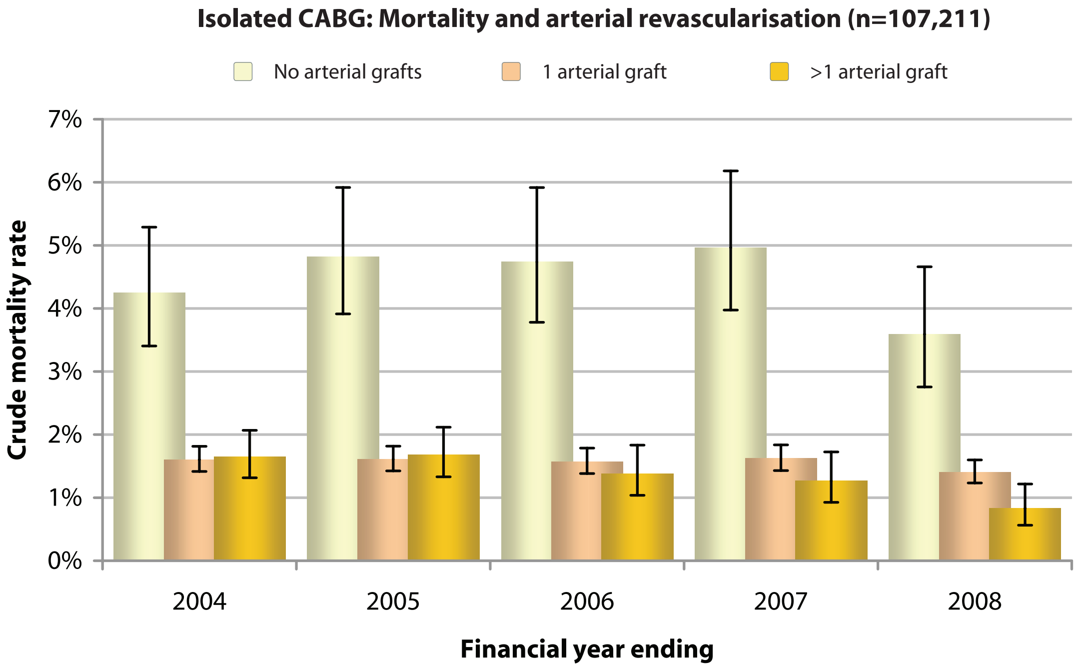
Risk factors and arterial grafting

There are marked differences between patients who have 0, 1 and more than 1 arterial grafts. The patients who receive no arterial grafts are older, more likely to be female, overweight, undergoing non-elective surgery have impaired left ventricular function, be undergoing redo surgery, diabetic and have renal disease. All of these factors are associated with increased in-hospital mortality and worse medium-term survival. The mortality graphs shown on page 127 therefore need to be interpreted with great caution. Similarly, patients with multiple arterial grafts are a very different population from those have a single arterial graft, with an overall much lower risk profile.



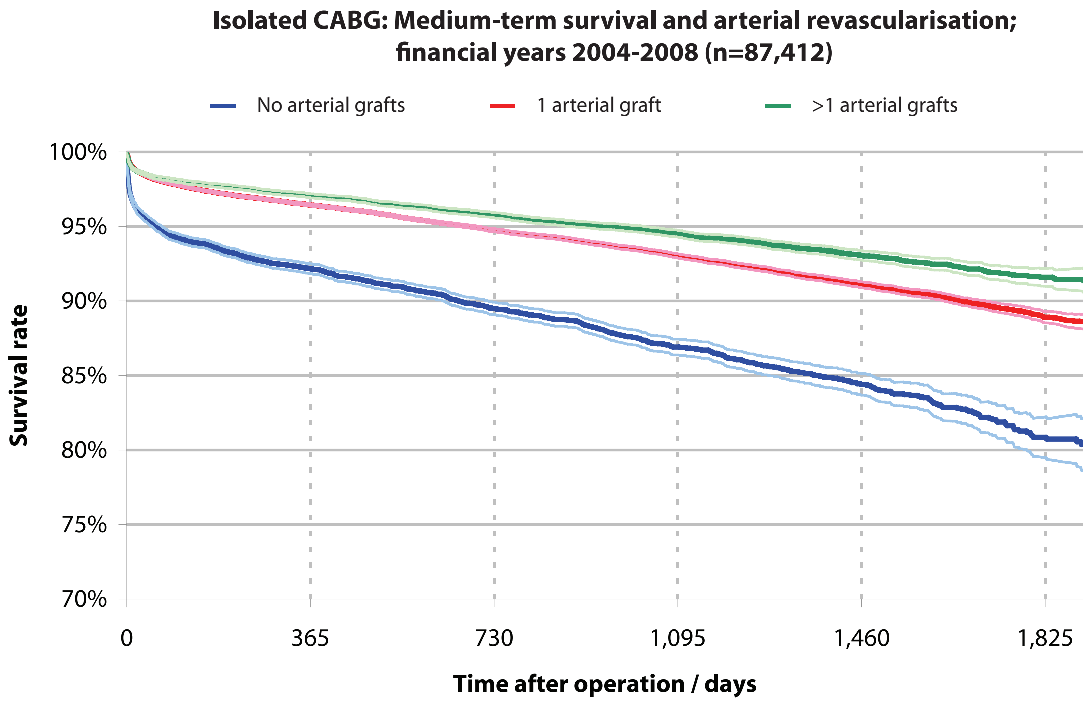
Mortality and arterial revascularisation

In line with the highest incidence of risk factors seen in the group of patients who have no arterial grafts, the mortality for these patients is higher than for those receiving one or more arterial grafts. There is no difference in operative mortality rates between patients receiving one and more than one arterial graft, despite the multiple arterial graft group having a generally lower incidence of important risk factors.



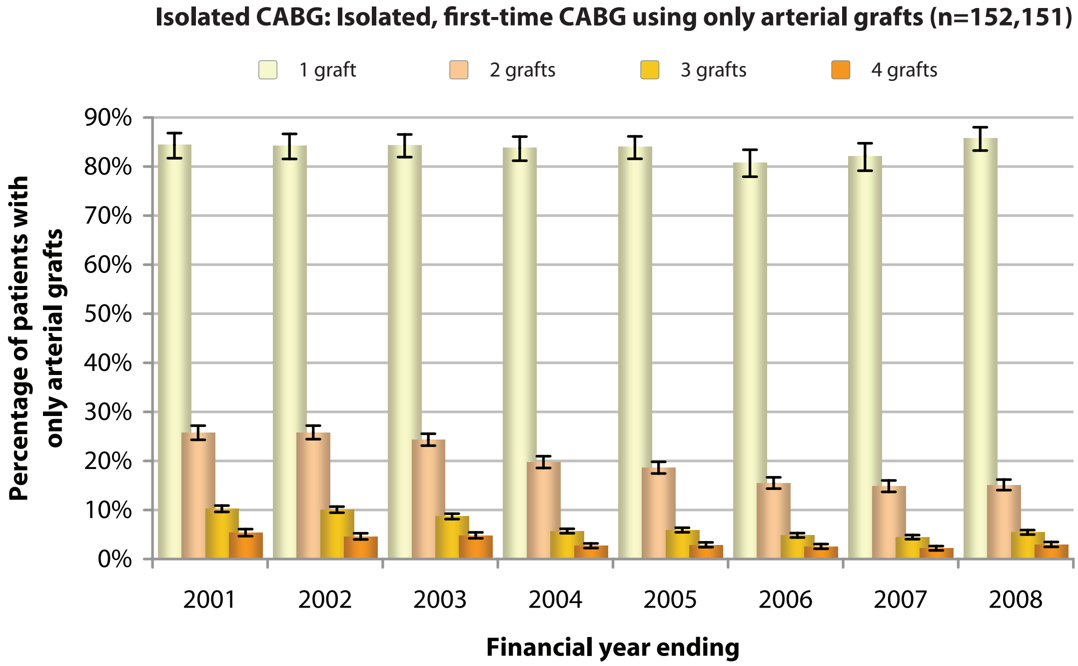
Survival and arterial revascularisation

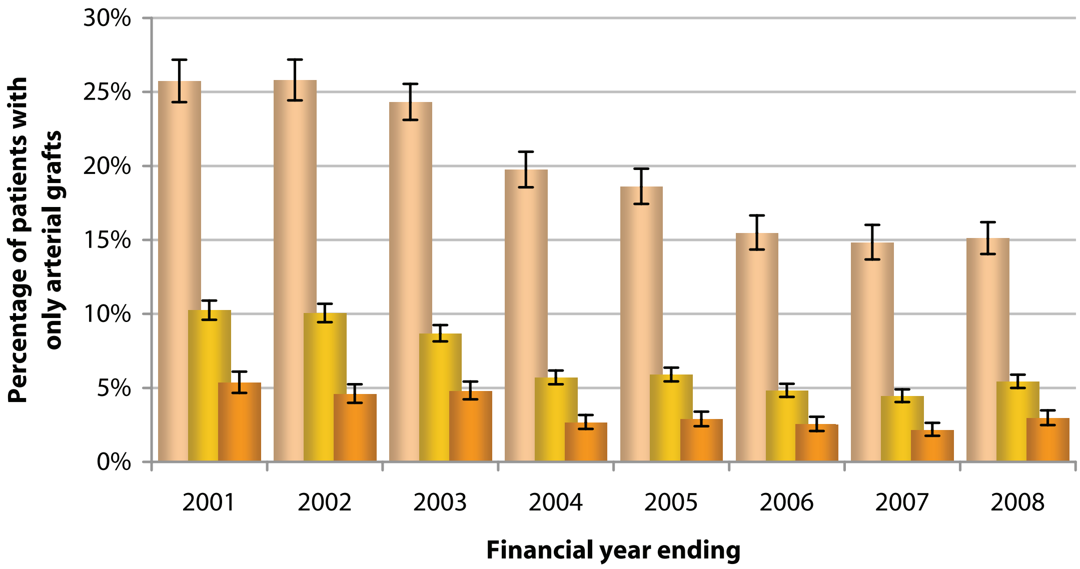
There is a marked difference in medium-term survival between patients with no arterial grafts, one and more than one. However, as described above, these patient populations are very different.



Total arterial revascularisation

The overall proportion of patients undergoing surgery between 2004 and 2008 who have undergone total arterial revascularisation is 10%. Of these patients 85% received just one arterial graft.





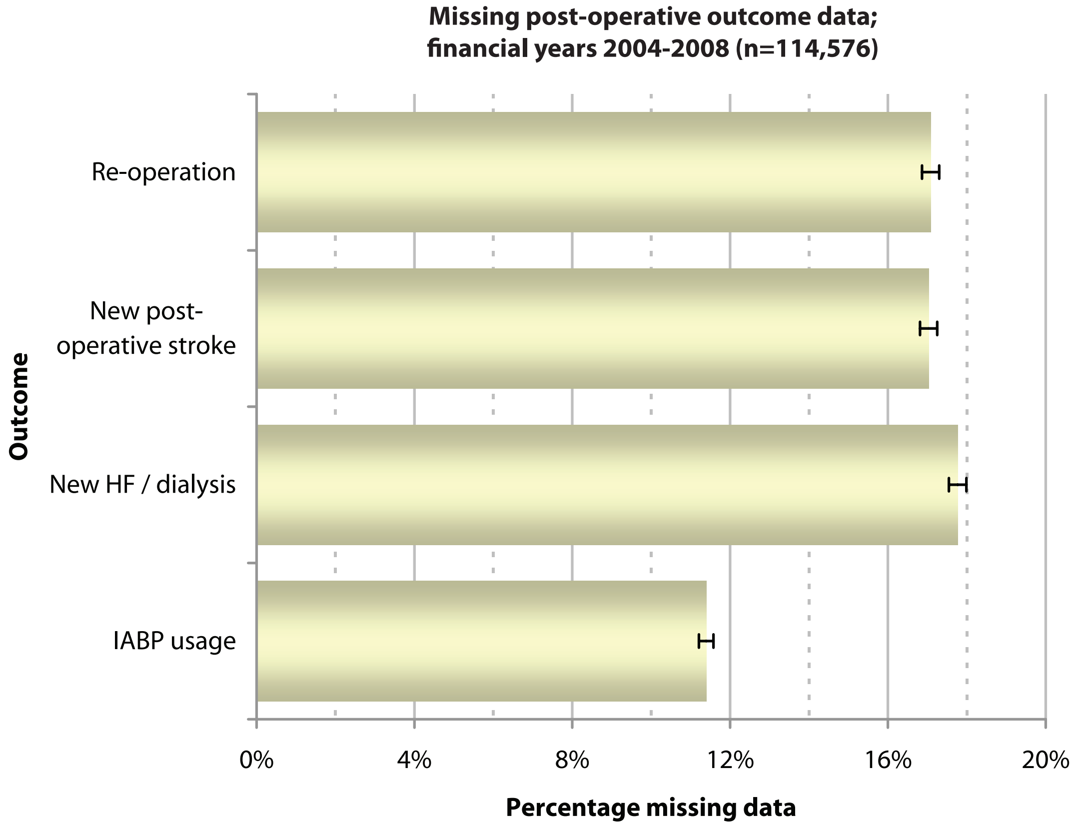
Other post-operative outcomes

The SCTS database contains a number of fields that enable post-operative outcomes to be recorded. In the previous section we have looked at each risk factor and have analysed the outcomes of in-hospital mortality, post-operative length-of-stay and medium-term survival in relationship to those variables. The database also has fields for re-operation, new post-operative stroke, new post-operative haemodialysis or filtration post-operatively and post-operative intra-aortic balloon pump insertion. As shown on page 39, the incidence of missing data for the pre-operative variables is generally very low, and most units have also been diligent in collecting accurate post-operative mortality and length-of-stay data, but the other post-operative morbidity fields are less complete.

Interpreting databases when there is such a high incidence of missing data, can be potentially misleading.

Missing post-operative outcome data in the data acquired since the publication of the last report

		Financial year					
		2004	2005	2006	2007	2008	**Total**
Outcome	Overall counts	24,431	24,536	22,251	20,512	22,846	**114,576**
	Re-operation	23.8%	17.1%	14.4%	15.1%	14.2%	**17.1%**
	New post-operative stroke	25.0%	22.1%	17.3%	12.5%	6.8%	**17.0%**
	New HF / dialysis	25.7%	21.0%	18.3%	13.0%	9.6%	**17.8%**
	IABP	14.4%	13.5%	11.0%	9.5%	7.9%	**11.4%**



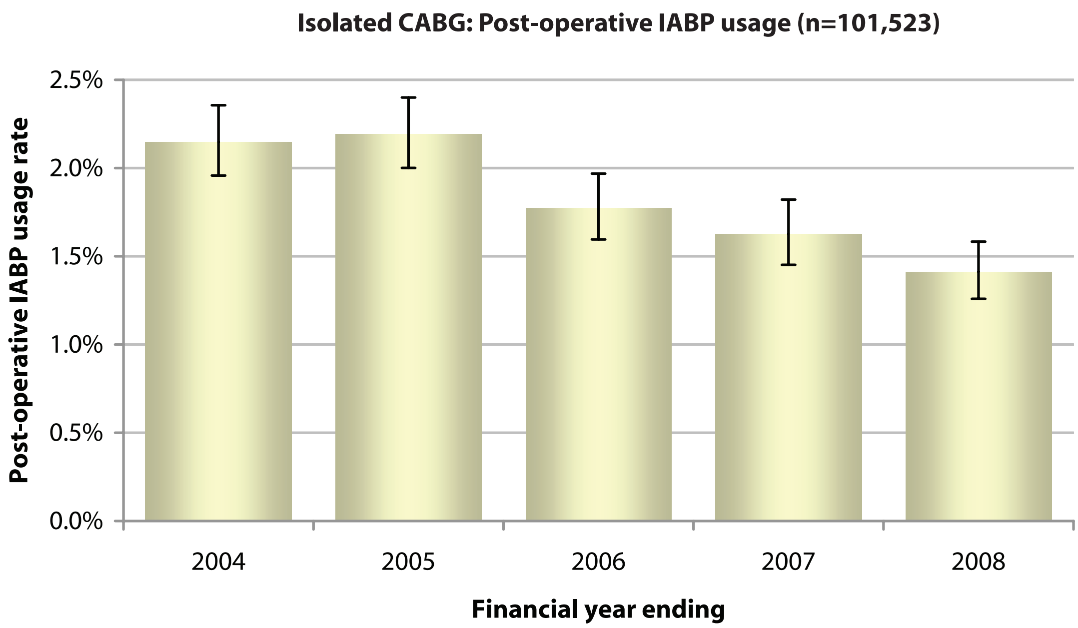
Post-operative intra-aortic balloon pump

Post-operative IABP distribution

There has been a year-on-year decrease in the proportion of patients who receive post-operative intra-aortic balloon pump (IABP) insertion from 2.2% in 2004 down to 1.4% in 2008. This probably represents better intra-operative care and myocardial preservation, as we know the casemix has become more complex over time.

Post-operative IABP distributions over time

		Financial year				
		2004	2005	2006	2007	2008
Post-op IABP	No	20,455	20,752	19,449	18,266	20,737
	Yes	449	465	351	302	297
	Unspecified	3,527	3,319	2,451	1,944	1,812
	All	**24,431**	**24,536**	**22,251**	**20,512**	**22,846**



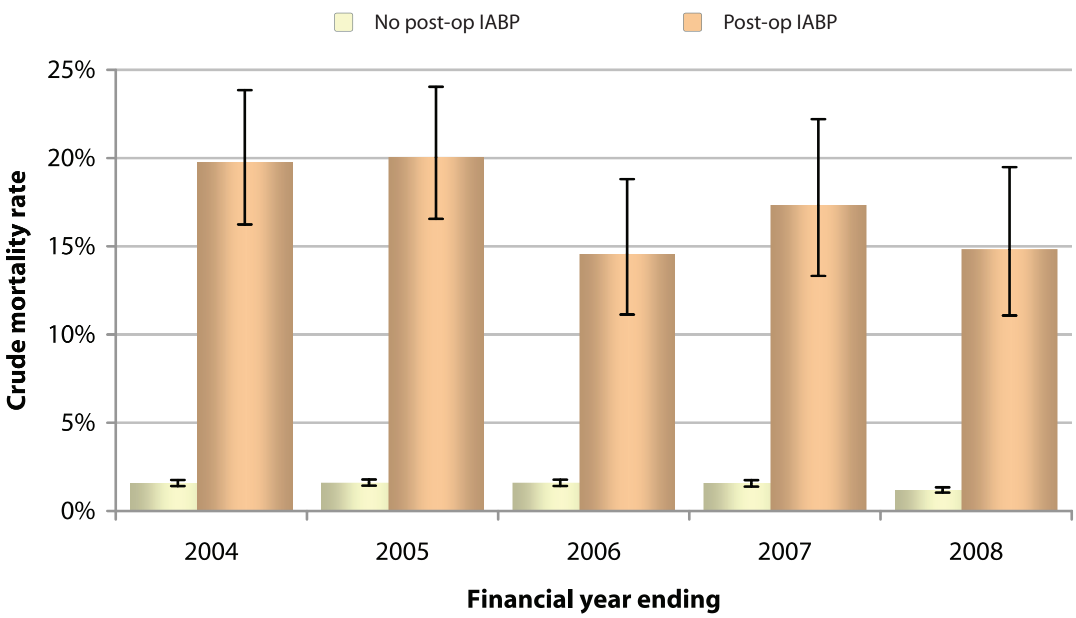
Mortality and post-operative IABP

The overall in-hospital mortality rate for patients who require a post-operative IABP is 17.7% and for those who do not it is 1.5%. Of interest, the mortality rate for patients in whom the balloon pump status was not specified is 1.8%, very close to those in whom we know an IABP was not inserted, suggesting that when IABP insertion is unspecified is almost certainly reflects the fact that a balloon was not used.

Mortality, post-operative IABP and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	All
Post-operative IABP	No	1.6% 20,432	1.6% 20,741	1.6% 19,392	1.6% 18,200	1.2% 20,706	**1.5%** **99,471**
	Yes	19.8% 445	20.0% 464	14.6% 350	17.3% 300	14.8% 297	**17.7%** **1,856**
	Unspecified	1.6% 3,504	1.5% 3,318	1.7% 2,449	2.1% 1,897	2.6% 1,805	**1.8%** **12,973**
	All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**

Isolated CABG: Crude mortality and post-operative IABP (n=101,327)



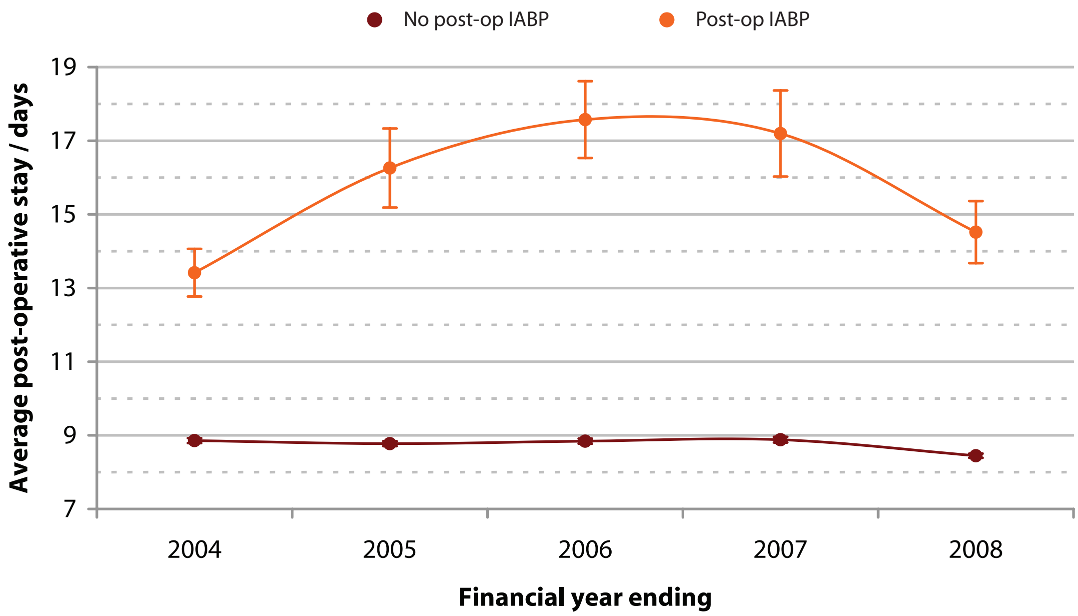
Post-operative stay and post-operative IABP usage

Insertion of a post-operative IABP was associated with a consistently and significantly greater length of post-operative stay.

Post-operative stay, post-operative IABP and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

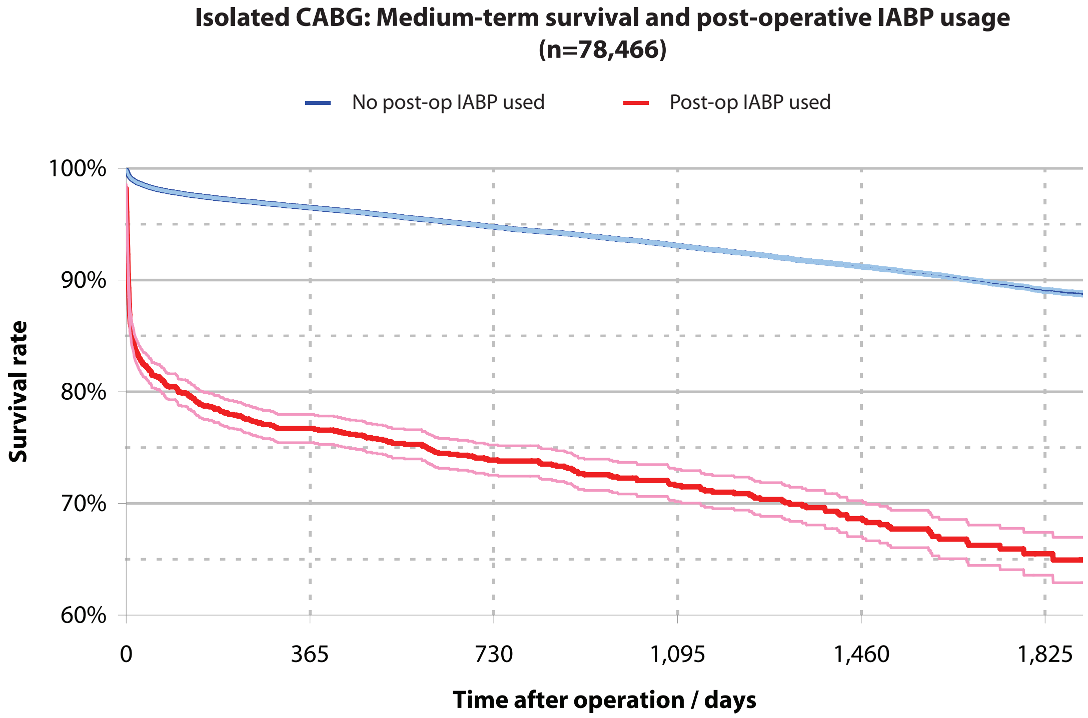
		Financial year				
		2004	2004	2006	2007	2008
Post-op IABP	No	8.9 19,945	8.8 20,611	8.8 18,425	8.9 17,572	8.4 20,692
	Yes	13.4 442	16.3 459	17.6 343	17.2 296	14.5 297
	Unspecified	8.5 2,901	9.0 2,623	8.9 1,836	8.7 1,350	8.9 1,523

Isolated CABG: Post-operative stay and post-operative IABP; bars denote standard errors (n=99,082)



Survival and post-operative IABP usage

Not surprisingly use of a post-operative IABP was associated with a significantly worse medium-term survival rate. Much of this is due to the high early mortality, but the two survival curves continue to diverge, probably reflecting the underlying poorer left ventricular function in this group.



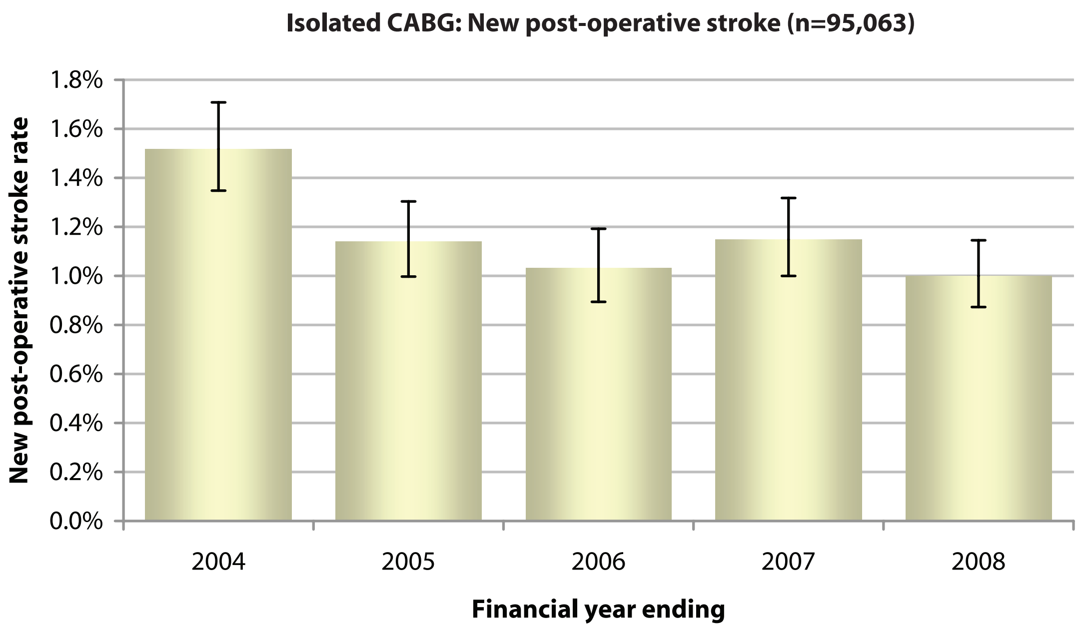
New post-operative stroke

New post-operative stroke distribution

There has been a significant decrease in the incidence of missing data on post-operative stroke in the database from 34% in 2004 to 7.4% in 2008. Despite this decrease in missing data, the incidence of reported stroke has decreased from 1.5% to 1.0% over the same time-period. This decrease is statistically significant (χ^2 analysis of trends $p<0.001$).

New post-operative stroke distributions over time

		Financial year				
		2004	2005	2006	2007	2008
New stroke	No	18,039	18,896	18,206	17,734	21,083
	Yes	278	218	190	206	213
	Unspecified	6,114	5,422	3,855	2,572	1,550
	All	**24,431**	**24,536**	**22,251**	**20,512**	**22,846**



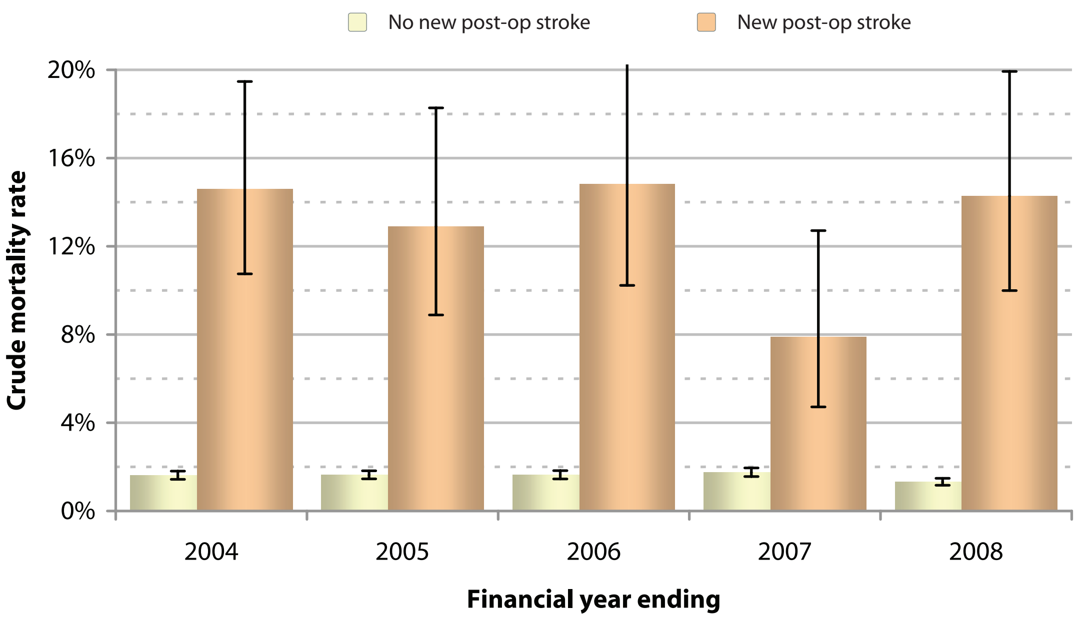
Mortality and post-operative stroke

Post-operative stroke remains one of the most feared and devastating complications after coronary artery bypass surgery and whilst the incidence is rare the consequences are severe. The overall in-hospital mortality rate for those who avoid a stroke is 1.6%, but for those who suffer one it is 13.0%. The mortality rate for those in whom post-operative stroke is unspecified is close to those in who it is recorded as *no,* at 2.2%.

Mortality, new post-operative stroke and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	**All**
New stroke	No	1.6% 18,001	1.6% 18,885	1.6% 18,149	1.7% 17,632	1.3% 21,061	**1.6%** **93,728**
	Yes	14.6% 274	12.9% 217	14.8% 189	7.9% 203	14.3% 210	**13.0%** **1,093**
	Unspecified	2.2% 6,106	2.5% 5,421	2.0% 3,853	2.0% 2,562	1.9% 1,537	**2.2%** **19,479**
	All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**

Isolated CABG: Crude mortality and new post-operative stroke (n=94,821)



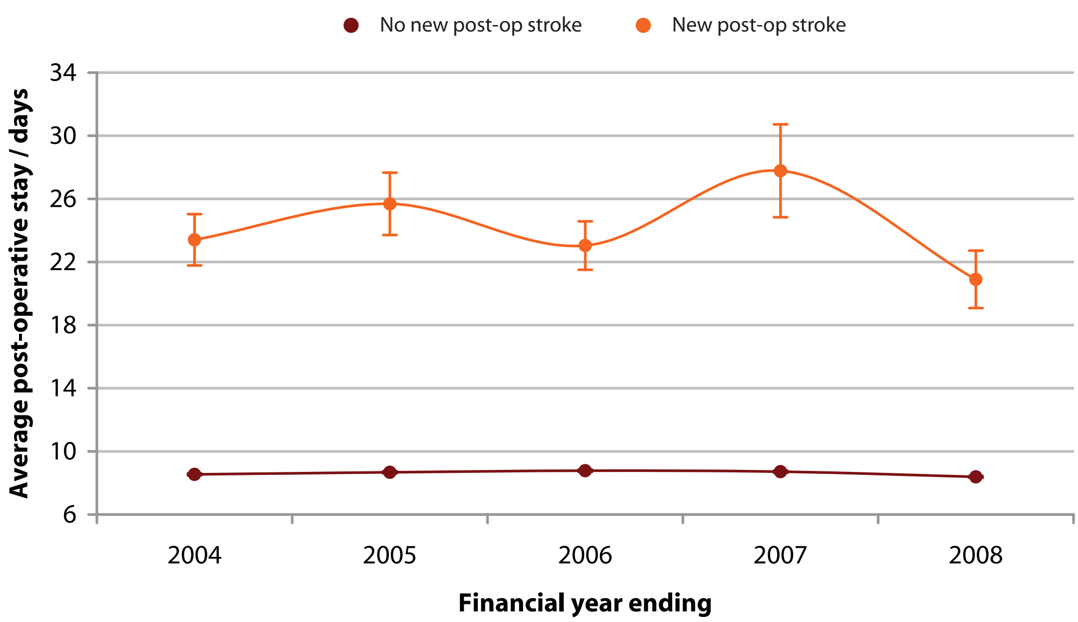
Post-operative stay and new post-operative stroke

As well as being a devastating complication with respect to in-hospital mortality, post-operative stroke is also associated with a marked increase in length-of-stay, with all the associated difficulties for patients and increase in utilisation of resources. The average length-of-stay in patients who suffered a post-operative stroke in 2008 was 21 days.

Post-operative stay, new post-operative stroke and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

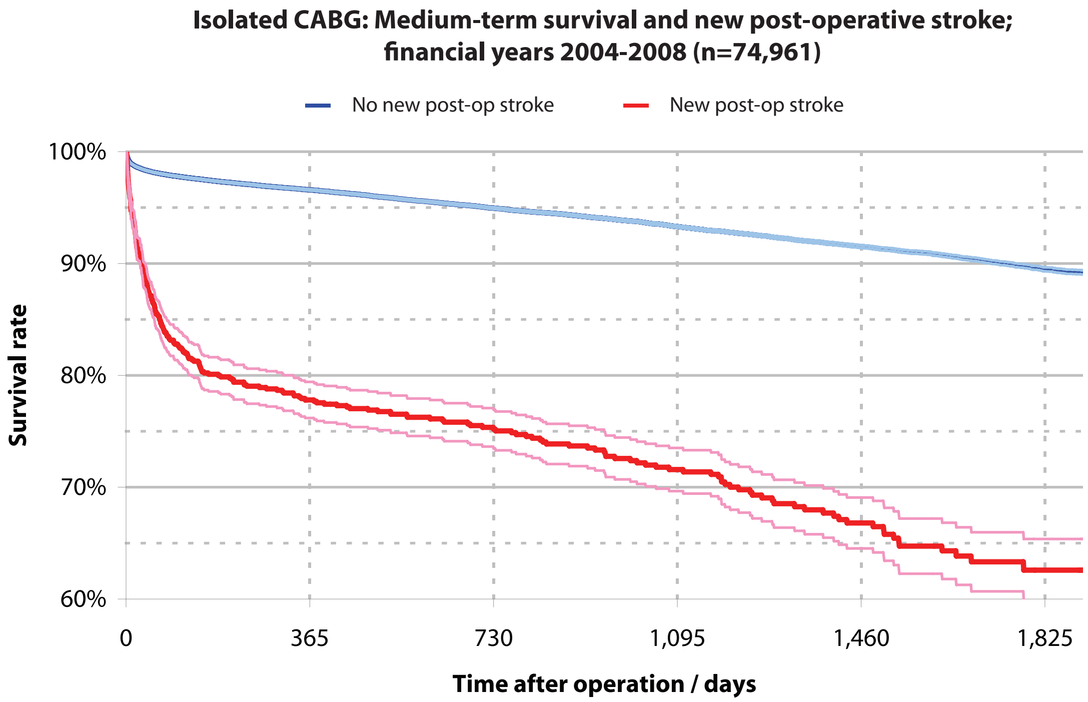
		Financial year				
		2004	2004	2006	2007	2008
New stroke	No	8.5 17,604	8.7 18,521	8.8 17,759	8.7 17,167	8.4 20,774
	Yes	23.4 271	25.7 216	23.0 185	27.8 198	20.9 210
	Unspecified	9.3 5,413	9.2 4,956	9.5 2,660	9.6 1,853	9.2 1,528

Isolated CABG: Post-operative stay and new post-operative stroke; bars denote standard errors (n=92,905)



Survival and new post-operative stroke

Patients who have a post-operative stroke have a high in-hospital mortality rate and a poor medium-term survival rate. The survival curves of those who have a stroke and those who do not, continue to diverge.



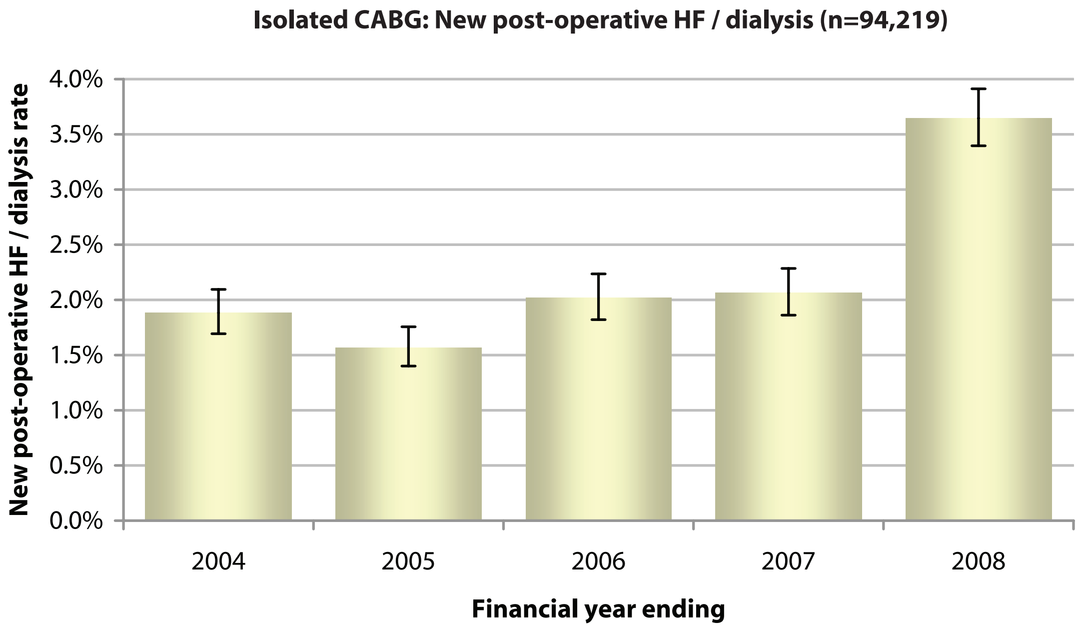
New post-operative haemofiltration / dialysis

New post-operative HF / dialysis distribution

The incidence of patients who undergo new post-operative haemofiltration (HF) / dialysis has increased over time, and in 2008 was as high as 3.6%. This probably reflects two different phenomena: the increasingly complex casemix coming to coronary artery bypass surgery and a change in clinical practice towards earlier haemofiltration of sick patients on the intensive care unit.

New post-operative HF / dialysis distributions over time

		Financial year				
		2004	2005	2006	2007	2008
New HF / dialysis	No	17,815	19,075	17,820	17,472	19,903
	Yes	342	304	367	368	753
	Unspecified	6,274	5,157	4,064	2,672	2,190
	All	**24,431**	**24,536**	**22,251**	**20,512**	**22,846**

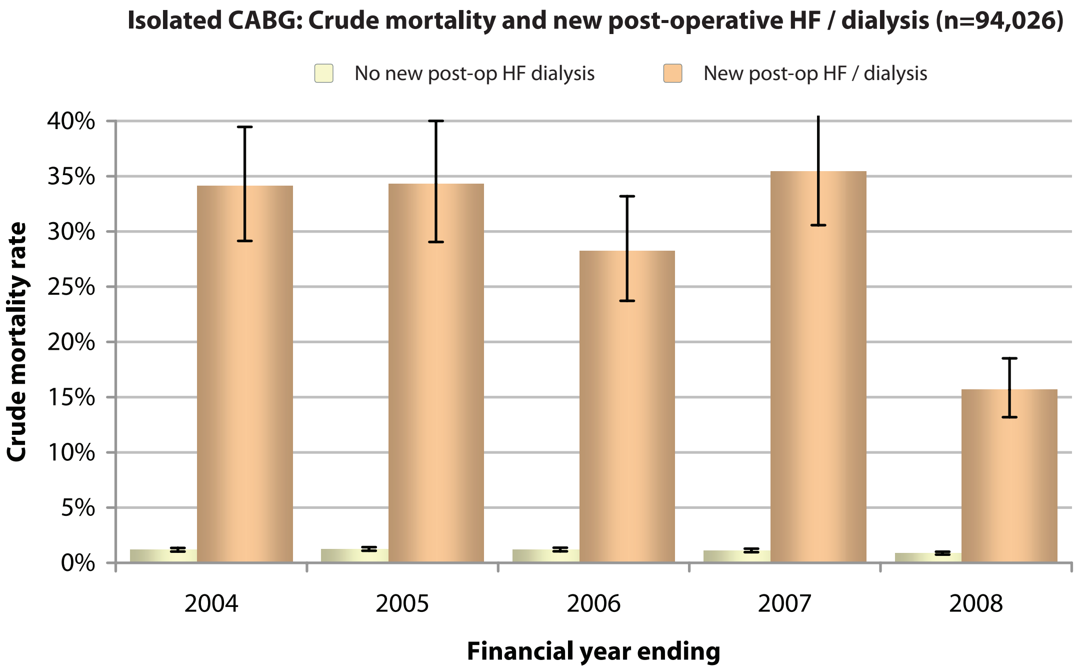


Mortality and post-operative HF dialysis

Historically, the mortality rate associated with new haemofiltration / dialysis has been high at around 30%. Associated with the increased rate of intervention seen in 2008, and probably related to a tendency towards earlier renal intervention in sick patients, the mortality rate seen in 2008 has fallen to 15%.

Mortality, new post-operative HF / dialysis and financial year; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Financial year					
		2004	2005	2006	2007	2008	**All**
New HF / dialysis	No	1.2% 17,778	1.2% 19,063	1.2% 17,764	1.1% 17,417	0.9% 19,879	**1.1%** **91,901**
	Yes	34.1% 340	34.3% 303	28.2% 365	35.4% 364	15.7% 753	**26.8%** **2,125**
	Unspecified	2.2% 6,263	2.6% 5,157	2.1% 4,062	1.9% 2,616	2.1% 2,176	**2.2%** **20,274**
	All	**1.9%** **24,381**	**1.9%** **24,523**	**1.8%** **22,191**	**1.8%** **20,397**	**1.5%** **22,808**	**1.8%** **114,300**



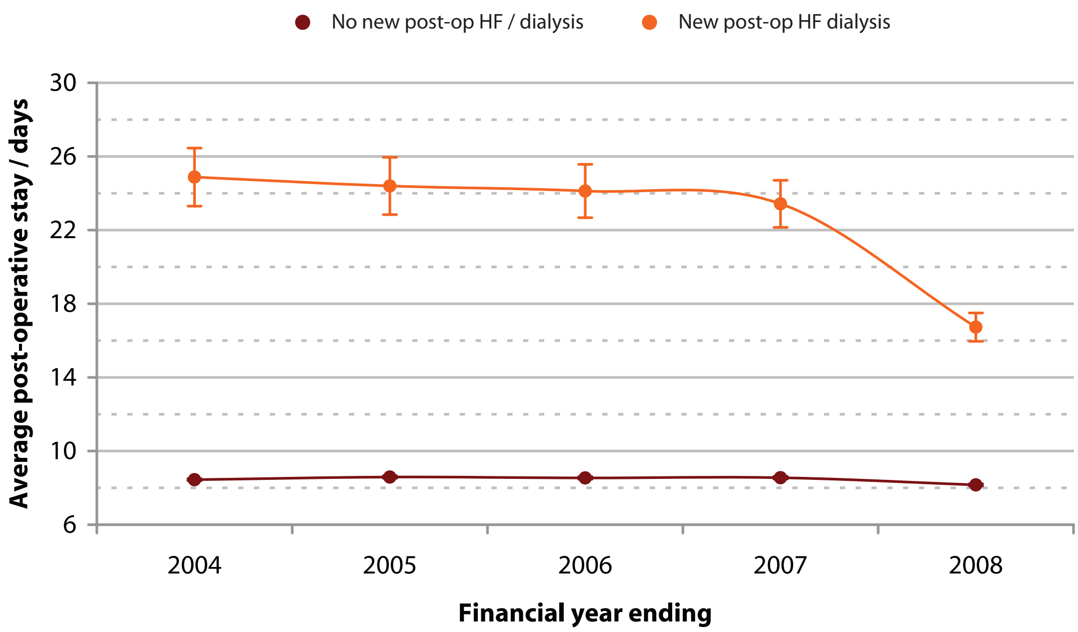
Post-operative stay and new post-operative HF / dialysis

Post-operative HF / dialysis is associated with markedly increased length of post-operative stay. Of interest, in line with the increased use of HF / dialysis and decrease in the in-hospital mortality rate seen in 2008, there has also been a sharp decrease in the length-of-stay in these patients in the most recent year of analysis.

Post-operative stay, new post-operative HF / dialysis and financial year; the upper numbers represent the average stay in days and the lower numbers the procedure count within the sub-group

		Financial year				
		2004	2004	2006	2007	2008
New HF dialysis	No	8.4 17,380	8.6 18,704	8.5 17,380	8.6 16,902	8.2 19,598
	Yes	24.9 338	24.4 298	24.1 362	23.4 362	16.7 748
	Unspecified	9.3 5,570	9.4 4,691	9.8 2,862	10.2 1,954	9.3 2,166

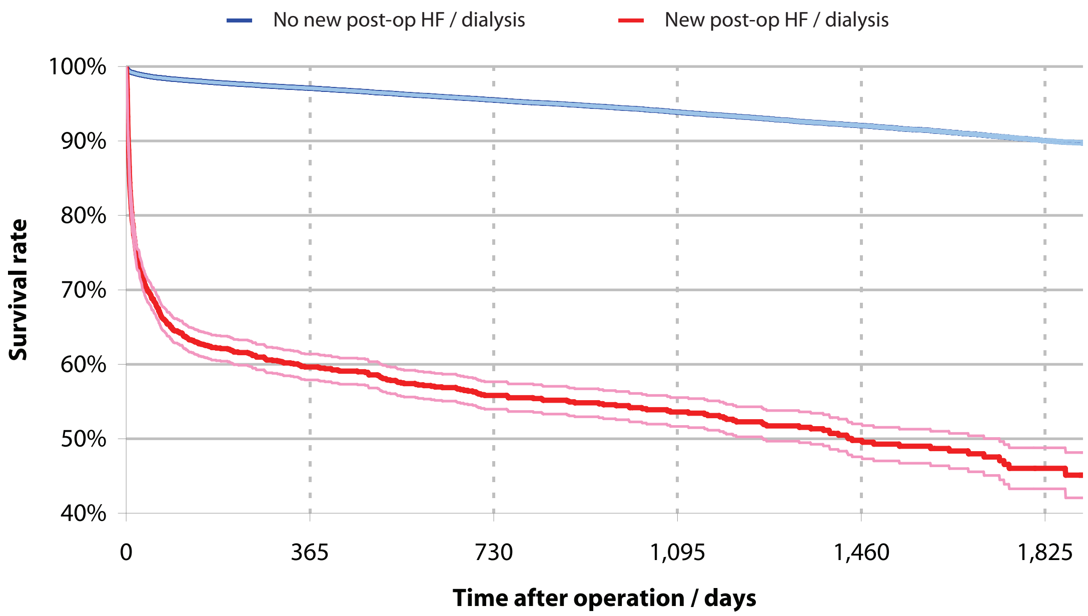
Isolated CABG: Post-operative stay and new post-operative HF dialysis; bars denote standard errors (n=92,072)



Survival and new post-operative HF / dialysis

The medium-term survival following new post-operative HF / dialysis is very poor. In addition to the high early mortality rate, the survival curves for those who do and do not suffer this complication continue to diverge. The overall medium-term survival rate for patients requiring new HF / dialysis is less than 50% at 5 years.

Isolated CABG: Medium-term survival and new post-operative HF / dialysis; financial years 2004-2008 (n=74,86)



Re-operation

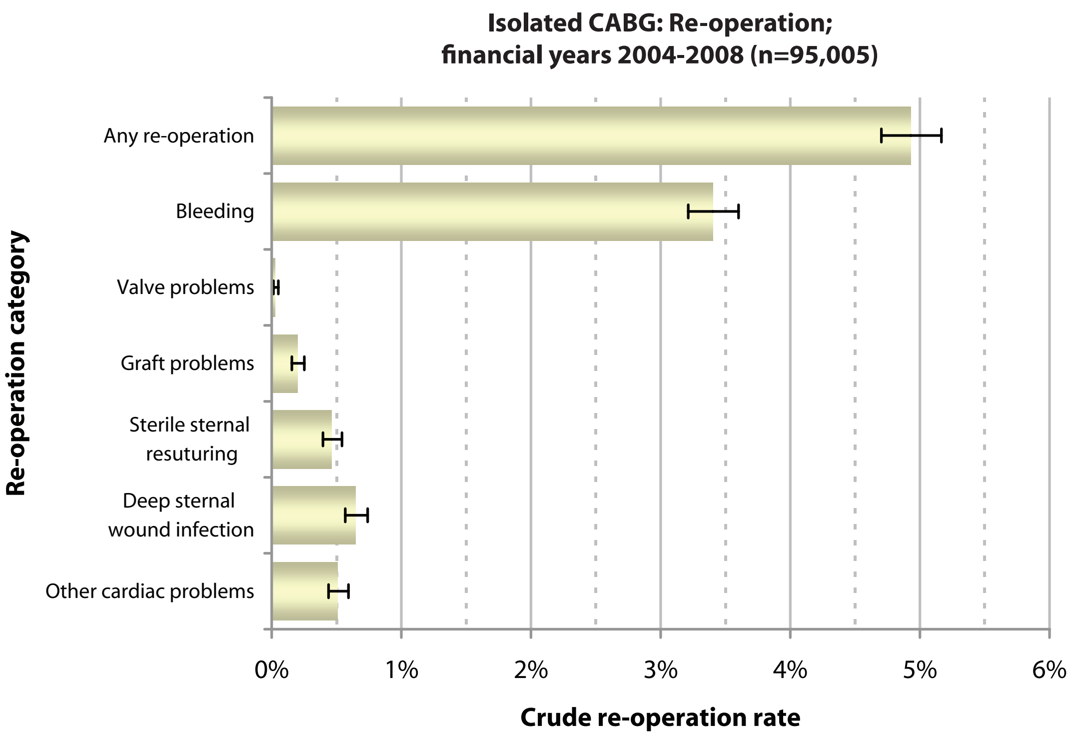
The SCTS database sub-divides re-operation into a series of categories:

- no re-operation required
- re-operation for bleeding or tamponade
- re-operation for valvular problems
- re-operation for graft problems
- re-operation for sterile sternal re-suture
- re-operation for deep sternal wound infection
- re-operation for other cardiac problems

We have shown the results for all these categories for the procedures performed over the last 5 years and then looked in more detail at two of the categories: re-exploration for bleeding or tamponade and re-operation for deep sternal wound infection. The majority (69%) of all re-operations were for bleeding / tamponade. The reported incidence of re-operation for deep sternal wound infection was 0.6%, with a further 0.5% having a sterile sternal re-suture.

Re-operation data for the financial years 2004-2008; more than one response-option may be recorded in the database, so the total of responses may be greater than the total number of operations performed

		Re-operation carried out			
		No	Yes	Unspecified	Rate
Re-operation	For bleeding or tamponade	91,773	3,232	19,571	3.4%
	For valvular problems	94,980	25	19,571	0.0%
	For graft problems	94,817	188	19,571	0.2%
	For sterile sternal re-suture	94,565	440	19,571	0.5%
	For deep sternal wound infection	94,389	616	19,571	0.6%
	For other cardiac problems	94,521	484	19,571	0.5%
	Any re-operation	**90,322**	**4,683**	19,571	**4.9%**

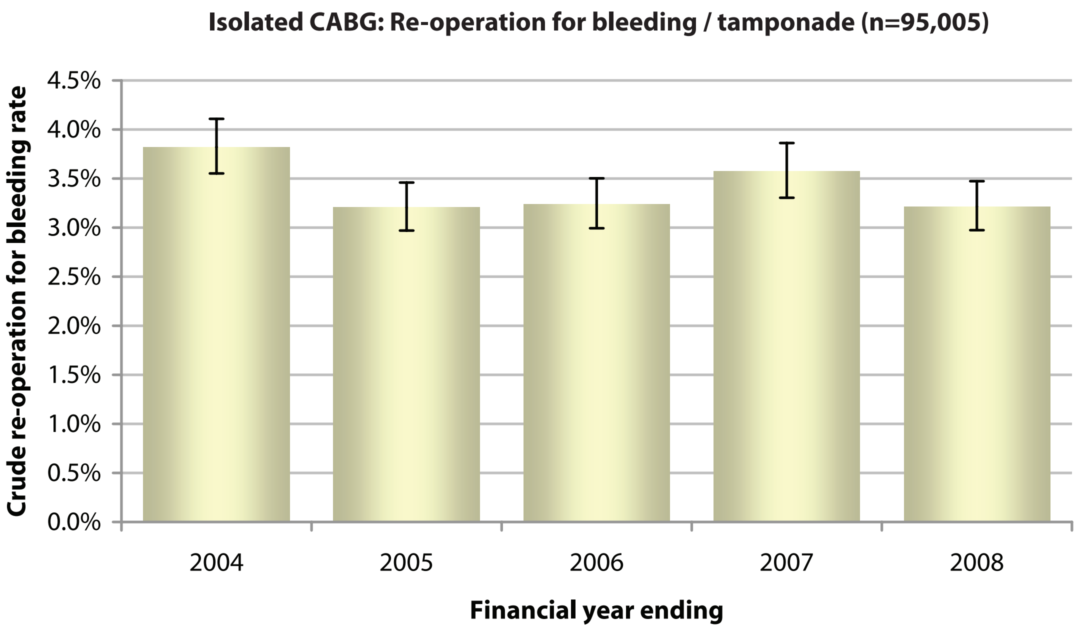


Re-operation for bleeding

Coronary artery bypass surgery is a major operation requiring multiple anastomoses to major arterial blood vessels, and there is inevitably a risk of post-operative haemorrhage. The overall incidence of re-operations for bleeding or tamponade between 2004 and 2008 is reported as 3.4%. There is quite a high incidence of missing data, but this has decreased from 33% in 2004 to 17% in 2008.

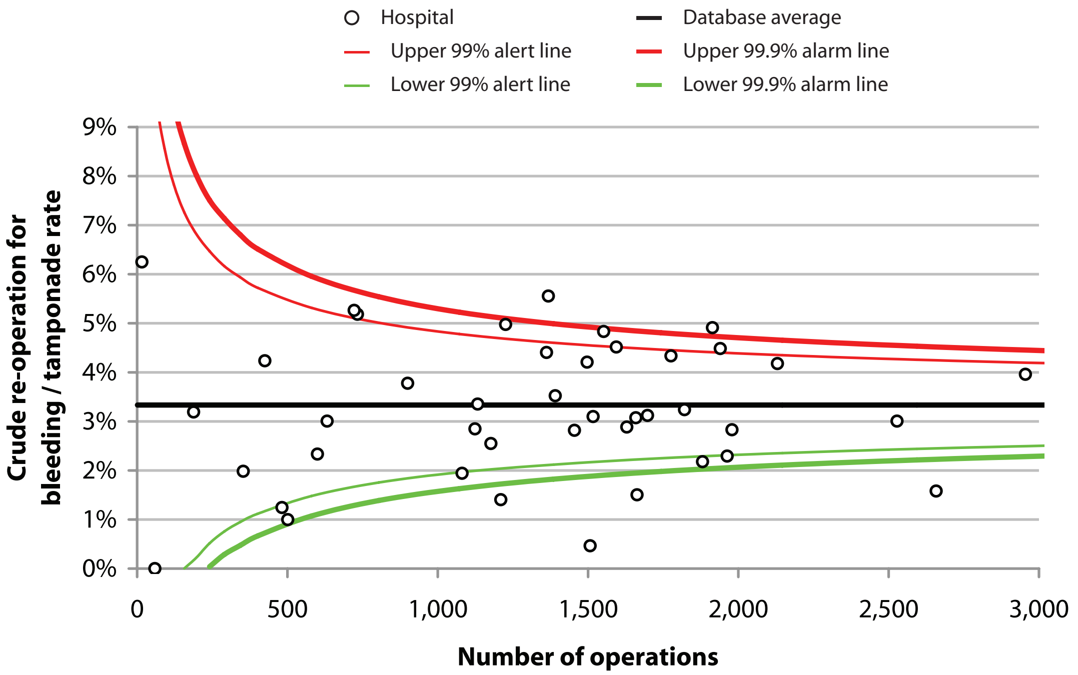
Re-operation for bleeding

		Re-operation for bleeding			
		No	Yes	Unspecified	Rate
Financial year	2004	17,898	711	5,822	3.8%
	2005	19,687	652	4,197	3.2%
	2006	18,434	617	3,200	3.2%
	2007	16,785	622	3,105	3.6%
	2008	18,969	630	3,247	3.2%
	All	**91,773**	**3,232**	19,571	**3.4%**

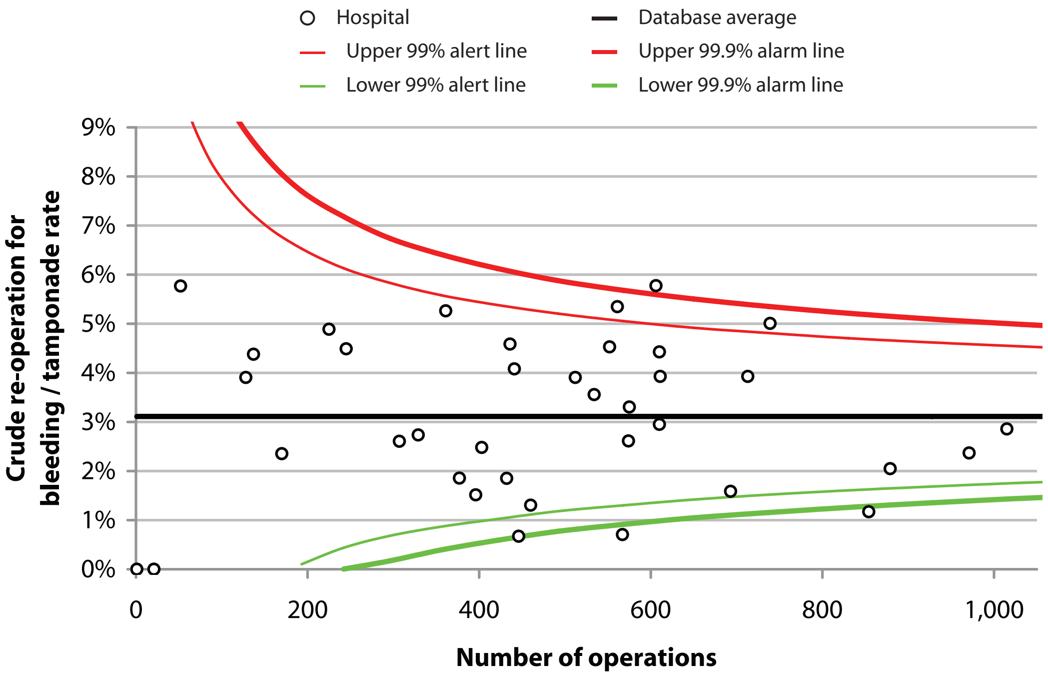


The funnel plot below shows the incidence of re-exploration for bleeding for each centre in the database. This graph must be interpreted with caution, given the high incidence of missing data described above, but the superficial interpretation of the analysis is that the are 2 centres who have a re-exploration rate outside the 99.9% control limits, and a further 6 falling outside the 99% limit. We do not think any clear interpretation can be made from this analysis, but we believe that it will be useful for hospitals with good data to benchmark themselves against the scatter shown here, to understand whether their re-exploration rates are high and require further consideration. The lower plot only includes data from 2008 (where the data are most complete) and only includes centres with a low incidence of missing data. The mean re-exploration for bleeding rate is just over 3%, and the scatter of rates by centre is similar to the complete 3-years' data.

Isolated CABG: Funnel plot on re-operation for bleeding by hospital; financial years 2006-2008 (n=56,057)



Isolated CABG: Funnel plot on re-operation for bleeding by hospital; hospitals with <10% missing data; financial year 2008 (n=17,543)

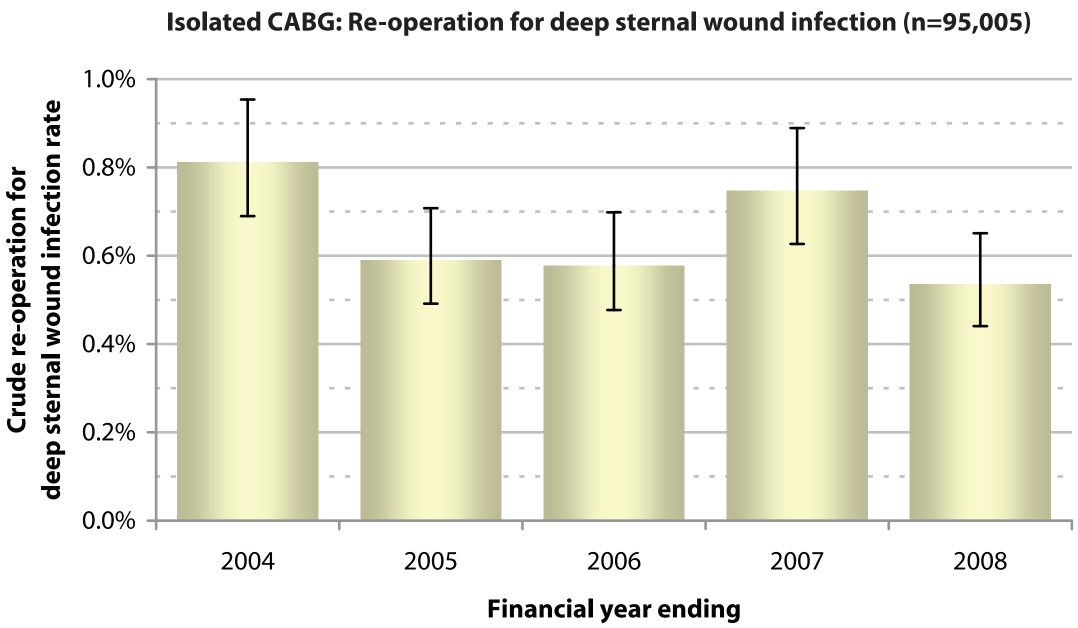


Re-operation for deep sternal wound infection

Deep sternal wound infection is another feared and devastating complication of coronary artery bypass surgery, but again our analysis is inhibited by the high incidence of missing data for this outcome variable. Again the incidence of missing data has decreased over time. In 2008 the re-operation rate for deep sternal infection was 0.5%.

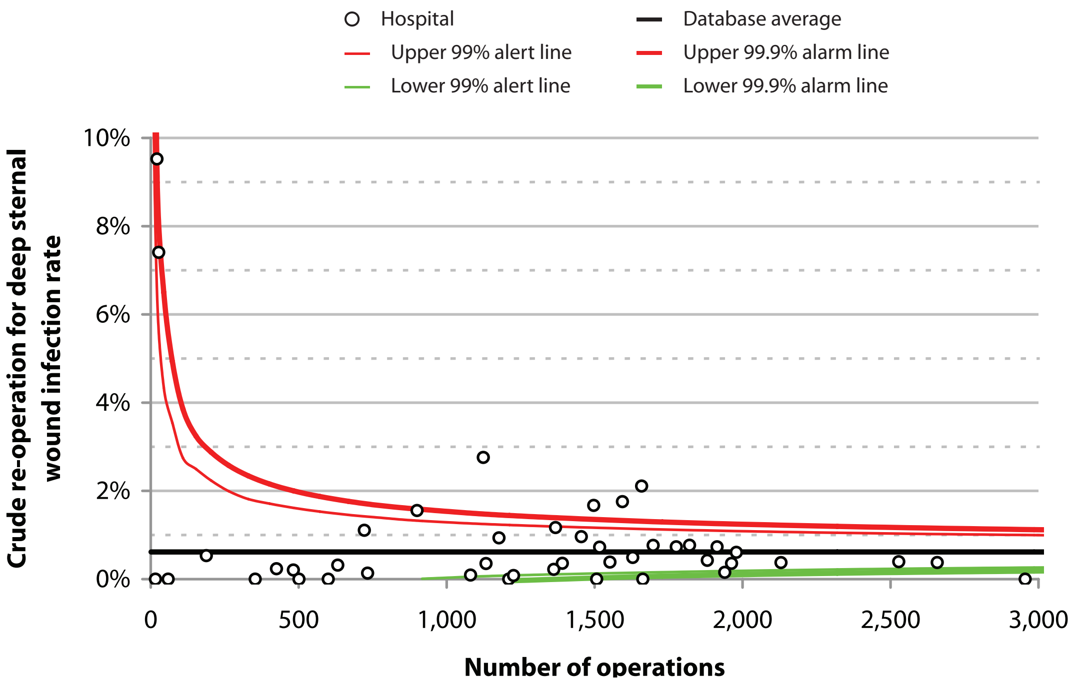
Re-operation for deep sternal wound infection

		Re-operation for deep sternal wound infection			
		No	Yes	Unspecified	Rate
Financial year	2004	18,458	151	5,822	0.8%
	2005	20,219	120	4,197	0.6%
	2006	18,941	110	3,200	0.6%
	2007	17,277	130	3,105	0.7%
	2008	19,494	105	3,247	0.5%
	All	**94,389**	**616**	19,571	**0.6%**

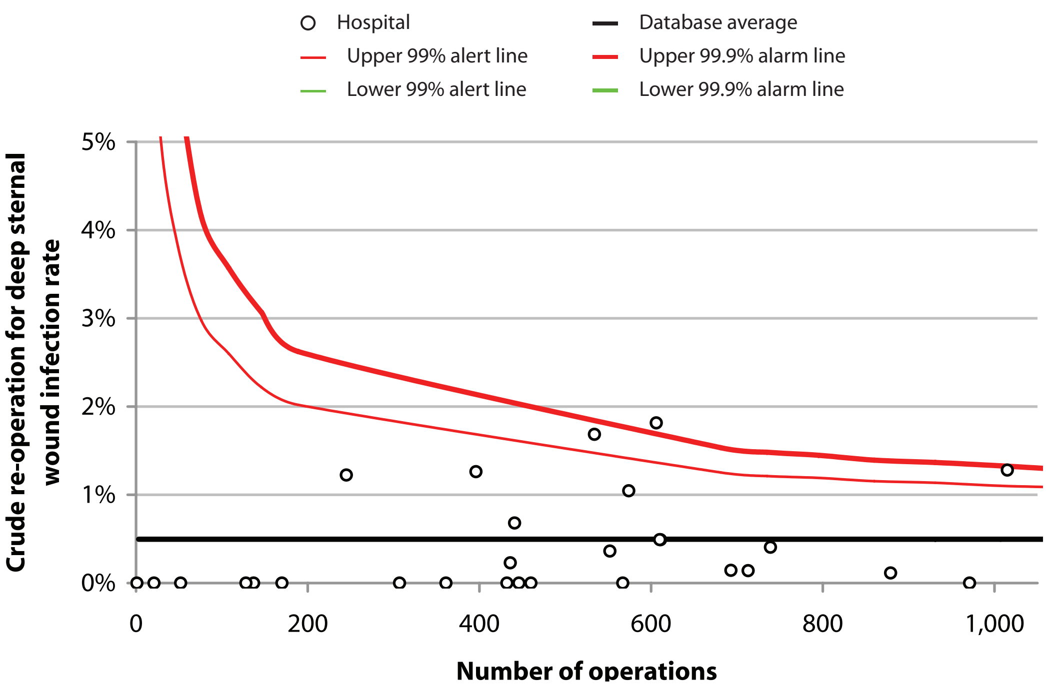


The top funnel plot shows the re-operation rates for deep sternal wound infection by centre. Again this graph should be interpreted with caution due to the high incidence of missing data, but superficial scrutiny suggest that there are 4 centres who have rates that fall outside the upper alarm line, which might warrant further detailed investigation. The bottom plot shows data from 2008 alone, from centres with less than 10% of missing data. Because of the shorter time-period more centres have no cases of re-operation, but the average rate is similar.

Isolated CABG: Funnel plot on re-operation for deep sternal wound infection by hospital; financial years 2006-2008 (n=56,057)

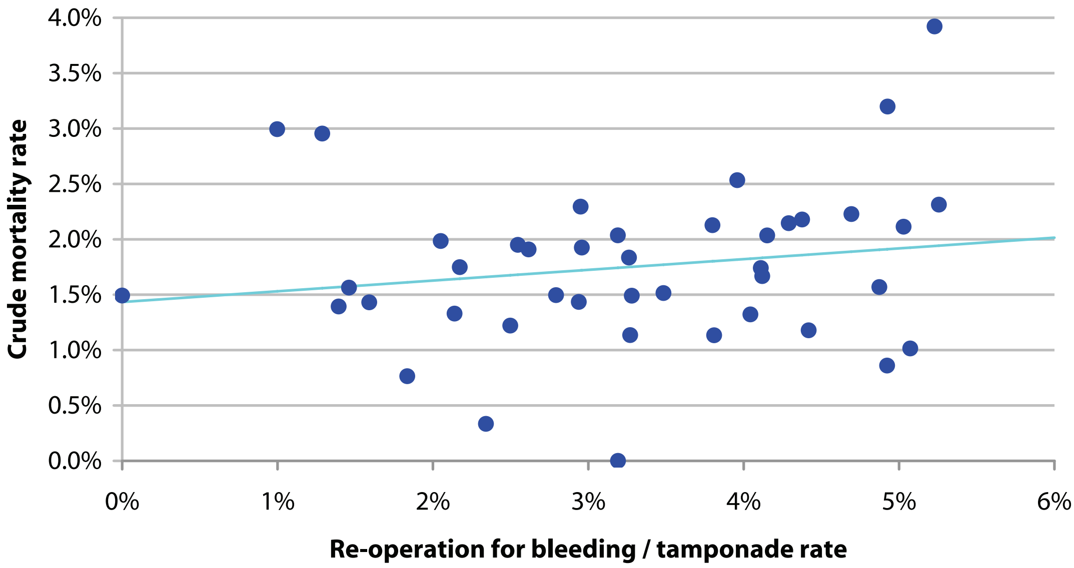


Isolated CABG: Funnel plot on re-operation for deep sternal wound infection by hospital; hospitals with <10% missing data; financial year 2008 (n=13,097)



The scatter plot of re-exploration rate against crude in-hospital mortality has excluded 3 centres, in which there has been a high re-exploration rate associated with a very small number of cases. There is no apparent association between the re-exploration rate and mortality ($r^2 = 0.03$, $p = 0.14$).

Isolated CABG: Correlation between mortality and re-operation for bleeding; financial years 2004-2008 (n=94,753)



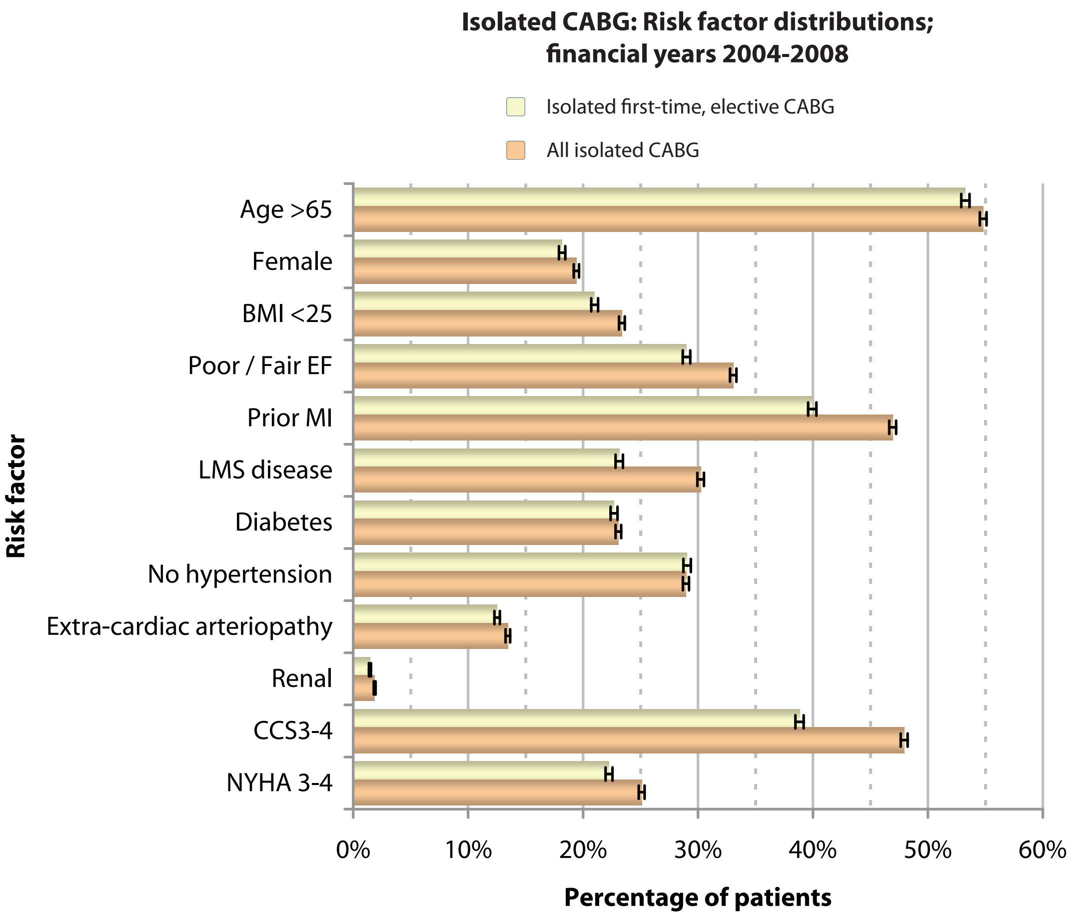
Isolated first-time, elective CABG

Key points from first-time elective CABG analyses

- These patients are seen in the outpatient clinic and admitted from home for their surgery. They will have made a clear, considered choice for surgery.
- Elective patients are more likely to be low risk with respect to almost all risk factors compared to all-comers for CABG.
- The overall in-hospital mortality for these patients is 1%. The medium-term survival rate is dependent on age and other risk factors, but for patients under the age of 61 years it is better than 95% at 5 years
- The reported complication rates for re-operation for bleeding, new haemofiltration / dialysis and post-operative stroke are 2.9%, 1.8% and 0.9% respectively.

Risk factor analyses

The incidence of most risk factors is significantly lower in patients who undergo elective surgery. This is quite marked with respect to impaired left ventricular function, prior MI, left main stem disease and severe symptoms of both angina and breathlessness.



Outcomes

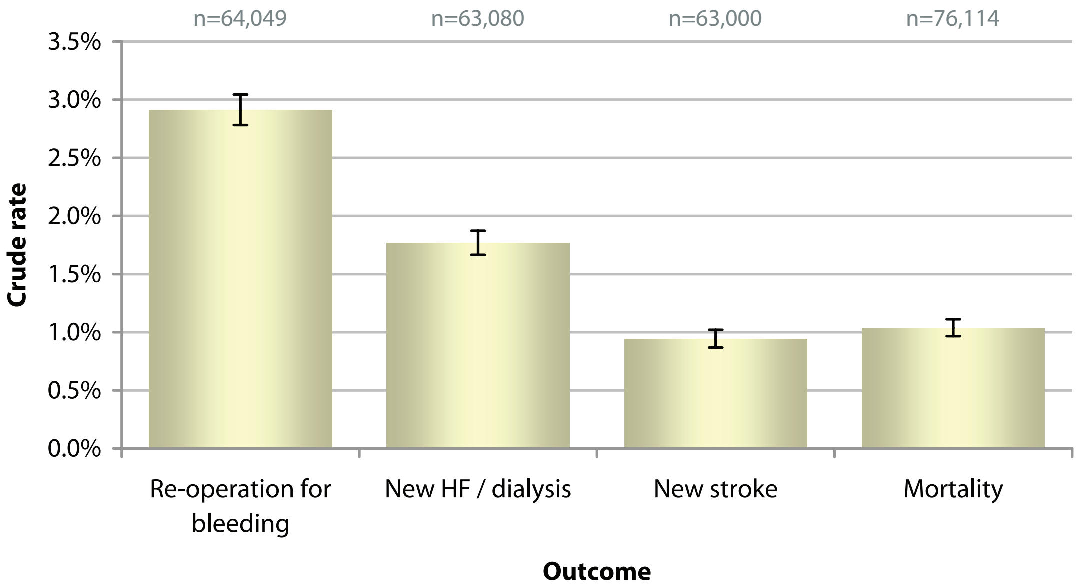
Immediate post-operative outcomes

The post-operative outcomes for elective patients are excellent. The overall in-hospital mortality rate is 1.0%, and the rates of re-operation for bleeding, new haemofiltration / dialysis and post-operative stroke are 2.9%, 1.8% and 0.9% respectively. These would seem to be appropriate *all comers* risks to quote to elective patients who are seen in the outpatient clinic and decisions about other treatment options (such as PCI and medication) should be made against these outcomes.

Outcomes for patients undergoing isolated, first-time, elective CABG; financial years 2004-2008

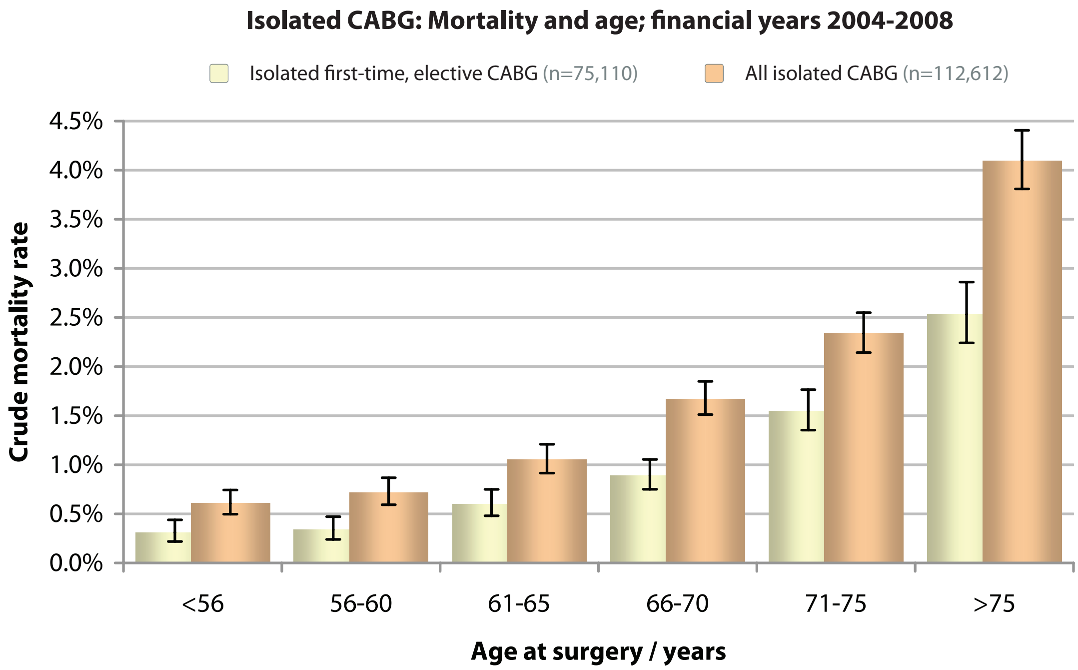
		Outcome			
		No	Yes	Unspecified	Rate and 95% confidence interval
Outcome	Re-operation for bleeding	62,185	1,864	12,212	2.9% (2.8-3.0%)
	New HF / dialysis	61,966	1,114	13,181	1.8% (1.7-1.9%)
	New post-operative stroke	62,407	593	13,261	0.9% (0.9-1.0%)
	Mortality	75,325	789	147	1.0% (1.0-.1.1%)

Isolated, first-time, elective CABG: Outcome rates; financial years 2004-2008



Mortality and age

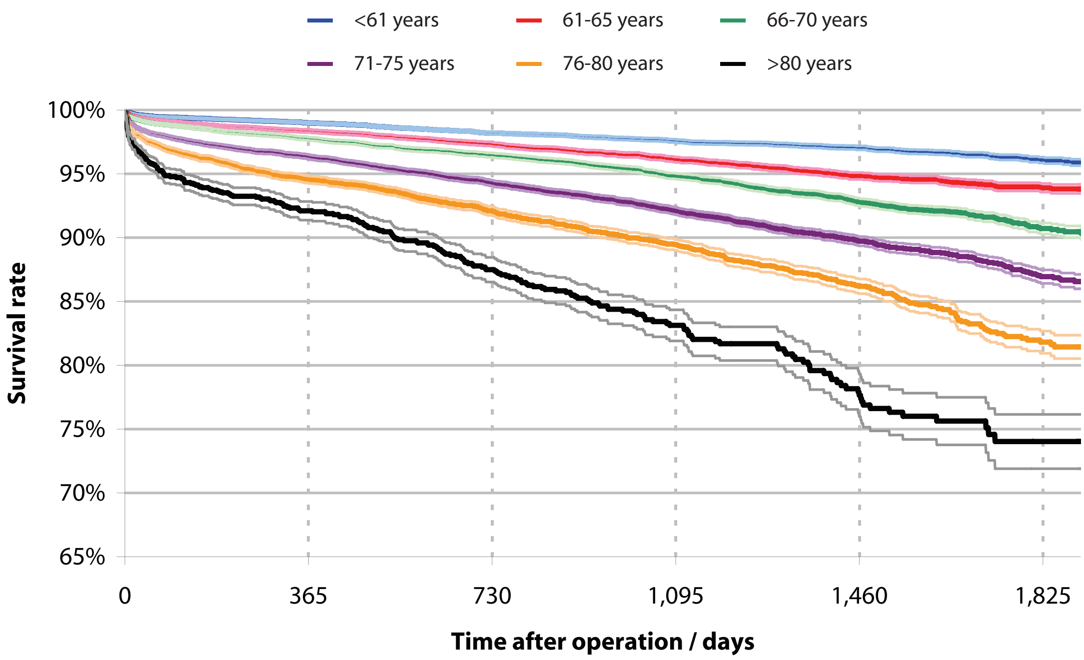
The mortality rate for first-time, elective CABG is lower than for all-comers (p<0.001), for all age groups (p=0.001 for age group <56 years; otherwise p<0.001). For patients up to the age of 60, mortality is less than 0.5%; for those between 61 and 70 years old it is less than 1.0%. Informed consent for elective patients should be based around these figures.



Medium-term survival

The medium-term survival for elective patients undergoing isolated CABG surgery is critically dependent on age. For patients under the age of 61 years the medium-term survival rate is better than 95% at 5 years and even for those up to the age of 70 it is better than 90% at 5 years.

Isolated, first-time, elective CABG: Medium-term survival and age at surgery; financial years 2004-2008 (n=59,095)



EuroSCORE

Key points from *EuroSCORE* analyses

- The ***EuroSCORE*** is a risk-scoring tool developed from a pan-European study in the early 1990s. It has found worldwide use for predicting mortality after CABG surgery. It has a simple additive version, and a more complex, and more accurate, logistic version (www.euroscore.org).
- Recent work has suggested that the ***EuroSCORE*** (in both forms) significantly over-predicts observed mortality, both in the United Kingdom and around the world (Bhatti *et al.* 2005 and Choong *et al.* 2009).
- The proportion of patients in the higher risk ***EuroSCORE*** groups has increased over time, at the expense of lower risk patients.
- The additive ***EuroSCORE*** significantly and consistently over-predicts observed mortality in all but the highest risk patients.
- The logistic ***EuroSCORE*** significantly and consistently over-predicts observed mortality in all risk groupings.
- Because of improvements in surgical outcomes over time, the degree by which both ***EuroSCORE*** models over-predict observed mortality has increased.

As shown in the table on page 40, despite the overall high completeness rates of risk factor data in the submissions to the database from which this report is generated, there is a significant level of missing data for the fields from which the ***EuroSCORE*** is calculated. To generate a *complete* ***EuroSCORE*** ideally all the fields that are included in the algorithm should be completed (see page 486). When there are missing data there are 2 potential simple approaches:

1. To only attribute a ***EuroSCORE*** to those patients who have all the appropriate data fields completed.
2. To score all entries, attributing a non-scoring value to any ***EuroSCORE*** fields with missing data.

We have analysed the data in both ways and, as shown below, the distributions and observed mortality rates are similar when we have scored all records, and just those with complete fields. We have therefore opted for the second approach for the remainder of the analyses, and have scored all records making that assumption. So if a patient's data report them as having renal failure they will score 2 points on the additive ***EuroSCORE***; if the record reports no renal failure they will get no score; and if the renal disease field is blank it will be treated in the same way as if renal failure were reported as absent. From a pragmatic viewpoint it is more likely that a factor is absent when the data are missing, but using this technique will probably slightly underscore the overall risk. In any comparative analysis by units, those hospitals with a high incidence of missing data may be underscored compared to others, and we would hope this would act as a further stimulus towards complete data collection.

i Bhatti F, Grayson AD, Grotte GJ, Fabri BM, Au J, Jones MT and Bridgewater B. The logistic ***EuroSCORE*** in cardiac surgery: how well does it predict operative risk? *Heart.* 2006; **92(12):** 1817-20.

ii Choong CK, Sergeant P, Nashef S, Smith JA and Bridgewater B. The ***EuroSCORE*** Risk Stratification System in the Current Era: How accurate is it and what should be done if it is inaccurate? *Eur J Cardiothorac Surg.* 2009; **5(1):** 59-61

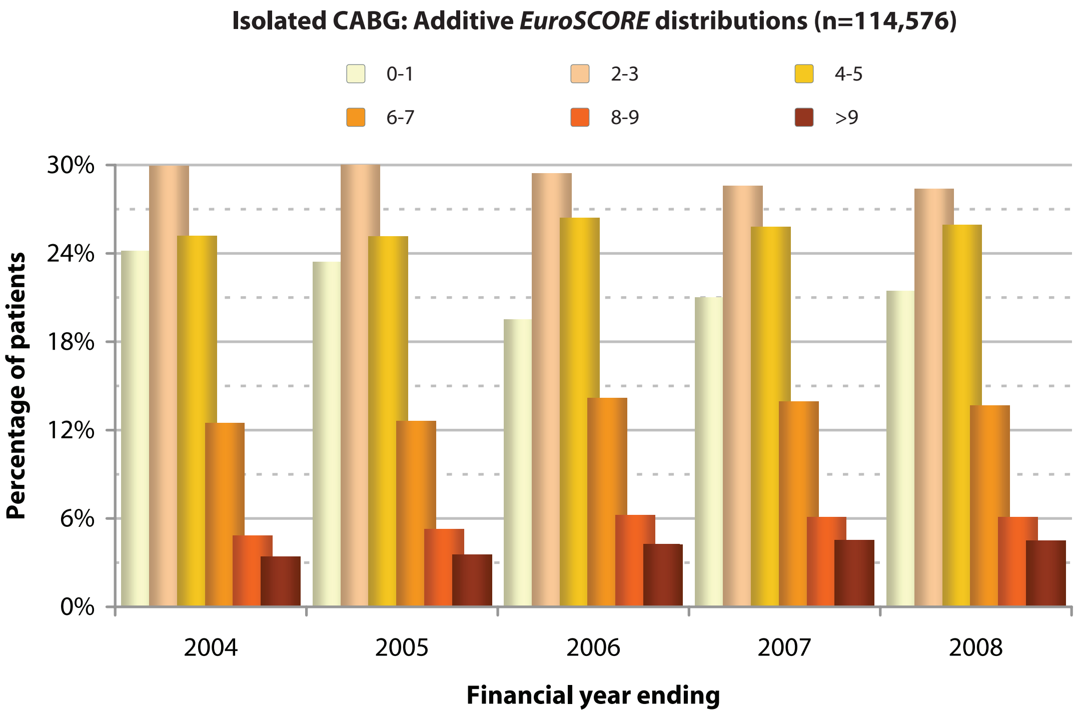
The additive *EuroSCORE*

The simple additive ***EuroSCORE*** can be calculated at the *end of the bed*, by adding together scores from the various risk factors. It is now known to over-predict observed risk in the United Kingdom, and does not have as good an ability to discriminate between patients with differing degree of risk as the logistic ***EuroSCORE***.

Over time the proportion of patients who are low-risk has fallen at the expense of patients who are moderate- and high-risk.

Additive ***EuroSCORE*** distributions; financial years 2004-2,008

		Additive *EuroSCORE* groupings						
		0-1	2-3	4-5	6-7	8-9	>9	**All**
Financial year	2004	5,900	7,313	6,151	3,048	1,183	836	**24,431**
	2005	5,743	7,366	6,175	3,092	1,292	868	**24,536**
	2006	4,339	6,551	5,874	3,157	1,385	945	**22,251**
	2007	4,311	5,864	5,294	2,862	1,250	931	**20,512**
	2008	4,903	6,483	5,923	3,120	1,394	1,023	**22,846**
	All	**25,196**	**33,577**	**29,417**	**15,279**	**6,504**	**4,603**	**114,576**

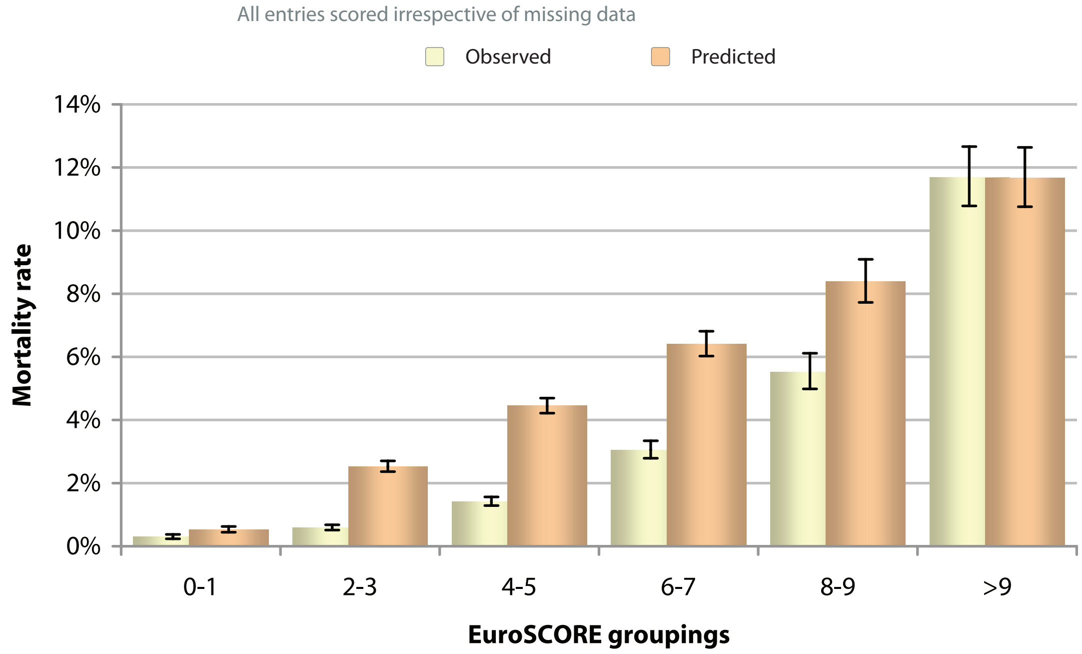


The observed mortality is significantly less than predicted by the additive ***EuroSCORE***, for all but the very highest risk patients. For patients with ***EuroSCORE***s between 2 and 5, the degree of *over-prediction* is marked at more than 3 times the observed mortality.

Observed mortality according to the additive ***EuroSCORE*** groupings; all entries are scored irrespective of missing risk factor data; financial years 2004-2,008

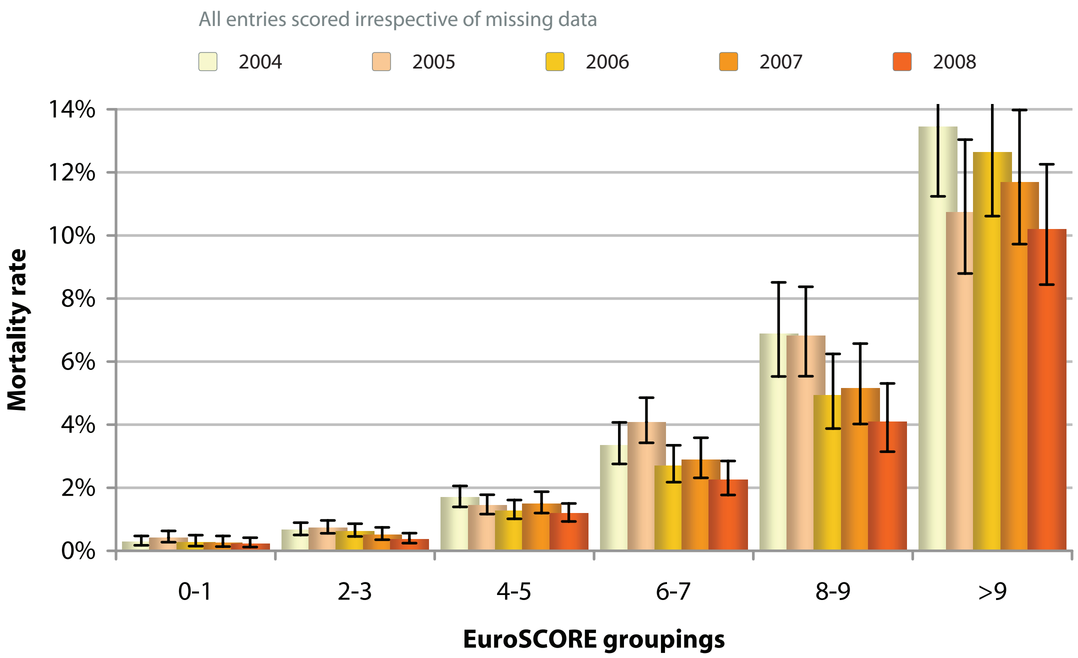
		Post-operative mortality				
		Alive	Deceased	Unspecified	**Observed mortality rate**	***EuroSCORE* predicted rate**
Additive *EuroSCORE* grouping	0-1	25,075	75	46	0.30%	0.53%
	2-3	33,300	198	79	0.59%	2.53%
	4-5	28,940	417	60	1.4%	4.5%
	6-7	14,764	465	50	3.1%	6.4%
	8-9	6,123	358	23	5.5%	8.4%
	>9	4,049	536	18	11.7%	11.7%
	All	**112,251**	**2,049**	**276**	**1.8%**	**3.8%**

Isolated CABG: Observed and predicted mortality according to the additive *EuroSCORE*; financial years 2004-2008 (n=114,300)



The observed mortality in each additive ***EuroSCORE*** group has decreased over time, suggesting better surgical quality-of-care (χ^2 trends through time: ***EuroSCORE*** grouping 0-1, p=0.238; 2-3, p=0.006; 4-5, p=0.042; 6-7, p<0.001; 8-9, p<0.001; >9, p=0.094).

Isolated CABG: Crude mortality and additive *EuroSCORE* grouping (n=114,300)



The logistic *EuroSCORE*

The logistic ***EuroSCORE*** again significantly over-predicts observed mortality for all risk groupings.

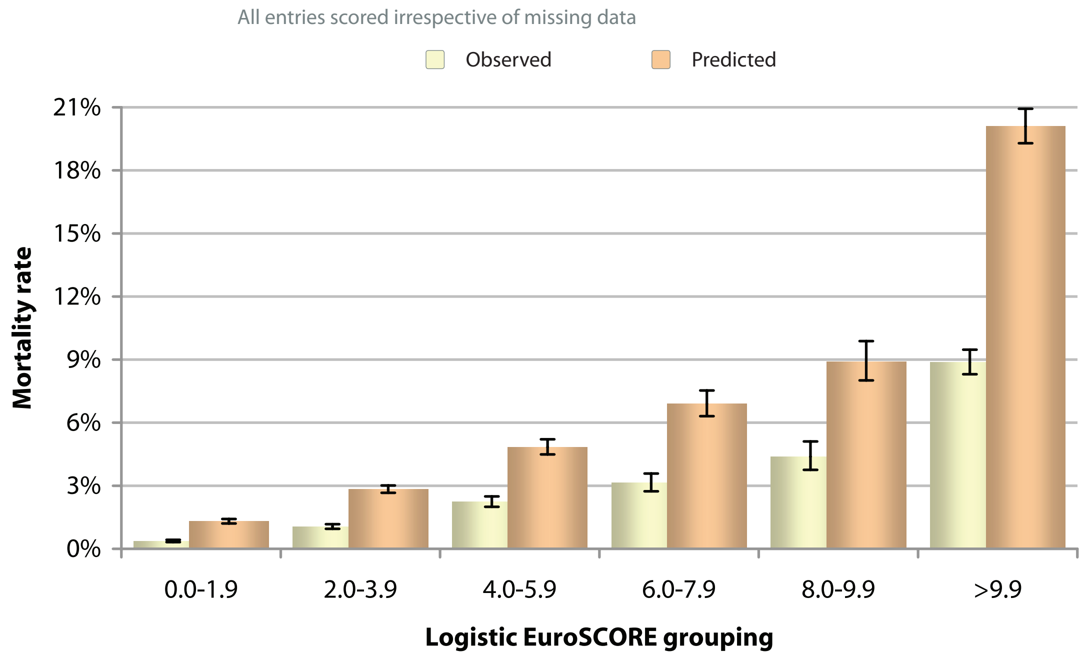
Again there has been a decrease in observed mortality for each logistic ***EuroSCORE*** group over time, suggesting better quality of surgical care.

The observed mortality is consistently lower than the mortality predicted by logistic ***EuroSCORE*** by a factor of around 2. The *over-prediction* of the logistic ***EuroSCORE*** across the spectrum of risk is more consistent than it is for the additive ***EuroSCORE***.

Observed mortality according to logistic ***EuroSCORE*** groupings; all entries are scored irrespective of missing risk factor data; financial years 2004-2,008

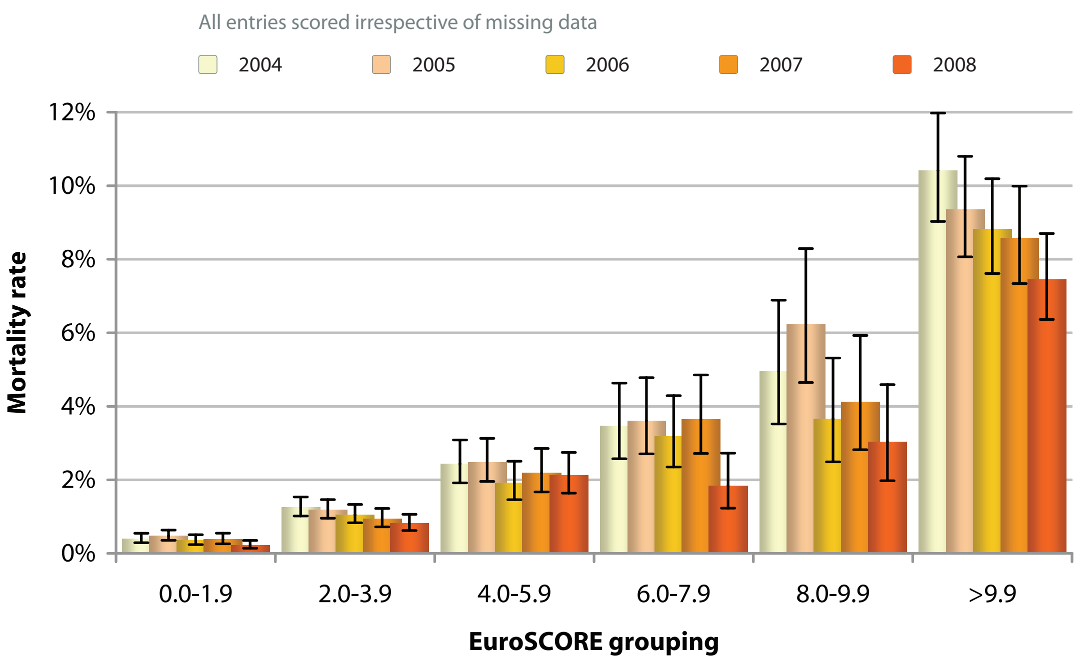
Logistic *EuroSCORE* grouping		Post-operative mortality				
		Alive	Deceased	Unspecified	**Observed mortality rate**	***EuroSCORE* predicted rate**
	0.0-1.9	45,438	169	94	0.37%	1.3%
	2.0-3.9	34,555	369	72	1.1%	2.8%
	4.0-5.9	13,714	313	40	2.2%	4.8%
	6.0-7.9	6,557	212	23	3.1%	6.9%
	8.0-9.9	3,512	161	8	4.4%	8.9%
	>9.9	8,475	825	39	8.9%	20.1%
	All	**112,251**	**2,049**	**276**	**1.8%**	**4.3%**

Isolated CABG: Observed and predicted mortality according to the logistic *EuroSCORE*; financial years 2004-2008 (n=114,300)



There has been a decrease in observed mortality over time across all the logistic ***EuroSCORE*** groupings, again suggesting better quality-of-care for patients (χ^2 trends through time: ***EuroSCORE*** grouping 0.0-1.9, p=0.023.; 2.0-3.9, p=0.004.; 4.0-5.9, p=0.294; 6.0-7.9, p=0.026; 8.0-9.9, p=0.012; >9.9, p=0.001)

Isolated CABG: Crude mortality and logistic *EuroSCORE* grouping (n=114,300)

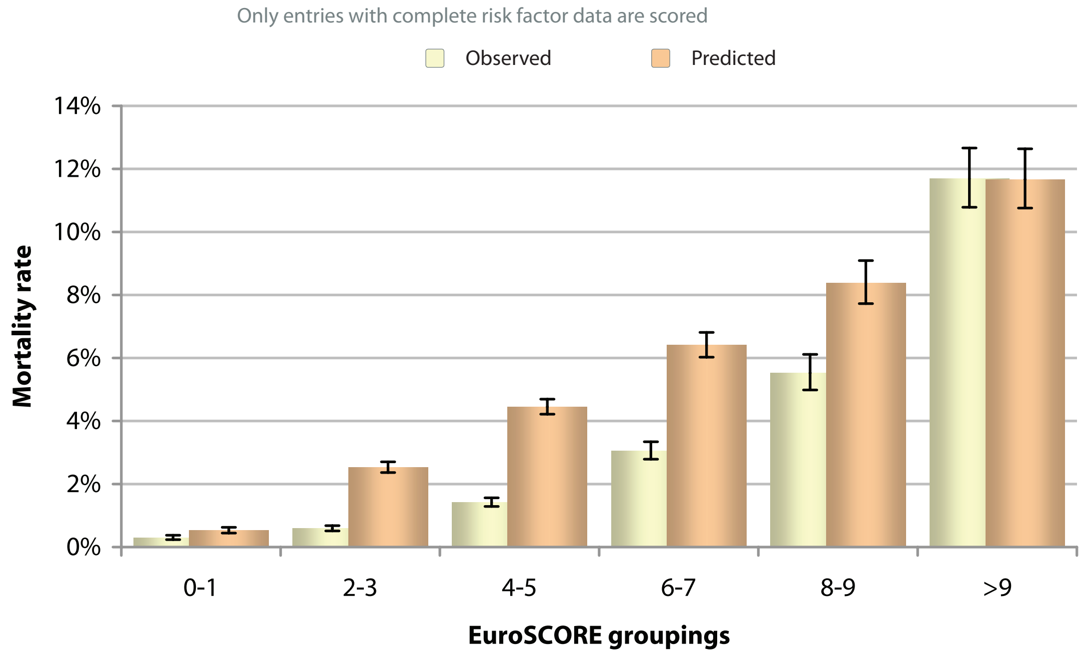


The data below show the analysis repeated when only patient records with complete risk factors are scored. The results are essentially the same as those reported when all the records are scored after making the assumption that missing data equated to the risk factor being absent. The additive ***EuroSCORE*** significantly over-predicts observed morality, but the degree of over-prediction is greater in the lower-risk groups than in the previous analysis. This suggests that there must be some degree of missing data, where that risk factor was actually present.

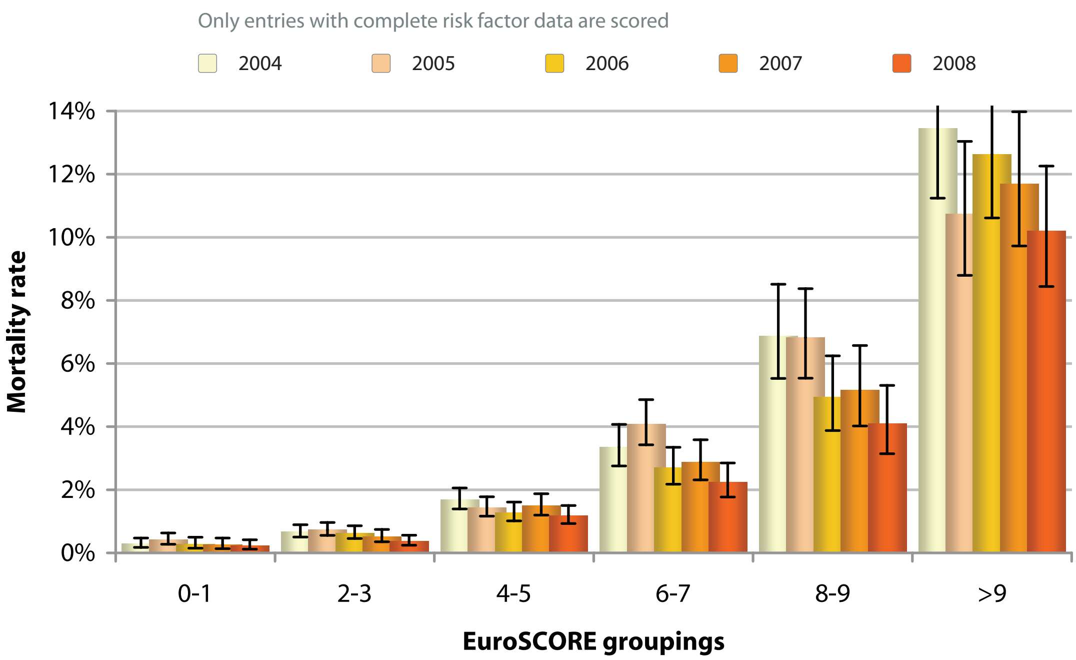
Observed mortality according to the additive ***EuroSCORE*** groupings; only entries with complete risk-factor data are scored; financial years 2004-2,008

		Post-operative mortality				
		Alive	Deceased	Unspecified	**Observed mortality rate**	***EuroSCORE* predicted rate**
Additive *EuroSCORE* grouping	0-1	18,543	43	17	0.23%	0.53%
	2-3	25,041	116	46	0.46%	2.5%
	4-5	21,916	313	34	1.4%	4.5%
	6-7	11,165	351	34	3.1%	6.4%
	8-9	4,673	251	15	5.1%	8.4%
	>9	3,087	411	15	11.8%	11.7%
	Unspecified	27,826	564	115	2.0%	
	All	**112,251**	**2,049**	**276**	**1.8%**	

Isolated CABG: Observed and predicted mortality according to the additive *EuroSCORE*; financial years 2004-2008 (n=85,910)



Isolated CABG: Crude mortality and the additive *EuroSCORE* grouping (n=85,910)



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Aortic valve surgery

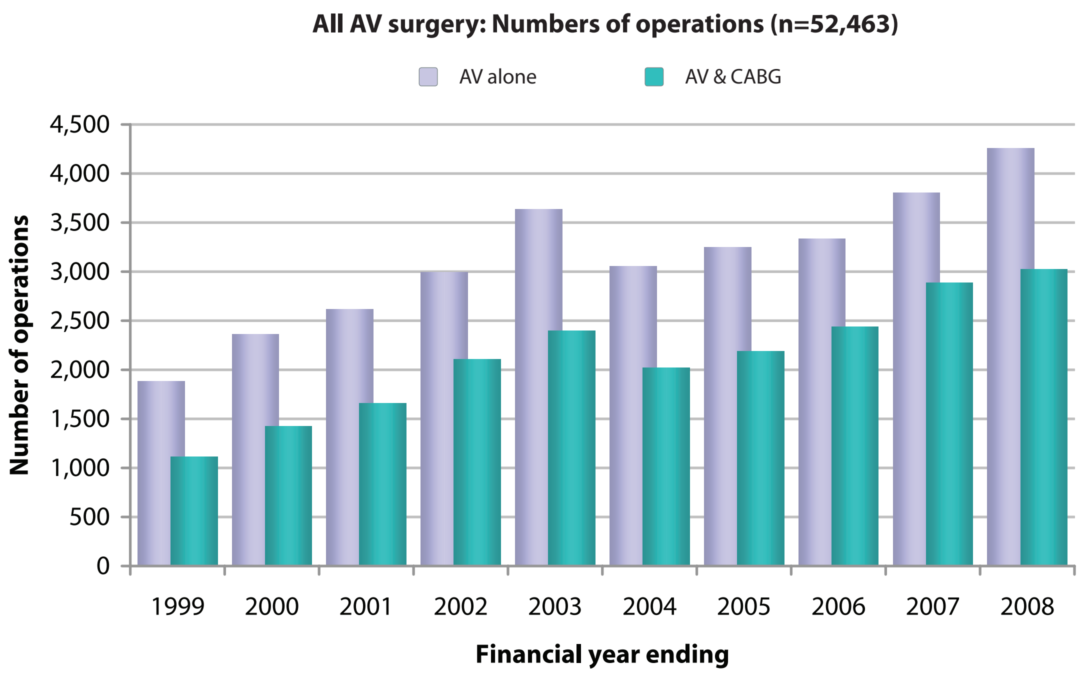
Aortic valve surgery

The aortic valve (AV) sits at the outlet of the major pumping chamber of the heart (the left ventricle) and ensures that blood flows out of the heart through a *one-way* valve. The aortic valve may become narrowed (aortic stenosis) or leaky (aortic regurgitation). The risk of developing aortic stenosis becomes greater as patients get older. In some patients aortic valve disease may be due to a congenital abnormality where the valve has two leaflets rather than the usual three, but more commonly it becomes abnormal due to degeneration and the deposition of calcium in the valve leaflets. The aortic valve may also be damaged by rheumatic heart disease and infections, as well as a number of other rare problems.

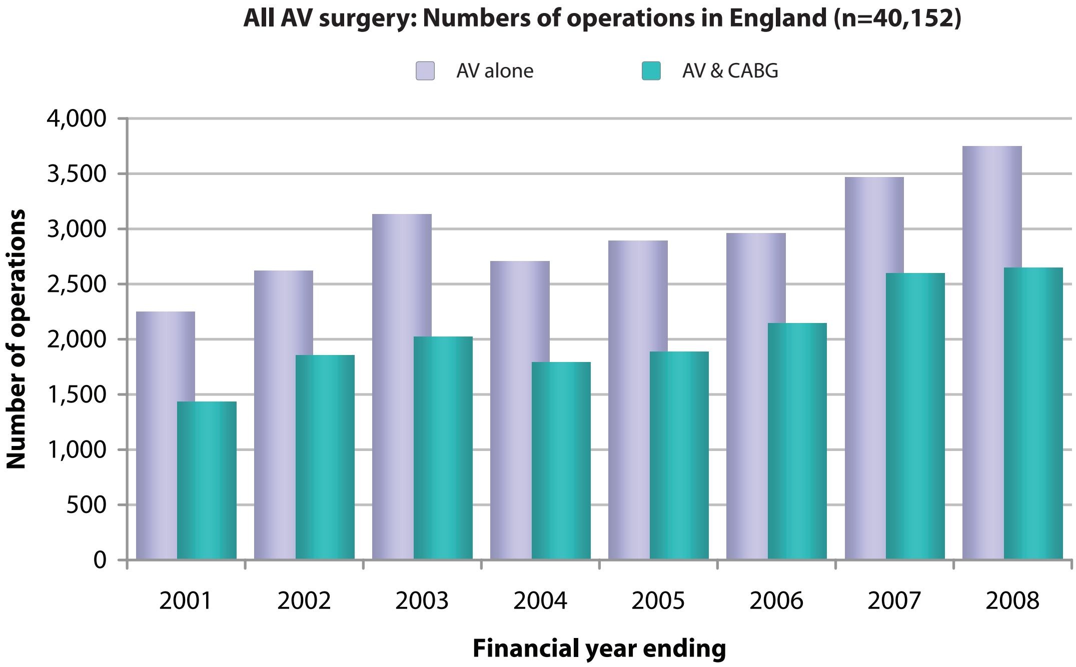
There are no effective medical treatments for severe aortic stenosis or regurgitation other than aortic valve replacement (AVR). Since aortic valve disease becomes more common as patients become older and coronary artery disease is also more prevalent in the elderly, it is common to undertake both aortic valve surgery and coronary artery bypass surgery at the same time. If patients have severe aortic stenosis and the coronary arteries are found to be narrowed as an incidental finding during pre-operative investigations, it is usual to undertake combined aortic valve replacement & coronary artery bypass surgery. Similarly, if a patient has coronary artery disease that requires surgery and pre-operative investigations reveal moderate aortic valve narrowing, the aortic valve is often replaced at that time to prevent the need for more complex, second-time cardiac surgery to replace the aortic valve in the future.

For the following section we have analysed all aortic valve replacements in the database either with or without concomitant coronary artery bypass surgery. Patients undergoing complex procedures on the ascending aorta in addition to valve replacement have been excluded, as have those undergoing multiple valve procedures or those with concomitant *other* operations.

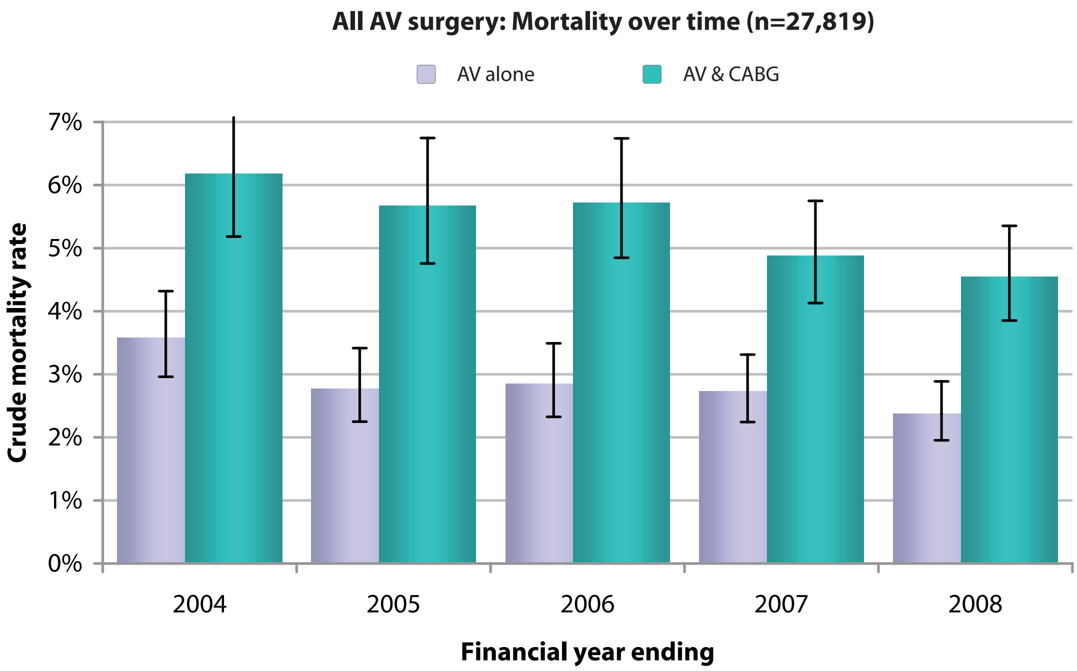
There is a huge amount of data on aortic valve surgery in the database and, to a large extent, the influence that many of the risk factors have on surgical outcomes are similar to those reported for coronary artery bypass surgery, and so we have not presented analyses on all risk factors in detail in this section. Instead, we have drawn up charts and tables for a few key risk factors (age, gender, operative priority, haemodynamic pathology and type of prosthetic implant) in the same general style as those presented in the CABG section, and then presented information on the remaining risk factors in two tables (see pages 182 & 184): one for isolated AVR and another for combined AVR & CABG, detailing the interactions between the risk factors and in-hospital mortality, post-operative stay, post-operative stroke and bleeding rates and medium-term survival. Reported mortality rates for combined AVR & CABG are higher than those recorded for isolated AVR, and we have explored this in more detail.



There has been a marked increase in the number of cases submitted to the database for both isolated AVR and combined AVR & CABG over time. This is a function of more hospitals submitting data and more cases being performed. The following graph just shows data from just the hospitals in England, most of which have submitted data throughout the time-period under analysis. This shows that there has been a greater than 50% increase in both isolated AVR and combined AVR & CABG surgery between 2001 and 2008.



The mortality for both isolated AVR and combined AVR & CABG has decreased over time (χ^2 test for trends p=0.006 and p=0.004 respectively).



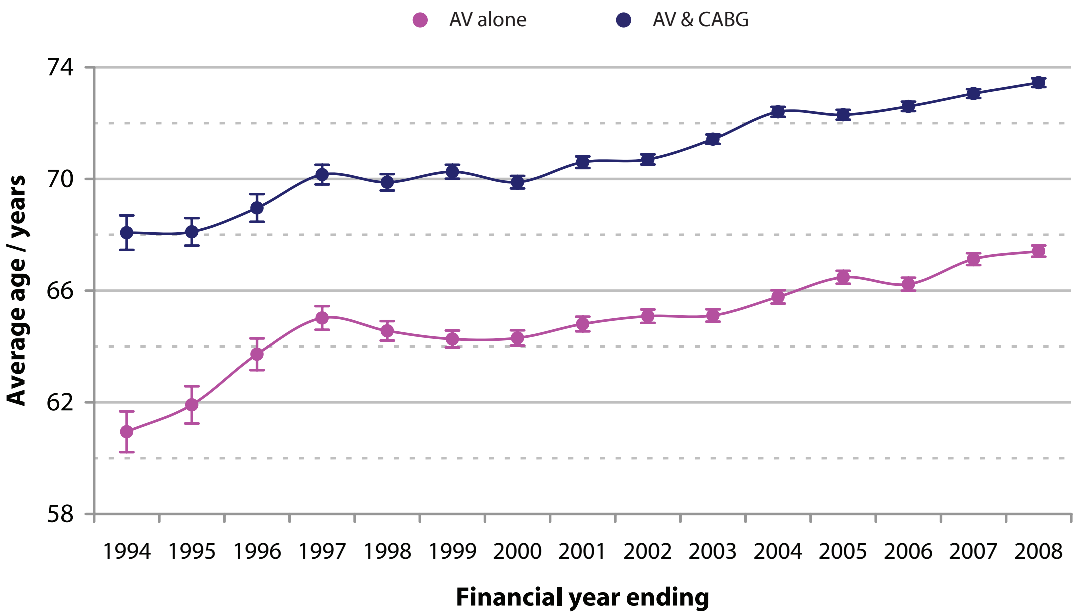
Risk factor analyses

Age

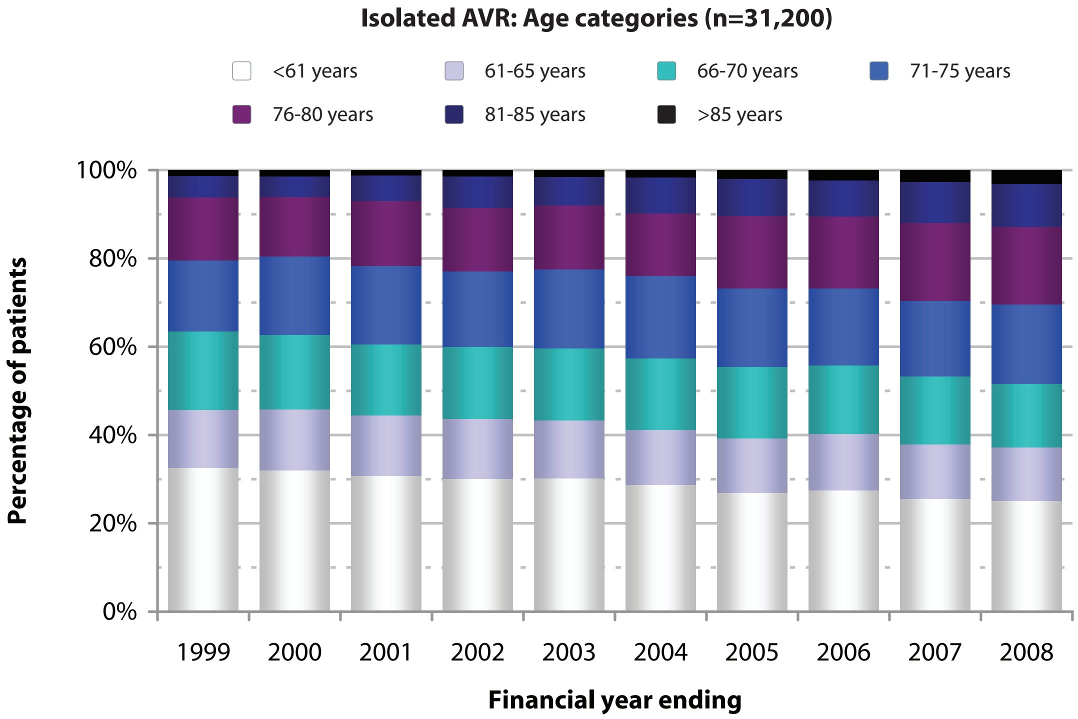
Average age

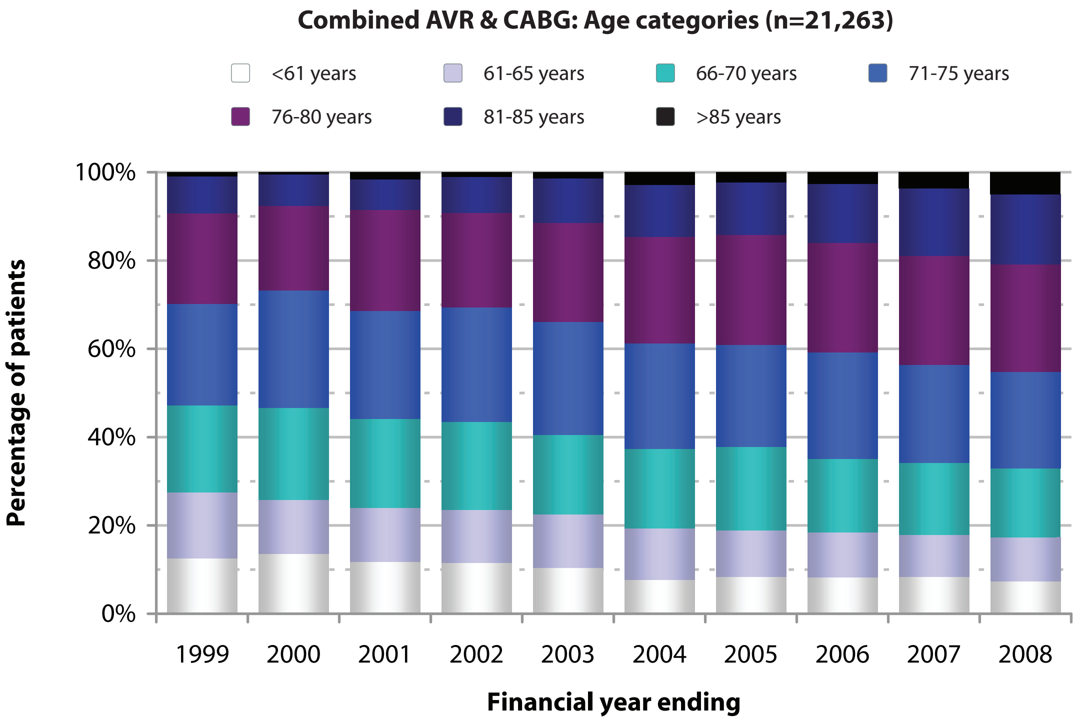
The average age for patients undergoing both isolated AVR and combined AVR & CABG has increased over time. The average age of patients undergoing isolated AVR surgery has increased from 61 years in 1994 to 68 in 2008. Patients undergoing combined AVR & CABG surgery have a average age approximately 5 years older.

All AV surgery: Average age; bars denote standard error (n=58,195)



There have been increases in the proportions of patients who are elderly and very elderly over time, both for isolated AVR surgery and combined AVR & CABG.





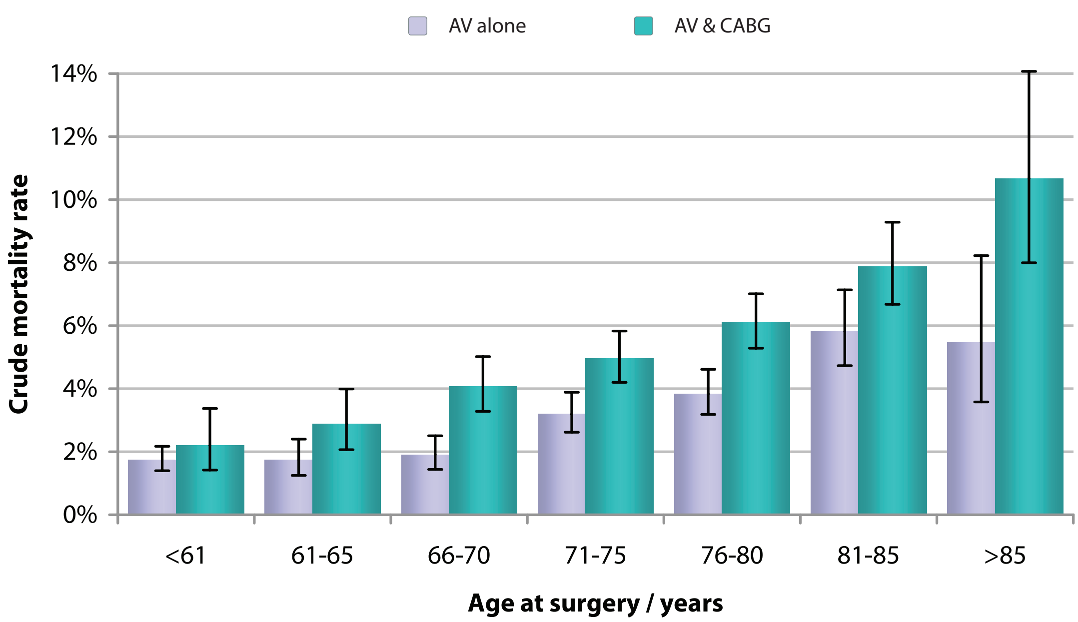
Mortality and age

Increasing age is strongly associated with increasing mortality rates for both isolated AVR and combined AVR & CABG surgery. The mortality for combined AVR & CABG surgery is consistently higher than for isolated aortic valve surgery. Of note, the mortality rate for the 420 patients over the age of 85 who had isolated AVR surgery between 2004 and 2008 was only 5.5%. Decision-making for emerging treatments by transcatheter aortic valve implantation in high-risk and elderly patients should been seen in the context of these results.

Mortality and age; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

Age at surgery / years	Procedure: Aortic valve	Procedure: Aortic valve & CABG	Procedure: All
<61	1.7% 4,700	2.2% 999	**1.8%** **5,699**
61-65	1.7% 2,188	2.9% 1,284	**2.2%** **3,472**
66-70	1.9% 2,733	4.1% 2,116	**2.8%** **4,849**
71-75	3.2% 3,130	5.0% 2,866	**4.0%** **5,996**
76-80	3.8% 2,919	6.1% 3,069	**5.0%** **5,988**
81-85	5.8% 1,546	7.9% 1,725	**6.9%** **3,271**
>85	5.5% 420	10.7% 431	**8.1%** **851**
Unspecified	NA 0	0.0% 1	**0.0%** **1**
All	**2.8%** **17,636**	**5.3%** **12,491**	**3.8%** **30,127**

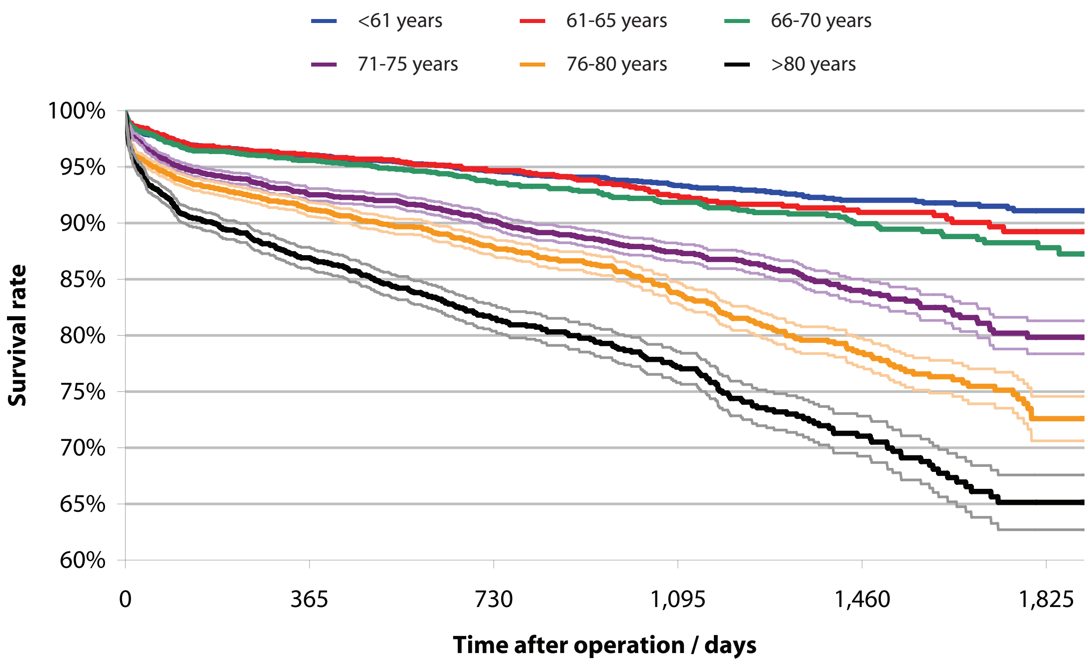
All AV surgery: Crude mortality and age; financial years 2004-2008 (n=30,126)



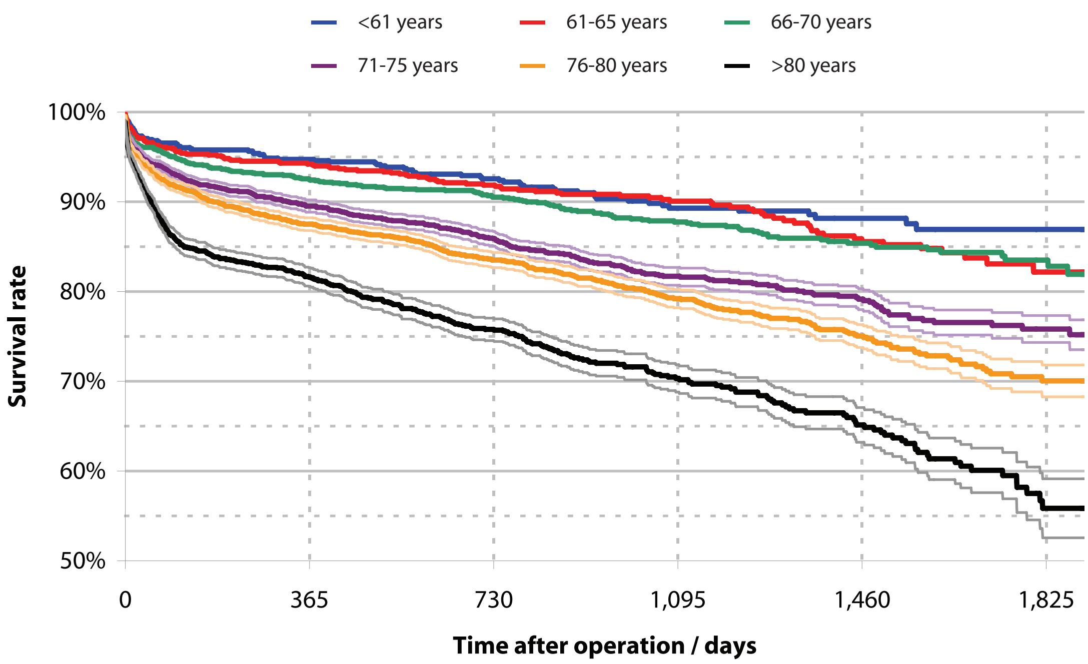
Survival and age

The medium-term survival for patients who have combined AVR & CABG surgery is worse than for those who have isolated AVR. The survival following both procedures is strongly associated with age at the time of surgery, with a lower survival rate for the elderly. The medium-term survival rate for patients under the age of 61 is better than 90% 5 years post-surgery. Conversely the medium-term survival rate for patients over 80 undergoing combined AVR & CABG surgery is 55% 5 years post-surgery.

Isolated AVR: Medium-term survival and age at surgery; financial years 2004-2008 (n=13,851)



Combined AVR & CABG: Medium-term survival and age at surgery; financial years 2004-2008 (n=9,838)



Gender

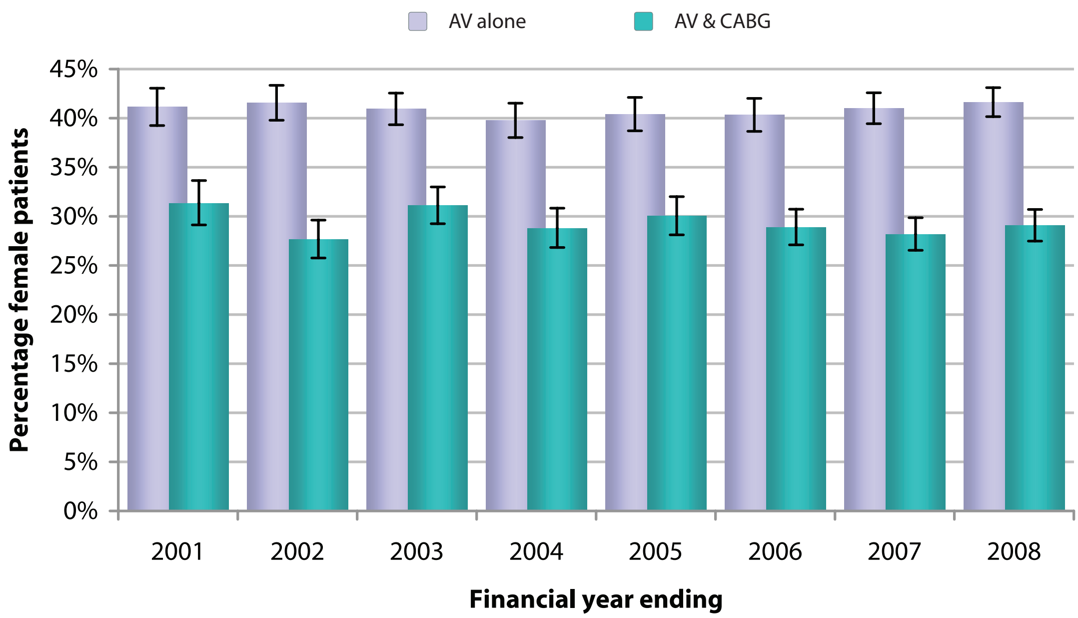
Gender distributions

About 40% of patients undergoing isolated AVR are female, compared to only 30% of those undergoing combined AVR & CABG surgery. These proportions have not changed substantially over time.

Gender distributions; financial years 2004-2008

		Procedure		
		Aortic valve	Aortic valve & CABG	**All**
Gender	Male	10,552	8,985	**19,537**
	Female	7,244	3,661	**10,905**
	Unspecified	1	0	**1**
	All	**17,797**	**12,646**	**30,443**

All AV surgery: Gender distributions (n=45,861)



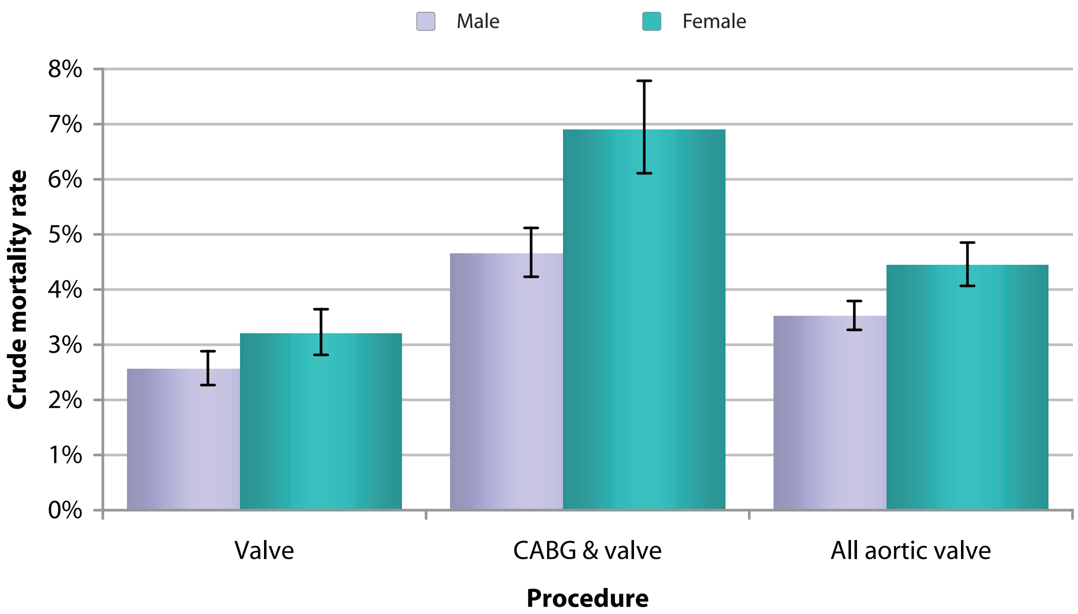
Mortality and gender

As with CABG surgery, mortality rates for both isolated AVR and combined AVR & CABG are higher for women than for men.

Mortality and age; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Aortic valve	Aortic valve & CABG	**All**
Gender	Male	4.6% 10,517	2.6% 8,937	**3.5%** **19,454**
	Female	6.8% 7,210	3.2% 3,637	**4.4%** **10,847**
	All	**5.30%** **17,728**	**2.8%** **12,574**	**3.8%** **30,302**

All AV surgery: Mortality and gender; financial years 2004-2008 (n=30,301)



Post-operative stay and gender

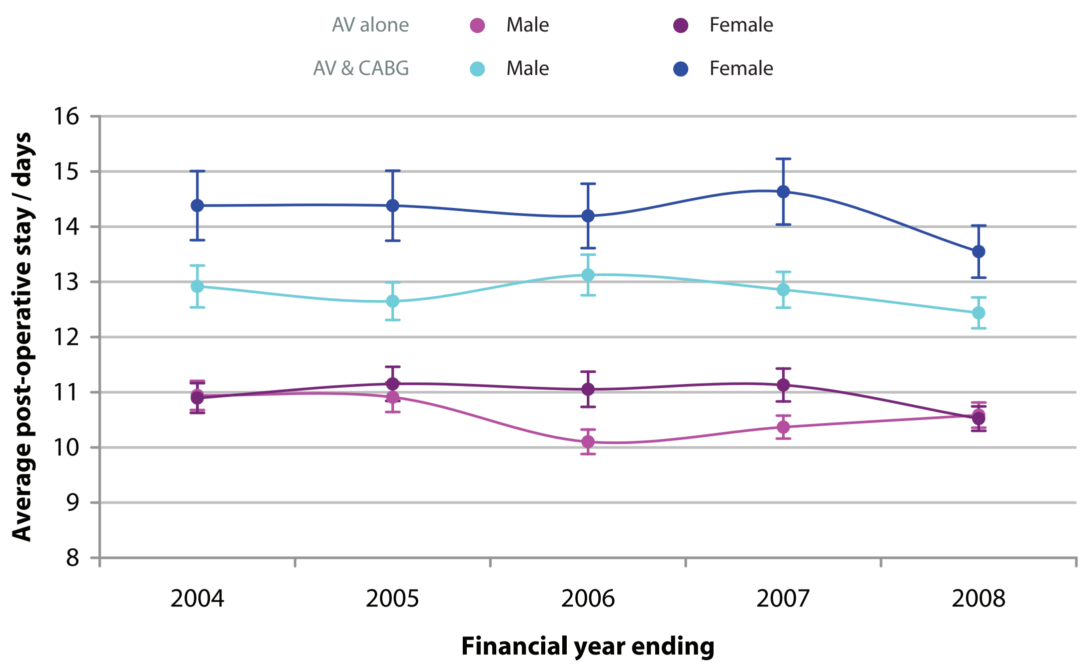
As with coronary artery bypass surgery, length-of-stay is greater for women than men.

This is more marked for combined AVR & CABG surgery than it is for isolated AVR.

Post-operative stay and gender; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

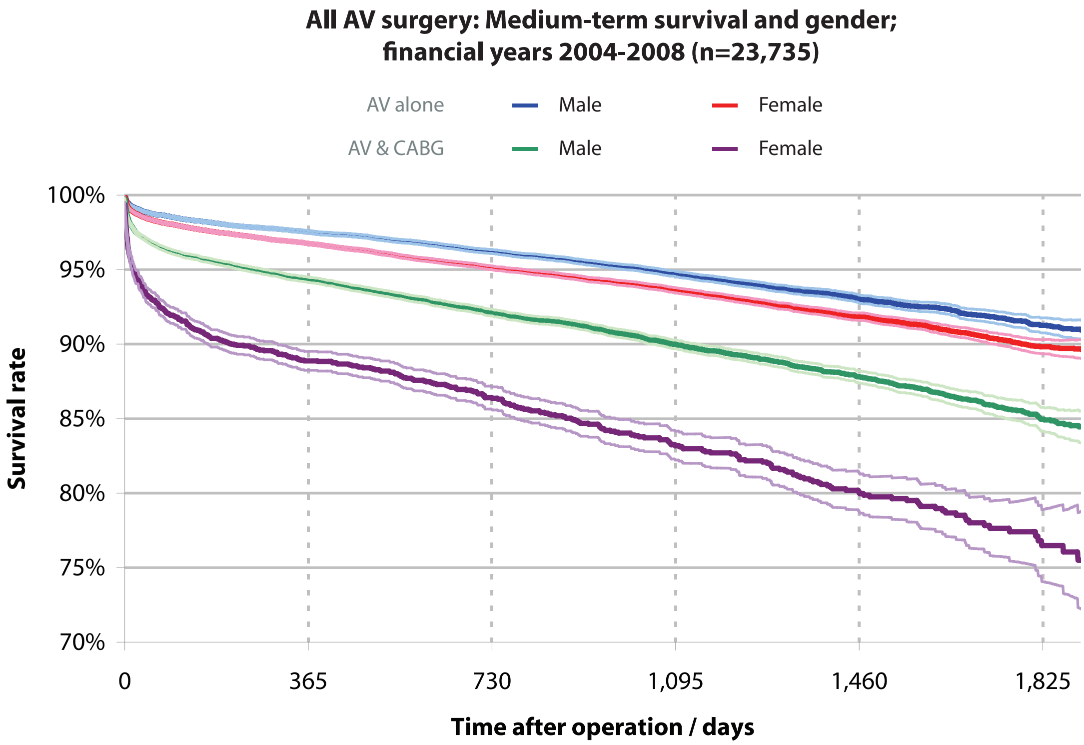
Financial year	Procedure: Aortic valve, Male	Procedure: Aortic valve, Female	Procedure: Aortic valve & CABG, Male	Procedure: Aortic valve & CABG, Female
2004	10.9 1,744	10.9 1,160	12.9 1,377	14.4 561
2005	10.9 1,854	11.2 1,266	12.6 1,472	14.4 642
2006	10.1 1,839	11.1 1,238	13.1 1,577	14.2 638
2007	10.4 2,108	11.1 1,508	12.9 1,975	14.6 777
2008	10.6 2,496	10.5 1,784	12.4 2,178	13.5 898
All	**10.6** **10,041**	**10.9** **6,956**	**12.8** **8,579**	**14.2** **3,516**

All AV surgery: Post-operative stay and gender; bars denote standard error (n=29,092)



Survival and gender

Medium-term survival is again worse for women than for men, and this is more marked for combined AVR & CABG surgery than it is for isolated AVR.



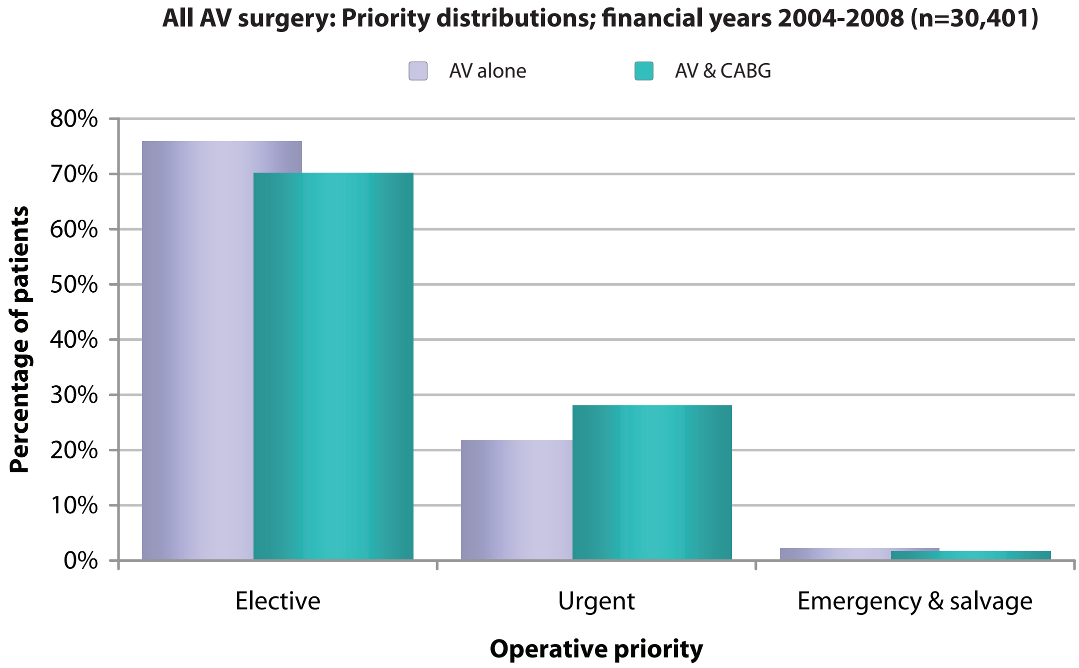
Priority

Priority distributions

75% of isolated AVRs are undertaken as elective operations. Only 2% are carried out as emergency operations with almost all the others being urgent in-hospital cases. The distribution is similar for combined surgery.

Priority distributions; financial years 2004-2008

		Procedure		
		Aortic valve	Aortic valve & CABG	**All**
Priority	Elective	13,494	8,872	**22,366**
	Urgent	3,883	3,550	**7,433**
	Emergency	369	202	**571**
	Salvage	30	11	**41**
	Unspecified	21	11	**32**
	All	**17,797**	**12,646**	**30,433**



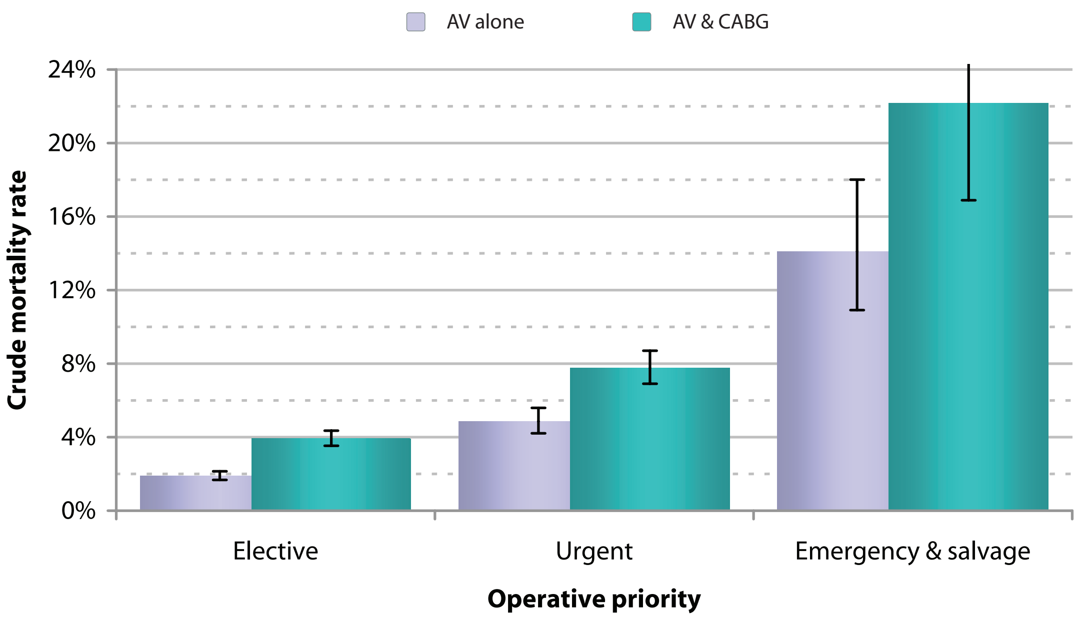
Mortality and priority

As with coronary surgery, mortality is strongly associated with operative priority for both isolated AVR and combined AVR & CABG surgery. The mortality rate for elective isolated AVR surgery is 1.9%.

Mortality and priority; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Aortic valve	Aortic valve & CABG	**All**
Priority	Elective	1.9% 13,440	3.9% 8,819	**2.7%** **22,259**
	Urgent	4.9% 3,870	7.8% 3,532	**6.2%** **7,402**
	Emergency	10.4% 367	21.9% 201	**14.4%** **568**
	Salvage	60.0% 30	27.3% 11	**51.2%** **41**
	Unspecified	4.8% 21	0.0% 11	**3.1%** **32**
	All	**2.8%** **17,728**	**5.3%** **12,574**	**3.9%** **30,302**

All AV surgery: Mortality and priority; financial years 2004-2008 (n=30,270)



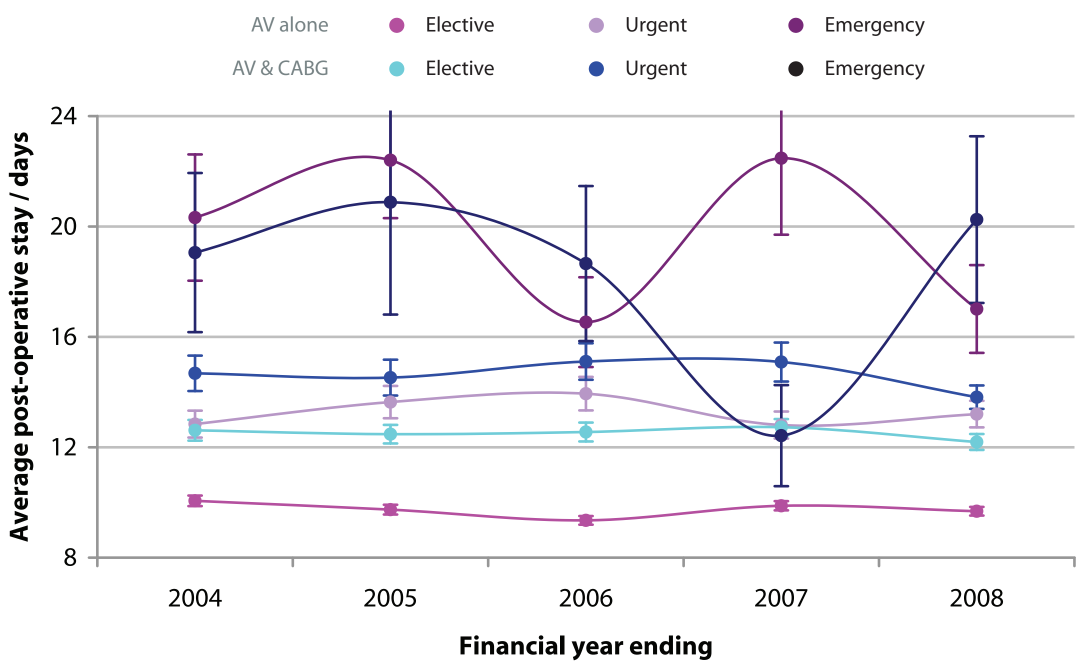
Post-operative stay and priority

There is, again, a difference in length-of-stay according to priority with urgent and emergency patients staying longer than elective patients.

Post-operative stay and priority; financial years 2004-2008; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

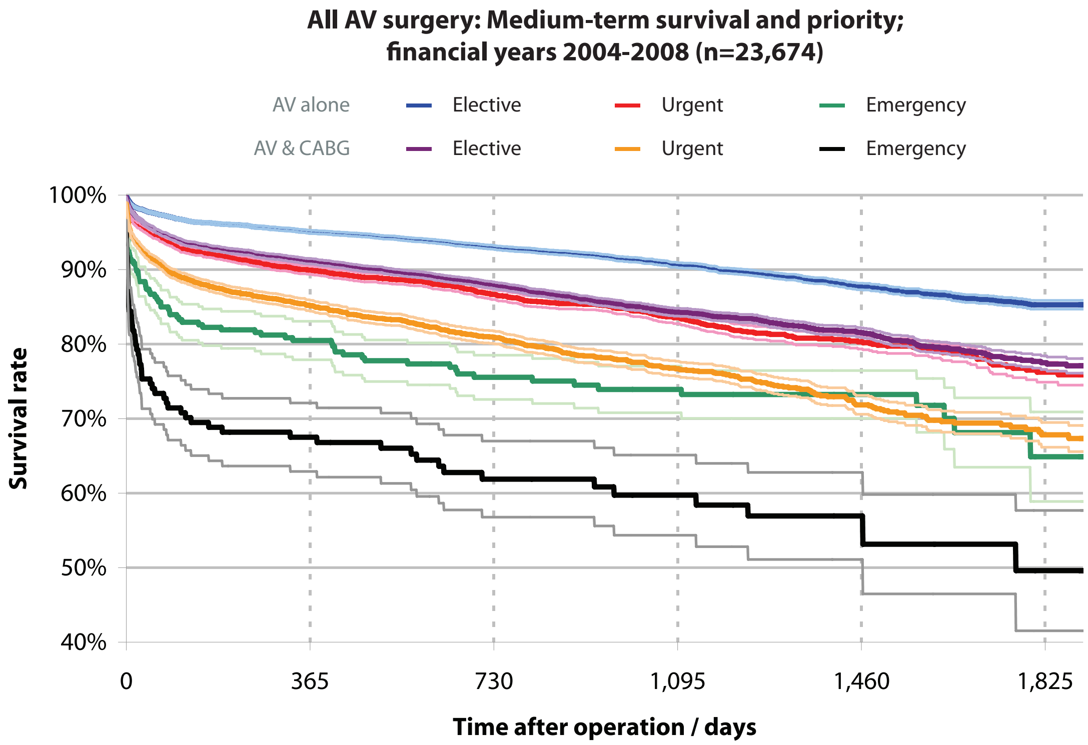
		Procedure		
		Aortic valve	Aortic valve & CABG	All
Priority	Elective	9.7 12,912	12.5 8,501	**10.8** **21,413**
	Urgent	13.3 3,686	14.6 3,381	**13.9** **7,067**
	Emergency	19.5 350	18.3 191	**19.1** **541**
	Salvage	14.6 28	22.8 11	**16.9** **39**
	Unspecified	11.1 21	9.5 11	**10.6** **32**
	All	**10.7** **16,997**	**13.2** **12,095**	**11.7** **29,092**

All AV surgery: Post-operative stay and priority; bars denote standard error (n=29,021)



Survival and priority

Priority of surgery is strongly associated with medium-term survival. The medium-term survival rate for emergency patients undergoing combined surgery is only 50% 5 years after surgery.



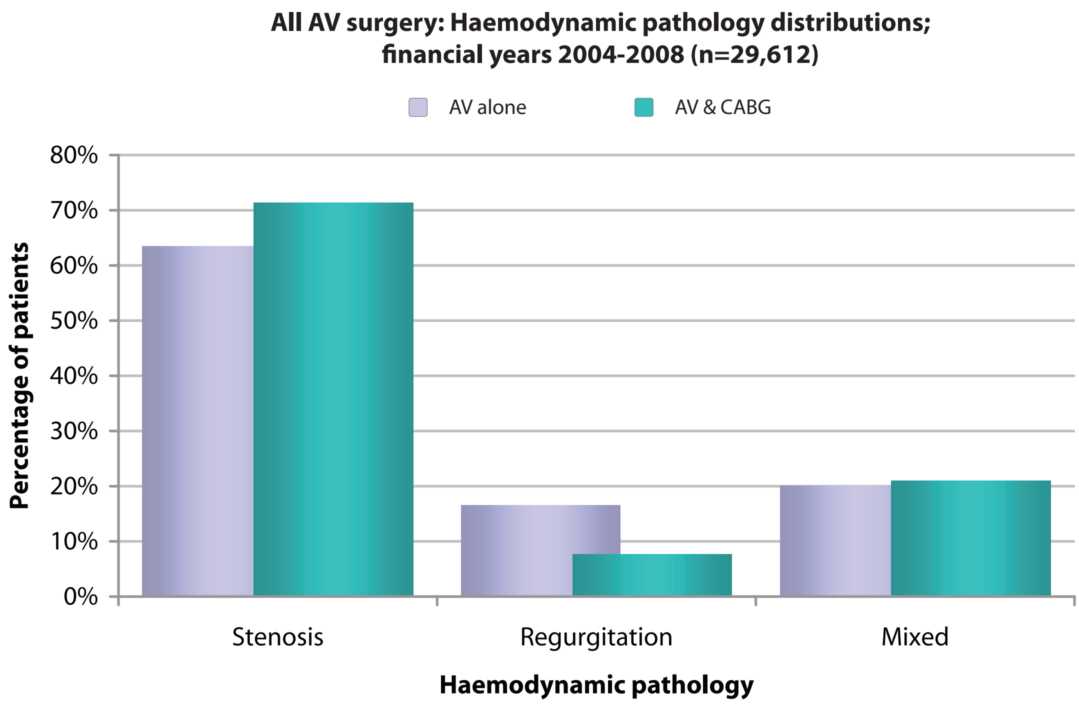
Haemodynamic pathology

Haemodynamic pathology distributions

Overall, 62% of isolated AVR operations were for aortic stenosis and 16% for aortic regurgitation, with a slightly higher proportion being for stenosis in the combined AVR & CABG group; these proportions have changed little over time.

Haemodynamic pathology distributions; financial years 2004-2008

		Procedure		
		Aortic valve	Aortic valve & CABG	**All**
Haemodynamic pathology	Stenosis	10,994	8,765	**19,759**
	Regurgitation	2,863	936	**3,799**
	Mixed	3,471	2,583	**6,054**
	Unspecified	469	362	**831**
	All	**17,797**	**12,646**	**30,443**



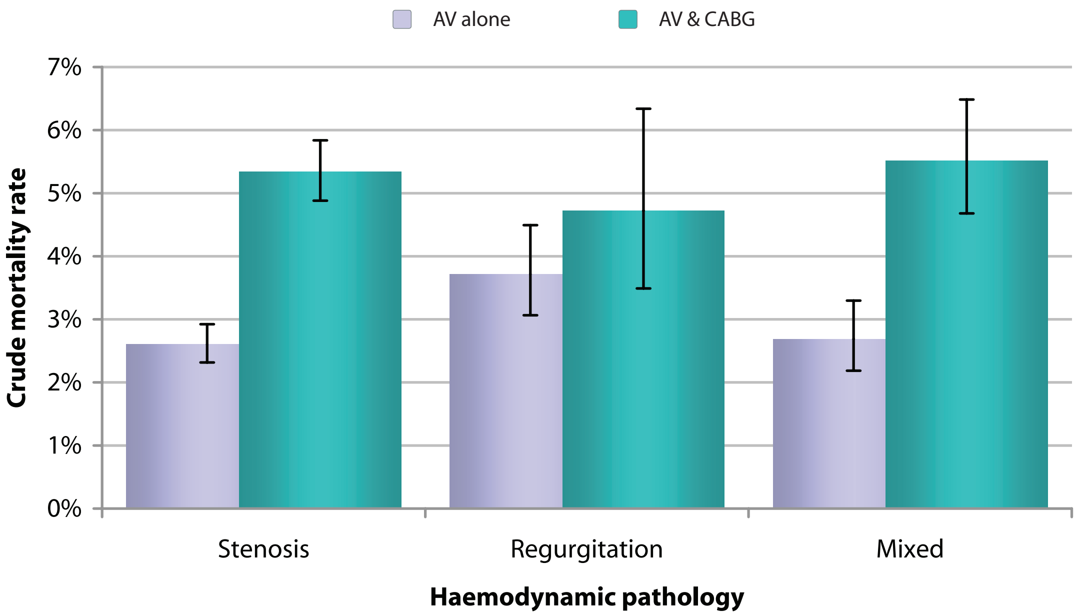
Mortality and haemodynamic pathology

The mortality rate for isolated operations for aortic stenosis is lower than that for regurgitation. The mortality rate for mixed stenosis / regurgitation is similar to that for stenosis alone. The mortality rates for combined AVR & CABG operations seem to be independent of the haemodynamic pathology.

Mortality and haemodynamic pathology; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Aortic valve	Aortic valve & CABG	**All**
Haemodynamic pathology	Stenosis	2.6% 10,948	5.3% 8,708	**3.8%** **19,656**
	Regurgitation	3.7% 2,853	4.7% 932	**4.0%** **3,785**
	Mixed	2.7% 3,460	5.5% 2,575	**3.9%** **6,035**
	Unspecified	3.4% 467	4.5% 359	**3.9%** **826**
	All	**2.8%** **17,728**	**5.3%** **12,574**	**3.9%** **30,302**

All AV surgery: Mortality and haemodynamic pathology; financial years 2004-2008 (n=29,476)

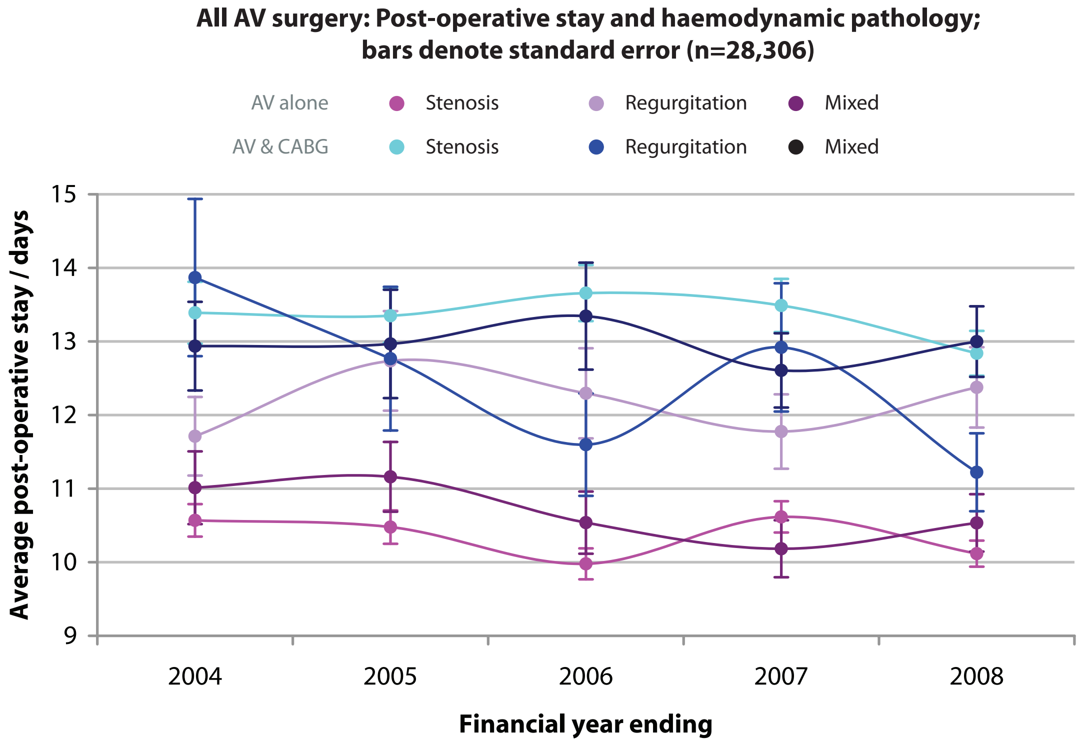


Post-operative stay and haemodynamic pathology

There is no real difference in the post-operative stay for patients who have had surgery for aortic stenosis or regurgitation. But, those having the more complex combined AVR & CABG operation tend to spend 3 days longer in hospital after their procedure than those having isolated AVR.

Post-operative stay and haemodynamic pathology; financial years 2004-2008; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

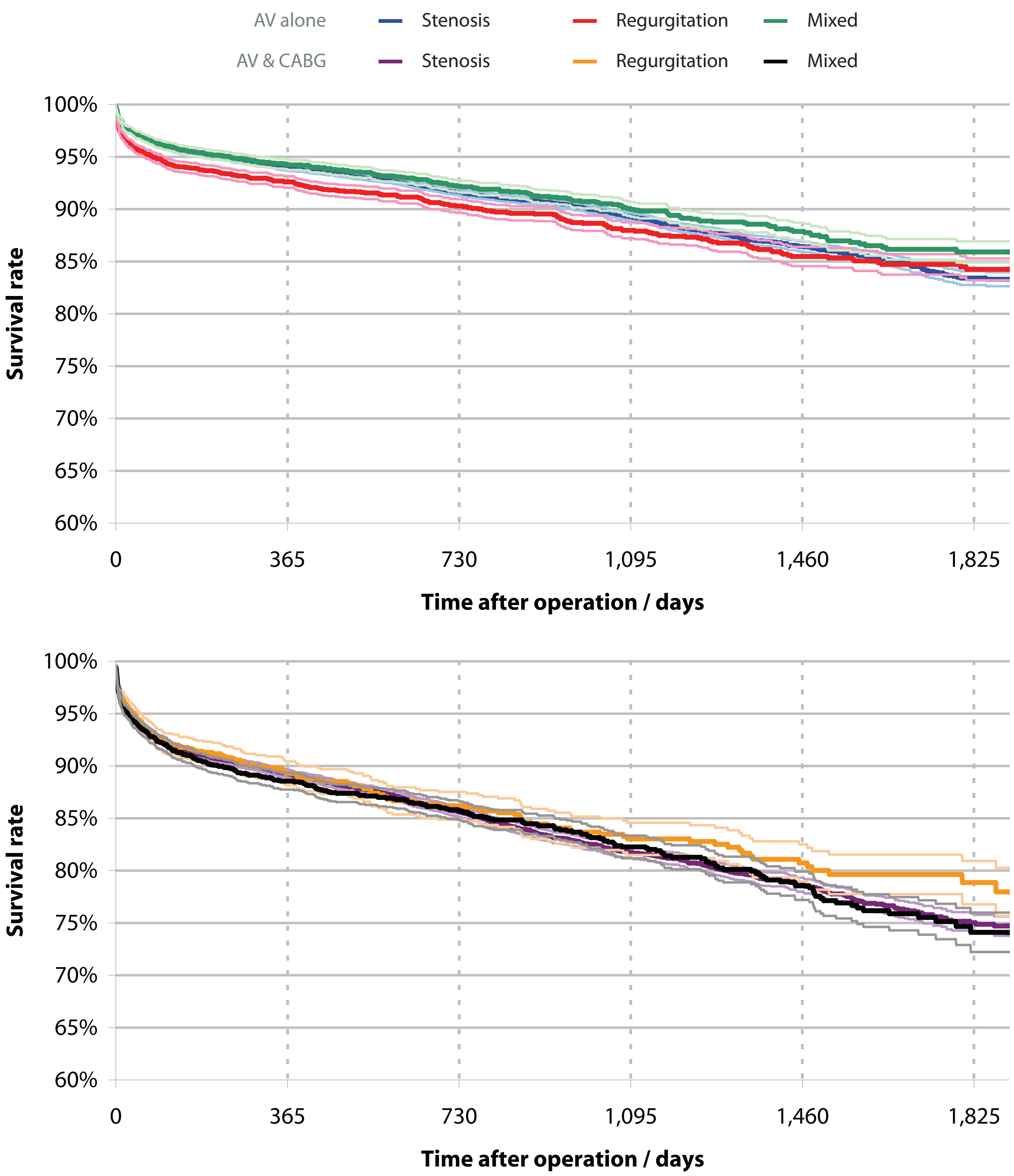
		Procedure		
		Aortic valve	Aortic valve & CABG	**All**
Haemodynamic pathology	Stenosis	10.3 10,464	13.3 8,359	**11.7** **18,823**
	Regurgitation	12.2 2,741	12.4 908	**12.2** **3,649**
	Mixed	10.7 3,351	13.0 2,483	**11.6** **5,834**
	Unspecified	11.1 441	13.8 345	**12.3** **786**
	All	**10.7** **16,997**	**13.2** **12,095**	**11.7** **29,092**



Survival and haemodynamic pathology

There is no difference in medium-term survival depending on the haemodynamic indication for aortic valve replacement.

All AV surgery: Medium-term survival and haemodynamic pathology; financial years 2004-2008 (n=23,685)



Isolated aortic valve surgery

Distributions and outcome rates for major risk factors not reported in detail

Risk factor		Count	Mortality rate (count; 95% CI)
Body mass index	Underweight	775	5.8% (771; 4.3-7.8%)
	Normal	4,662	2.8% (4,636; 2.3-3.3%)
	Overweight	6,680	2.5% (6,663; 2.1-2.9%)
	Obese	3,342	2.5% (3,329; 2.0-3.1%)
	Morbidly obese	1,390	3.3% (1,384; 2.4-4.4%)
	Unspecified	948	
Ejection fraction	Good	12,773	2.1% (12,725; 1.8-2.3%)
	Fair	3,506	4.1% (3,496; 3.5-4.8%)
	Poor	955	7.2% (951; 5.6-9.0%)
	Unspecified	563	
LMS disease	No	14,541	2.7% (14,495; 2.4-3.0%)
	Yes	137	9.6% (136; 5.4-16.1%)
	Unspecified	3,119	
Previous cardiac surgery	No	15,911	2.3% (15,850; 2.0-2.5%)
	Yes	1,583	8.5% (1,577; 7.2-10.0%)
	Unspecified	303	
Diabetes	No	15,598	2.6% (15,538; 2.4-2.9%)
	Yes	1,979	4.2% (1,973; 3.3-5.2%)
	Unspecified	220	
Hypertension	No	8,371	2.3% (8,343; 2.0-2.7%)
	Yes	9,190	3.2% (9,151; 2.9-3.6%)
	Unspecified	236	
Extra-cardiac arteriopathy	No	16,546	2.6% (16,489; 2.3-2.8%)
	Yes	1,070	6.4% (1,060; 5.0-8.1%)
	Unspecified	181	
Renal disease	No	16,812	2.5% (16,749; 2.3-2.8%)
	Yes	478	12.4% (475; 9.7-15.8%)
	Unspecified	507	
Angina	CCS0	9,494	2.8% (9,458; 2.5-3.2%)
	CCS1	2,634	2.4% (2,622; 1.9-3.1%)
	CCS2	3,116	2.3% (3,102; 1.8-2.9%)
	CCS3	1,349	3.6% (1,345; 2.7-4.8%)
	CC4	375	5.9% (374; 3.8-8.9%)
	Unspecified	829	
Dyspnoea	NYHA 1	2,609	1.8% (2,603; 1.4-2.5%)
	NYHA 2	6,824	1.7% (6,800; 1.4-2.1%)
	NYHA 3	6,520	3.0% (6,491; 2.6-3.5%)
	NYHA 4	1,487	8.5% (1,479; 7.2-10.1%)
	Unspecified	357	

Post-operative stay / days (count; SE)	Post-operative stroke rate (count; 95% CI)	Re-op for bleeding rate (count; 95% CI)	Survival rate at 5 years
12.4 (750; 0.44)	3.1% (641; 2.0-4.9%)	7.8% (628; 5.9-10.3%)	72.8%
11.0 (4,500; 0.17)	2.4% (4,061; 2.0-2.9%)	7.5% (3,958; 6.7-8.4%)	83.2%
10.2 (6,488; 0.13)	1.7% (5,901; 1.4-2.1%)	4.9% (5,745; 4.3-5.5%)	84.2%
10.5 (3,249; 0.17)	1.6% (2,999; 1.2-2.1%)	4.6% (2,938; 3.9-5.4%)	84.0%
11.4 (1,353; 0.32)	1.4% (1,238; 0.8-2.2%)	4.1% (1,193; 3.1-5.4%)	80.2%
10.1 (12,184; 0.09)	1.6% (11,324; 1.4-1.9%)	5.4% (10,841; 5.0-5.9%)	85.3%
11.7 (3,347; 0.21)	2.6% (3,053; 2.0-3.2%)	6.1% (2,992; 5.3-7.0%)	77.8%
14.3 (910; 0.49)	2.6% (835; 1.7-4.0%)	5.9% (820; 4.4-7.7%)	70.8%
10.5 (14,038; 0.09)	1.8% (13,594; 1.6-2.1%)	5.2% (12,790; 4.9-5.6%)	83.4%
15.7 (133; 1.83)	3.2% (125; 1.0-8.5%)	5.8% (120; 2.6-12.1%)	58.9%
10.4 (15,189; 0.08)	1.5% (13,983; 1.3-1.8%)	5.3% (13,398; 5.0-5.7%)	83.6%
13.9 (1,515; 0.40)	5.0% (1,384; 3.9-6.3%)	7.2% (1,354; 5.9-8.7%)	74.2%
10.5 (14,904; 0.09)	1.8% (13,783; 1.6-2.0%)	5.5% (13,193; 5.1-5.9%)	84.0%
12.2 (1,896; 0.27)	2.4% (1,735; 1.7-3.2%)	6.1% (1,693; 5.1-7.4%)	71.8%
10.4 (7,986; 0.12)	1.4% (7,408; 1.1-1.7%)	5.7% (7,079; 5.2-6.3%)	85.1%
10.9 (8,785; 0.11)	2.3% (8,092; 2.0-2.6%)	5.3% (7,805; 4.8-5.9%)	80.5%
10.5 (15,783; 0.08)	1.7% (14,579; 1.5-1.9%)	5.4% (13,968; 5.0-5.8%)	83.3%
13.2 (1,036; 0.48)	3.9% (956; 2.8-5.3%)	7.1% (928; 5.6-9.0%)	74.0%
10.4 (16,296; 0.08)	1.8% (14,847; 1.6-2.1%)	5.4% (14,463; 5.0-5.8%)	83.7%
19.4 (456; 1.04)	3.7% (405; 2.2-6.2%)	8.8% (400; 6.3-12.1%)	58.5%
10.9 (9,185; 0.12)	1.9% (8,690; 1.6-2.2%)	5.6% (8,270; 5.1-6.1%)	81.9%
10.4 (2,452; 0.20)	1.6% (2,372; 1.2-2.3%)	5.5% (2,155; 4.6-6.5%)	84.6%
10.0 (2,942; 0.17)	1.7% (2,853; 1.3-2.2%)	5.1% (2,636; 4.3-6.1%)	86.5%
11.1 (1,292; 0.30)	2.1% (1,239; 1.4-3.1%)	5.8% (1,132; 4.6-7.4%)	79.9%
12.1 (362; 0.70)	3.7% (348; 2.1-6.5%)	6.1% (330; 3.8-9.4%)	76.3%
9.8 (2,491; 0.19)	1.4% (2,115; 0.9-2.0%)	6.0% (2,148; 5.1-7.1%)	87.4%
9.5 (6,517; 0.10)	1.5% (6,070; 1.2-1.9%)	5.0% (5,758; 4.5-5.6%)	87.2%
11.3 (6,287; 0.14)	2.2% (5,945; 1.8-2.6%)	5.7% (5,631; 5.1-6.3%)	80.6%
14.9 (1,434; 0.42)	2.8% (1,363; 2.0-3.8%)	6.6% (1,304; 5.3-8.1%)	66.4%

Combined aortic valve & CABG surgery

Distributions and outcome rates for major risk factors not reported in detail

Risk factor		Count	Mortality rate (count; 95% CI)
Body mass index	Underweight	409	8.9% (406; 6.4-12.2%)
	Normal	3,088	6.3% (3,070; 5.4-7.2%)
	Overweight	5,127	4.5% (5,101; 4.0-5.1%)
	Obese	2,579	4.8% (2,567; 4.0-5.7%)
	Morbidly obese	871	5.0% (863; 3.7-6.7%)
	Unspecified	572	
Ejection fraction	Good	8,090	3.8% (8,047; 3.4-4.3%)
	Fair	3,407	7.0% (3,388; 6.1-7.9%)
	Poor	858	12.8% (850; 10.7-15.3%)
	Unspecified	291	
LMS disease	No	9,714	4.9% (9,654; 4.5-5.4%)
	Yes	1,529	7.7% (1,520; 6.4-9.2%)
	Unspecified	1,403	
Previous cardiac surgery	No	12,036	4.9% (11,969; 4.5-5.3%)
	Yes	484	14.7% (482; 11.8-18.3%)
	Unspecified	126	
Diabetes	No	9,916	5.0% (9,863; 4.6-5.5%)
	Yes	2,593	6.4% (2,576; 5.5-7.5%)
	Unspecified	137	
Hypertension	No	3,858	4.9% (3,845; 4.2-5.6%)
	Yes	8,649	5.5% (8,591; 5.0-6.0%)
	Unspecified	139	
Extra-cardiac arteriopathy	No	10,639	4.9% (10,584; 4.5-5.3%)
	Yes	1,859	7.9% (1,844; 6.7-9.2%)
	Unspecified	148	
Renal disease	No	11,883	5.0% (11,818; 4.6-5.4%)
	Yes	405	14.3% (400; 11.1-18.2%)
	Unspecified	358	
Angina	CCS0	2,695	5.5% (2,677; 4.6-6.4%)
	CCS1	1,677	3.7% (1,673; 2.9-4.8%)
	CCS2	3,952	4.2% (3,929; 3.6-4.9%)
	CCS3	2,878	5.6% (2,856; 4.8-6.5%)
	CC4	875	10.9% (871; 9.0-13.2%)
	Unspecified	569	
Dyspnoea	NYHA 1	1,585	4.8% (1,584; 3.8-6.0%)
	NYHA 2	4,853	3.6% (4,831; 3.1-4.2%)
	NYHA 3	5,010	5.6% (4,971; 5.0-6.3%)
	NYHA 4	1,021	12.1% (1,013; 10.2-14.4%)
	Unspecified	177	

Post-operative stay / days (count; SE)	Post-operative stroke rate (count; 95% CI)	Re-op for bleeding rate (count; 95% CI)	Survival rate at 5 years
14.7 (399; 0.80)	1.5% (327; 0.6-3.7%)	10.9% (329; 7.9-14.9%)	63.2%
13.0 (2,965; 0.25)	3.4% (2,650; 2.8-4.2%)	8.1% (2,603; 7.1-9.3%)	70.2%
12.9 (4,987; 0.20)	3.3% (4,521; 2.8-3.9%)	7.5% (4,428; 6.7-8.3%)	77.3%
13.2 (2,506; 0.27)	2.2% (2,260; 1.7-2.9%)	5.5% (2,217; 4.6-6.5%)	74.6%
14.6 (842; 0.56)	2.1% (772; 1.2-3.4%)	3.7% (757; 2.5-5.4%)	75.9%
12.4 (7,739; 0.15)	2.6% (7,150; 2.3-3.0%)	6.6% (6,879; 6.1-7.2%)	78.5%
14.3 (3,234; 0.29)	3.7% (2,920; 3.1-4.5%)	8.3% (2,868; 7.4-9.4%)	68.9%
17.1 (834; 0.64)	3.2% (721; 2.1-4.8%)	6.3% (719; 4.7-8.4%)	54.5%
13.1 (9,370; 0.15)	2.9% (9,037; 2.6-3.3%)	6.9% (8,458; 6.4-7.4%)	74.9%
14.1 (1,459; 0.41)	2.8% (1,389; 2.0-3.9%)	7.3% (1,307; 5.9-8.8%)	72.0%
13.1 (11,508; 0.13)	3.0% (10,471; 2.7-3.3%)	7.0% (10,146; 6.5-7.5%)	74.6%
14.6 (468; 0.76)	2.3% (432; 1.2-4.4%)	6.9% (420; 4.8-9.9%)	63.7%
12.8 (9,487; 0.14)	2.7% (8,679; 2.4-3.1%)	7.2% (8,356; 6.7-7.8%)	75.7%
14.6 (2,495; 0.31)	3.8% (2,264; 3.1-4.7%)	6.1% (2,231; 5.2-7.2%)	68.5%
12.6 (3,694; 0.22)	2.2% (3,361; 1.7-2.8%)	7.4% (3,265; 6.5-8.3%)	75.4%
13.4 (8,264; 0.16)	3.3% (7,566; 2.9-3.7%)	6.8% (7,315; 6.3-7.4%)	73.8%
12.8 (10,169; 0.13)	2.7% (9,270; 2.4-3.0%)	6.9% (8,934; 6.4-7.5%)	76.1%
15.7 (1,780; 0.43)	4.5% (1,634; 3.6-5.7%)	7.6% (1,612; 6.4-9.1%)	63.7%
12.9 (11,512; 0.13)	3.0% (10,389; 2.6-3.3%)	6.8% (10,196; 6.3-7.3%)	75.4%
21.2 (386; 1.22)	3.8% (338; 2.2-6.7%)	11.6% (328; 8.4-15.7%)	45.9%
13.6 (2,604; 0.29)	2.3% (2,495; 1.8-3.0%)	7.3% (2,337; 6.3-8.4%)	69.9%
12.5 (1,576; 0.37)	2.7% (1,455; 1.9-3.7%)	5.9% (1,417; 4.8-7.3%)	77.7%
12.3 (3,762; 0.20)	3.0% (3,572; 2.4-3.6%)	6.7% (3,324; 5.9-7.6%)	77.5%
13.8 (2,770; 0.30)	3.3% (2,606; 2.7-4.1%)	6.5% (2,463; 5.6-7.6%)	73.5%
16.0 (843; 0.60)	4.4% (811; 3.2-6.2%)	9.6% (780; 7.7-12.0%)	68.0%
11.8 (1,519; 0.30)	2.9% (1,204; 2.1-4.1%)	8.1% (1,271; 6.7-9.8%)	82.4%
11.9 (4,631; 0.18)	2.5% (4,237; 2.1-3.1%)	6.6% (4,081; 5.9-7.4%)	79.7%
13.9 (4,822; 0.22)	3.3% (4,566; 2.8-3.8%)	6.5% (4,315; 5.8-7.3%)	70.8%
17.9 (981; 0.66)	3.5% (919; 2.4-4.9%)	9.3% (903; 7.5-11.4%)	57.5%

Aspects of valve surgery practice

Implanted prosthesis

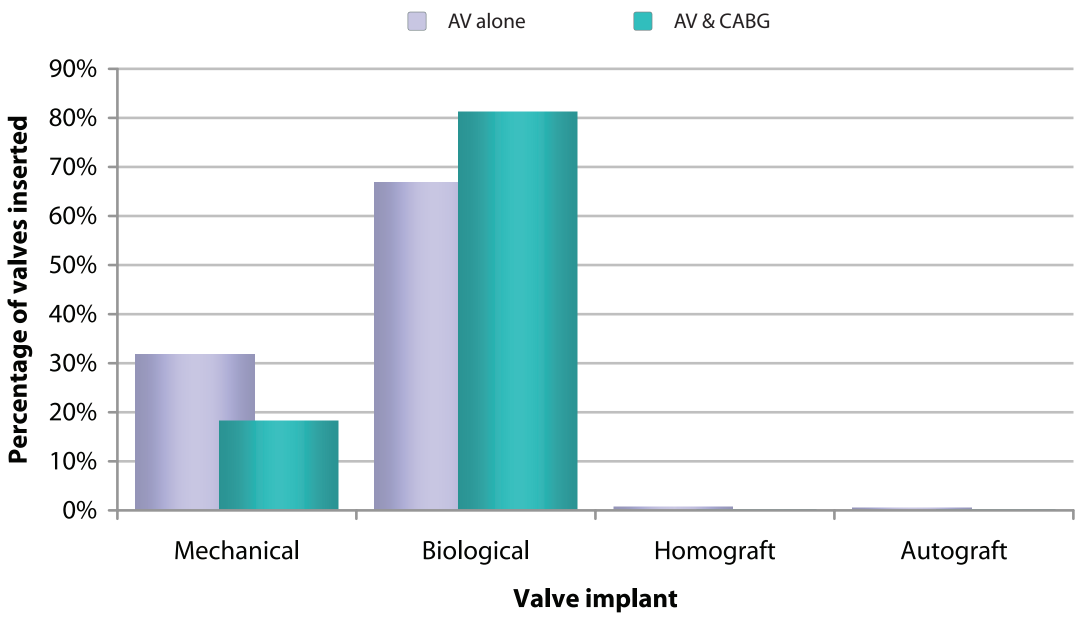
Any patient having a heart valve replaced has a choice of different types of prosthesis. In general there are 3 main choices: a mechanical valve, bioprosthesis (an animal valve) or a homograft (human valve). No replacement valve is perfect and each type has its own advantages and disadvantages. In general, mechanical valves last longer, but there is a tendency for blood clots to form around the hinges of the mechanical valve's leaflets and so patients with these implants need to take warfarin blood-thinning medications indefinitely. Patients with bioprostheses do not usually need to take warfarin indefinitely, but the valve tissues have a risk of wearing out and so they have historically been reserved for older patients.

Between 2004 and 2008, 30% of the implants for isolated AVR were mechanical valves, compared to 18% for combined AVR & CABG surgery, reflecting the increased age in the population for combined surgery. There were only very small numbers of homografts and autografts (an autograft is when the aortic valve is replaced with the patients one pulmonary valve, and the pulmonary valve is then replaced with a bioprosthesis).

Implanted prosthesis distributions; financial years 2004-2008

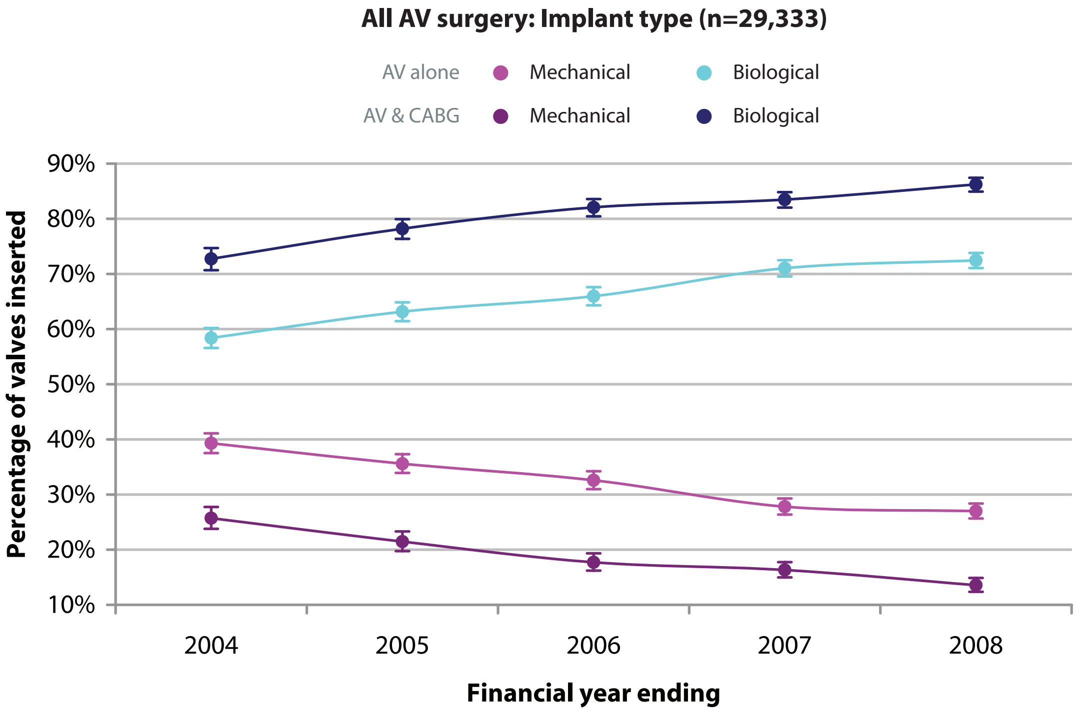
		Procedure		
		Aortic valve	Aortic valve & CABG	**All**
Implant type	Mechanical	5,476	2,224	**7,700**
	Biological	11,485	9,875	**21,360**
	Homograft	126	29	**155**
	Autograft	93	25	**118**
	Unspecified	617	493	**1,110**
	All	**17,797**	**12,646**	**30,443**

All AV surgery: Implant prosthesis distributions; financial years 2004-2008 (n=29,333)



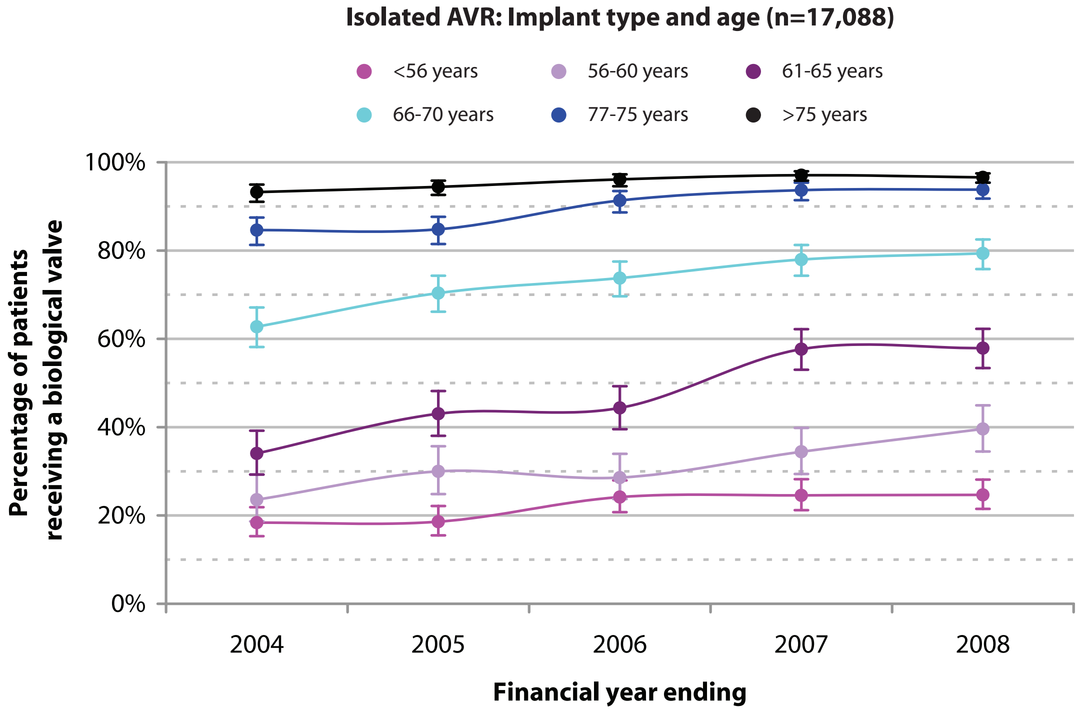
Changes in type of prosthesis with time

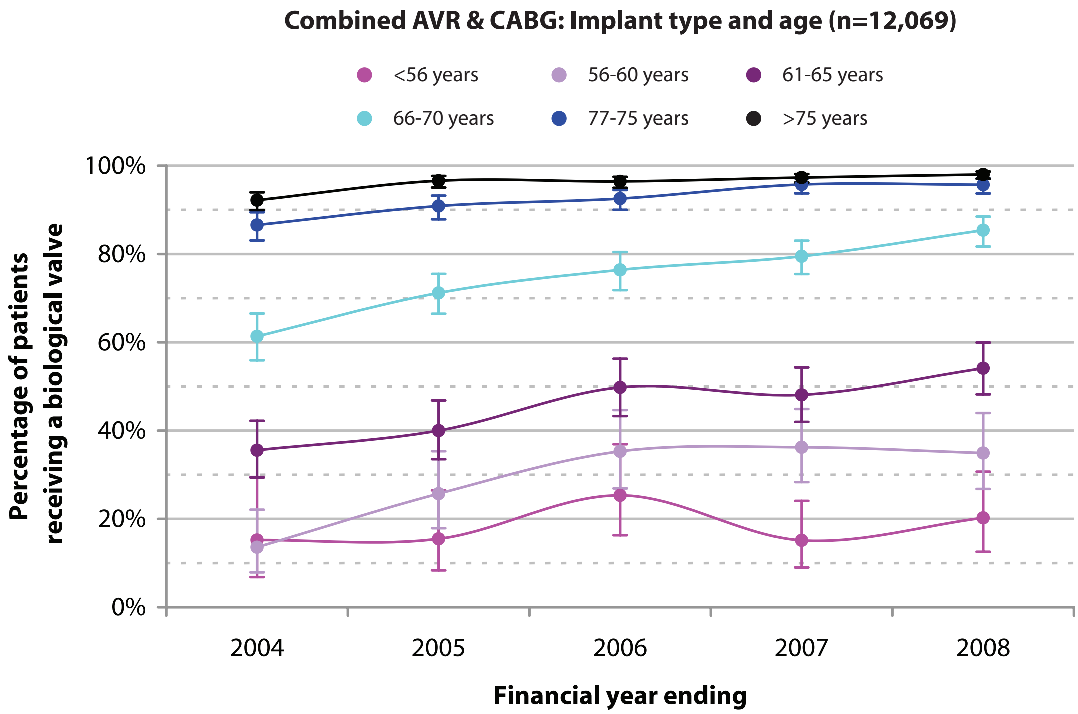
There have been marked changes in the type of prosthesis inserted over time, with big increases in the proportion of biological valves. In 2008 73% of all implanted prostheses for isolated AVR were biological implants and 88% for combined AVR & CABG surgery.



Prosthesis type and age

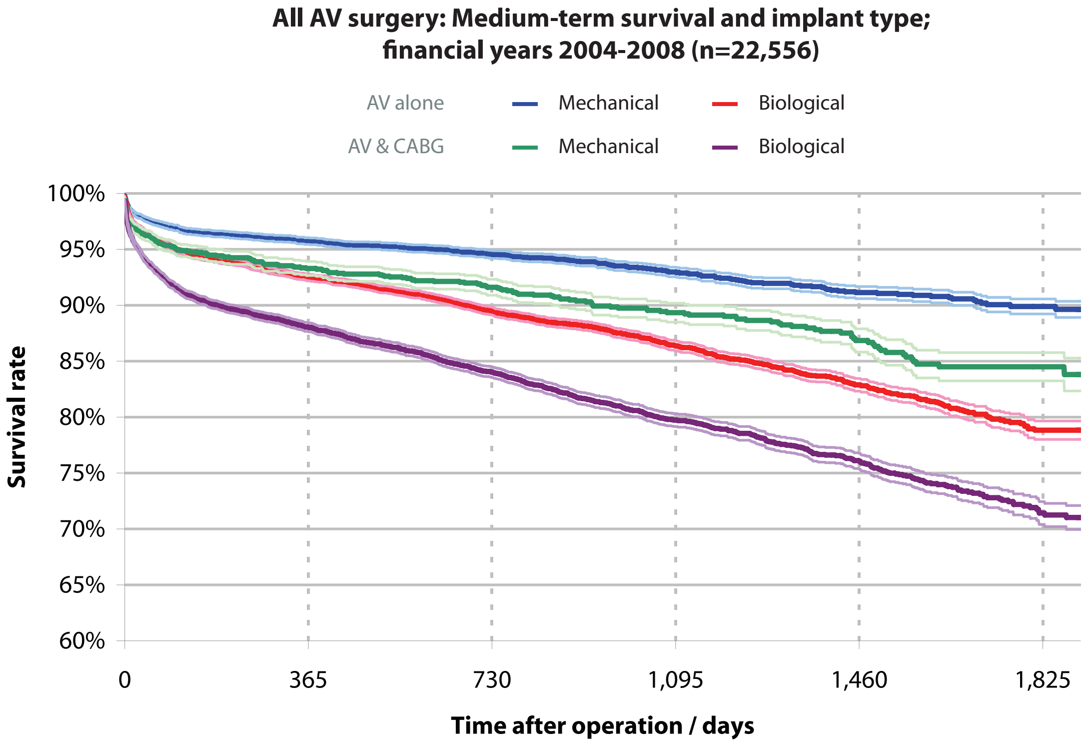
The vast majority of aortic valves inserted in patients over the age of 75 are biological valves. The proportion of biological valves for all younger age groups have shown significant increases over time. This decision-making is based on data that show better longevity for the modern generation biological valves, but this remains somewhat controversial (see references below). It will be important to track the outcomes of these biological valves, particularly in the youngest age groups, to see that the long-term freedom from structural deterioration is as good as expected.





Prosthesis type and medium-term survival

Patients who have mechanical valves have better medium-term survival than those who have biological valves, but this will be due to the older age and higher incidence of most risk factors in the group of patients having biological valves inserted. To unpick these issues any further would probably require more in-depth modelling to adjust for all pertinent risk factors (see references below). However, it is noteworthy that the medium-term survival rate for patients who have had an isolated AVR with a mechanical valve is 90%.



1. Pelletier LC, Carrier M, Leclerk Y, Dyrda I. The Carpentier-Edwards pericardial bioprosthesis; clinical experience with 600 patients. *Ann Thorac Surg.* 1995; **60:** S297-S302

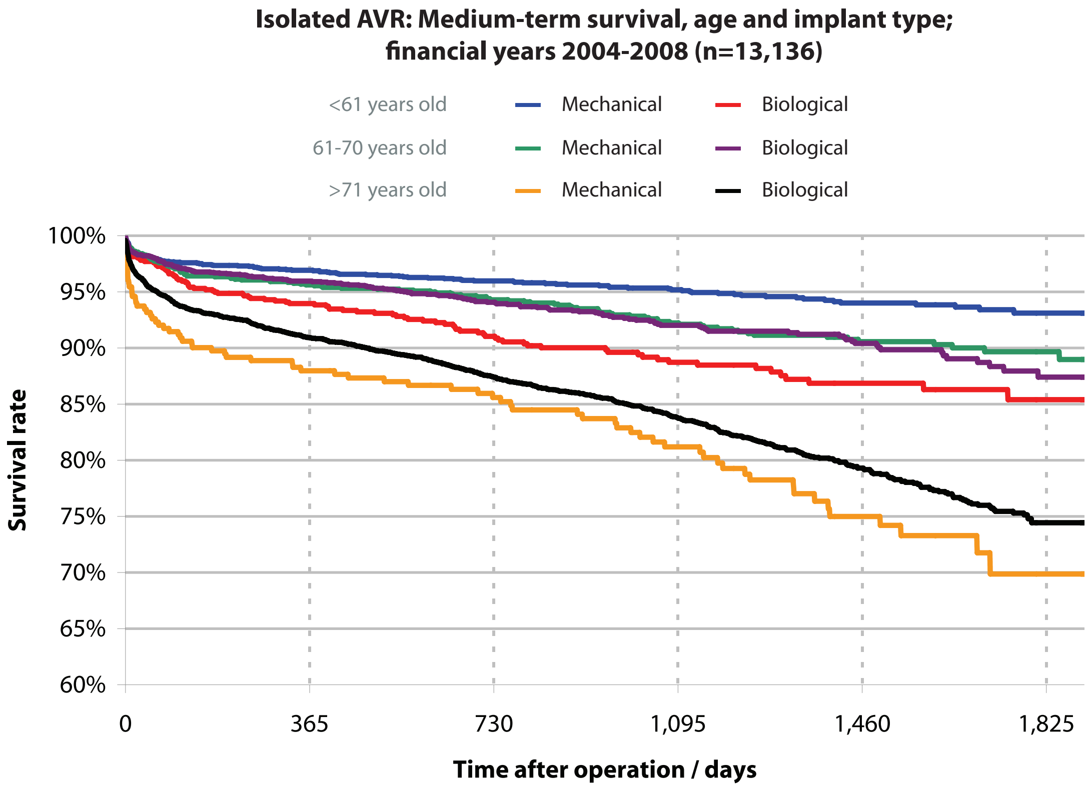
2. Banbury MK, Cosgrove DM, White JA, Blackstone EH, Frater RW, Okies JE. Age and valve size effect on the longterm durability of the Carpentier-Edwards aortic pericardial bioprosthesis. *Ann Thorac Surg.* 2001; **72:** 753-757.

3. Aupart MR, Mirza A, Meurisse YA, Sirinelli AL, Neville PH, Marchand MA. Perimount pericardial bioprosthesis for aortic calcified stenosis; 18-year experience with 1133 patients. *J Heart valve Dis.* 2006; **15(6):** 768-75.

4. Rizzoli G, Mirone S, Lus P, Polesel E, Bottio T, Salvador L, Zussa C, Gerosa G, Valfre C. Fifteen-year results with the Hancock II valve: a multicentre experience. *J Thorac Cardiovasc Surg.* 2006; **13(3):** 602-9.

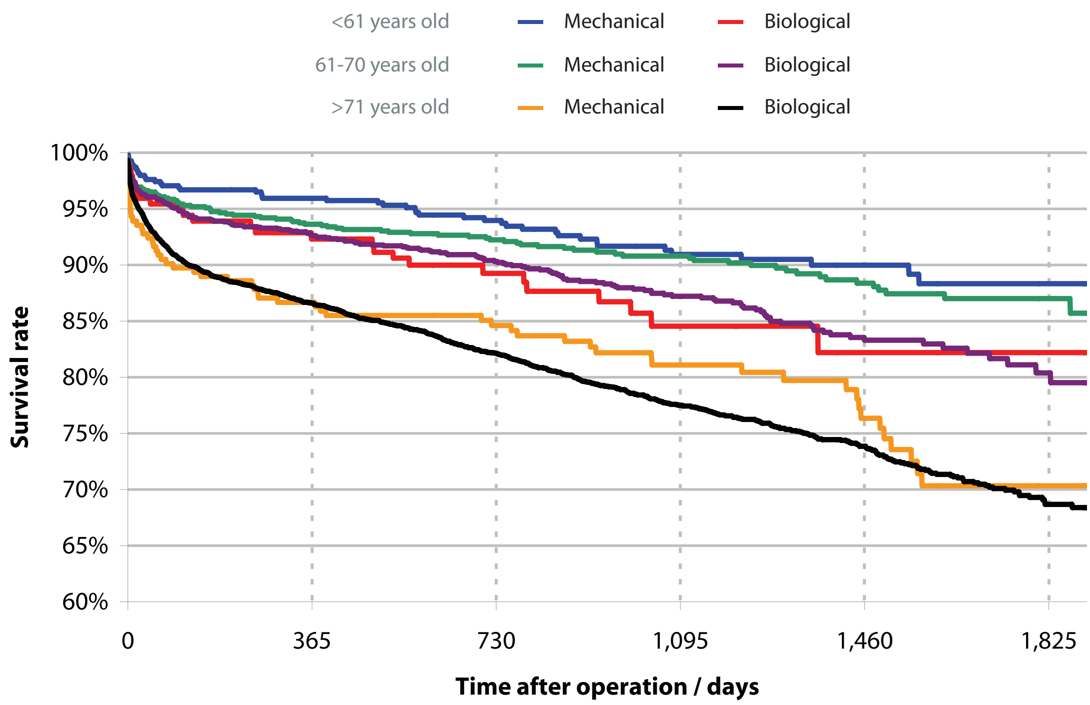
5. Brown ML, Schaff HV, Lahr BD, Mullany CJ, Sundt TM, Dearani JA, McGregor CG, Orszulak TA. Aortic valve replacement in patients aged 50 to 70 years; improved outcome with mechanical versus biologic prostheses. *J Thorac Cardiovasc Surg.* 2008; **135(4):** 878-84.

In the younger patients (less than 61 years) survival is better for those having mechanical rather than biological valves. For those over the age of 70, survival was better for those having biological valves. For those between 61 and 70, there was no difference. To explore these issues in more detail would require complex modelling to account for all possible risk factors.



For patients undergoing combined AVR & CABG surgery, survival in patients under 61 is better for those receiving mechanical rather than biological valves. For those 71 and older there was no difference. For patients aged between 61 and 70, those receiving mechanical valves had a better outcome.

Combined AVR & CABG: Medium-term survival, age and implant type; financial years 2004-2008 (n=9,374)



Other immediate post-operative outcomes

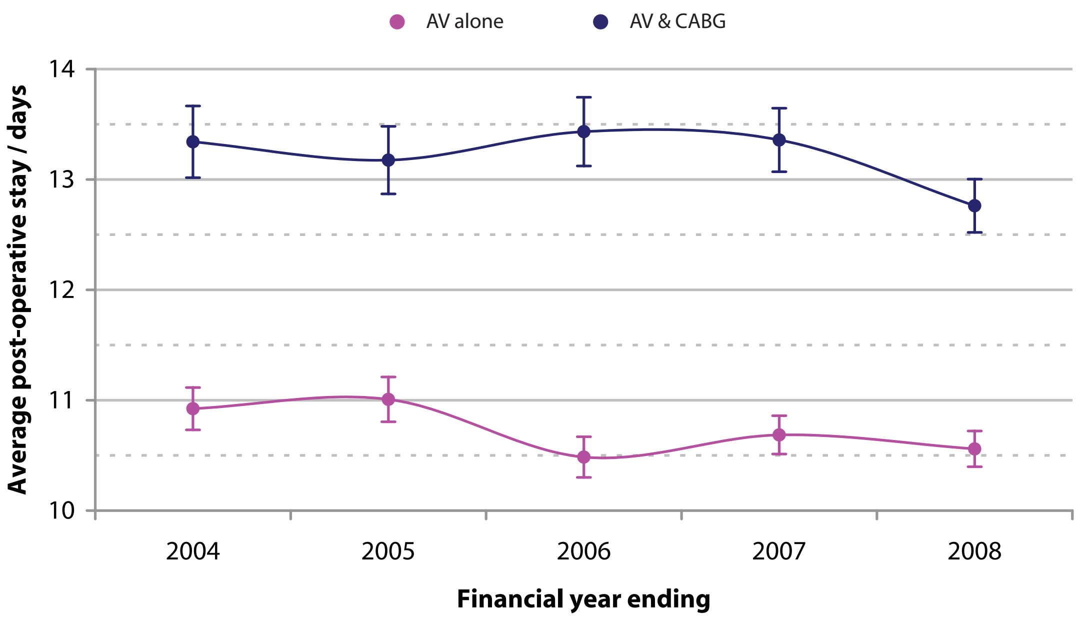
Post-operative stay

The average post-operative length-of-stay is greater for aortic valve surgery than it is for coronary artery bypass surgery (see page 54). The length-of-stay for combined AVR & CABG is greater than for isolated valve surgery.

Post-operative stay; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

		Procedure		
		Aortic valve	Aortic valve & CABG	**All**
Financial year	2004	10.9 2,904	13.3 1,938	**11.9** **4,842**
	2005	11.0 3,120	13.2 2,114	**11.9** **5,234**
	2006	10.5 3,077	13.4 2,215	**11.7** **5,292**
	2007	10.7 3,616	13.4 2,752	**11.8** **6,368**
	2008	10.6 4,280	12.8 3,076	**11.5** **7,356**
	All	**10.7** **16,997**	**13.2** **12,095**	**117** **29,092**

All AV surgery: Post-operative stay; bars denote standard error (n=29,092)



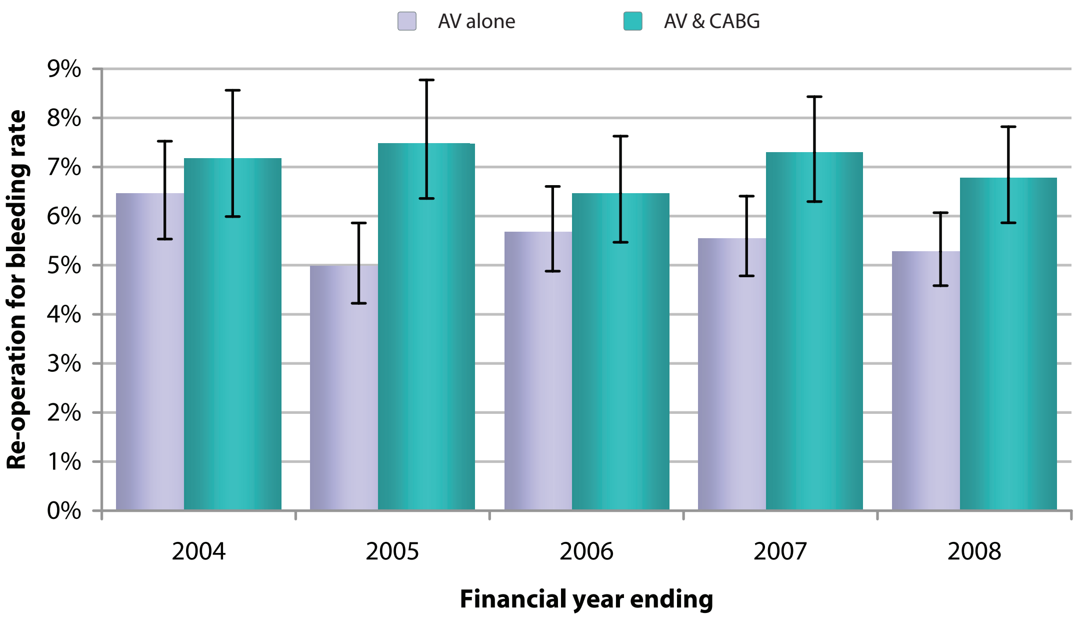
Re-operation for bleeding

Re-operation for bleeding is more common following aortic valve surgery than it is for coronary artery bypass surgery, with an overall rate of 5.5% for isolated AVR and 7% for combined AVR & CABG between 2004 and 2008.

Re-operation for bleeding; the upper numbers represent the crude percentage re-operation rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Aortic valve	Aortic valve & CABG	**All**
Financial year	2004	6.5% 2,446	7.2% 1,631	**6.7%** **4,077**
	2005	5.0% 2,851	7.5% 1,912	**6.0%** **4,763**
	2006	5.7% 2,887	6.5% 2,088	**6.0%** **4,975**
	2007	5.5% 3,177	7.3% 2,372	**6.3%** **5,549**
	2008	5.3% 3,619	6.8% 2,641	**5.9%** **6,260**
	All	**5.5%** **14,980**	**7.0%** **10,644**	**6.2%** **25,624**

All AV surgery [i]: Re-operation for bleeding (n=25,624)



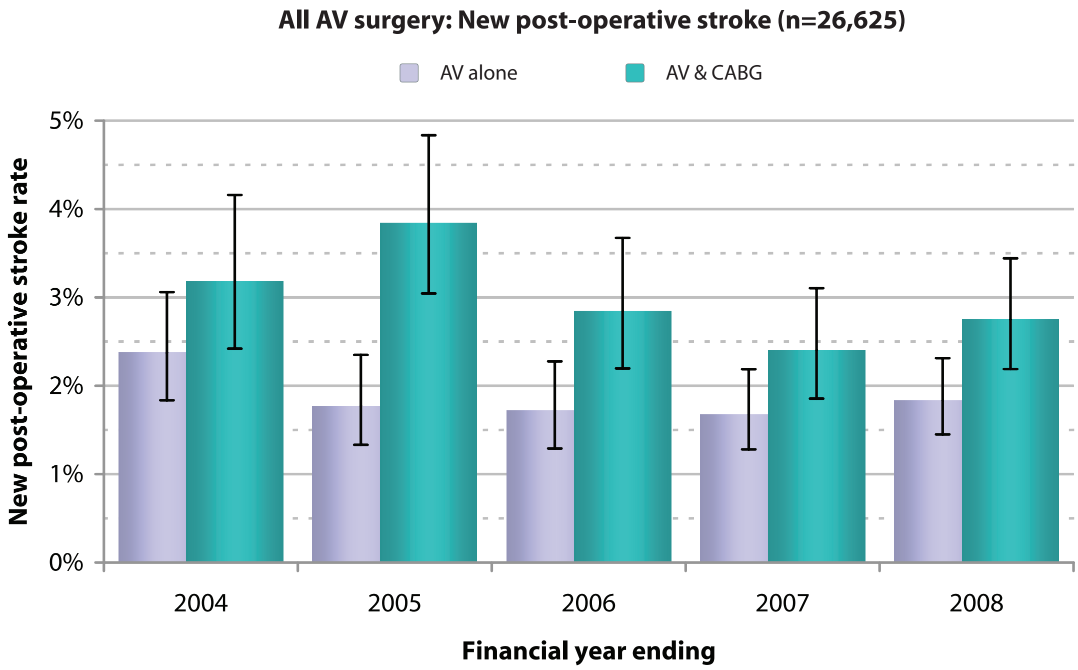
i Includes all aortic valve implants, including redo surgery

New post-operative stroke

The overall incidence of reported new-post-operative stroke is 1.9% for isolated AVR and 2.9% for combined AVR & CABG. These rates are higher than those recorded following isolated CABG (see page 134).

New post-operative stroke; the upper numbers represent the crude percentage stroke rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Aortic valve	Aortic valve & CABG	**All**
Financial year	2004	2.4% 2,569	3.2% 1,698	**2.7%** **4,267**
	2005	1.8% 2,820	3.8% 1,899	**2.6%** **4,719**
	2006	1.7% 2,912	2.8% 2,108	**2.2%** **5,020**
	2007	1.7% 3,340	2.4% 2,496	**2.0%** **5,836**
	2008	1.8% 3,982	2.7% 2,801	**2.2%** **6,783**
	All	**1.9%** **15,623**	**2.9%** **11,002**	**2.3%** **26,625**



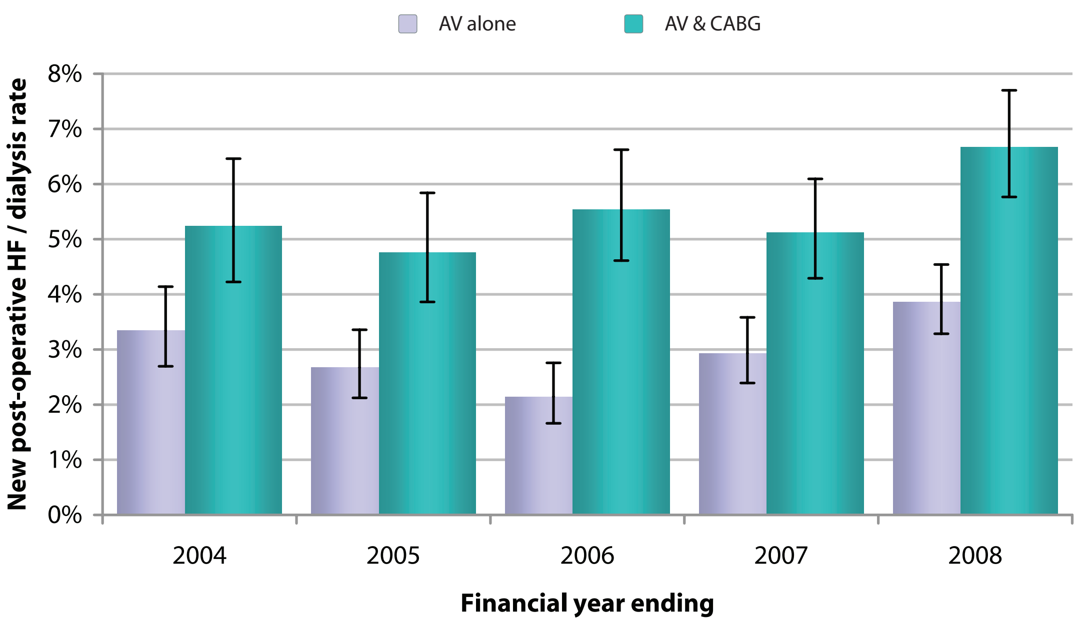
New post-operative HF / dialysis

The overall reported rates of new HF / dialysis were 3.0% and 5.5% following isolated AVR and combined AVR & CABG respectively. These rates are higher than those reported following CABG surgery (see page 138).

New post-operative HF / dialysis; the upper numbers represent the crude percentage HF / dialysis rate and the lower numbers the procedure count within the sub-group

Financial year	Procedure		
	Aortic valve	Aortic valve & CABG	**All**
2004	3.3% 2,541	5.2% 1,624	**4.1%** **4,165**
2005	2.7% 2,806	4.8% 1,892	**3.5%** **4,698**
2006	2.1% 2,892	5.5% 2,096	**3.6%** **4,988**
2007	2.9% 3,275	5.1% 2,422	**3.9%** **5,697**
2008	3.9% 3,803	6.7% 2,669	**5.0%** **6,472**
All	**3.0%** **15,317**	**5.5%** **10,703**	**4.1%** **26,020**

All AV surgery: New post-operative HF / dialysis (n=26,020)



EuroSCORE

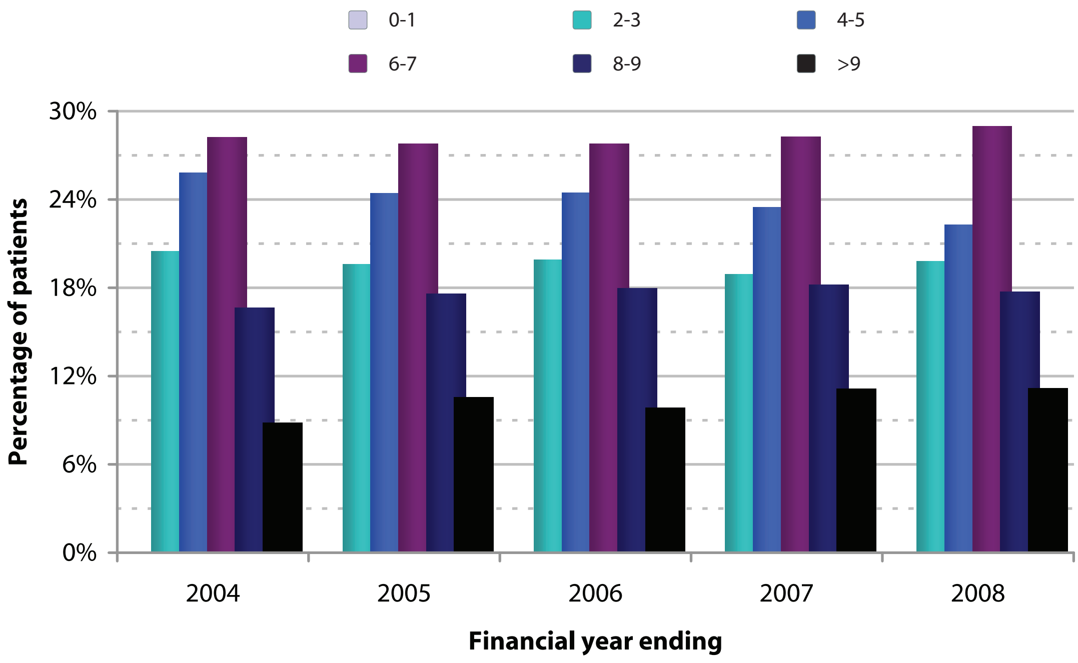
The additive *EuroSCORE*

The findings of the ***EuroSCORE*** analyses are very similar for aortic valve surgery as those presented for isolated CABG surgery. There has been an increase in the proportion of patients in the higher ***EuroSCORE*** groups, and ***EuroSCORE*** systematically over-predicts observed mortality (see page 152).

Additive ***EuroSCORE*** distributions; isolated aortic valve; financial years 2004-2008

		Additive *EuroSCORE* groupings						
		0-1	2-3	4-5	6-7	8-9	>9	**All**
Financial year	2004	0	626	788	862	508	270	**3,054**
	2005	0	637	794	903	572	344	**3,250**
	2006	0	665	816	928	600	329	**3,338**
	2007	0	720	894	1,076	693	424	**3,807**
	2008	0	861	969	1,260	771	487	**4,348**
	All	**0**	**3,509**	**4,261**	**5,029**	**3,144**	**1,854**	**17,797**

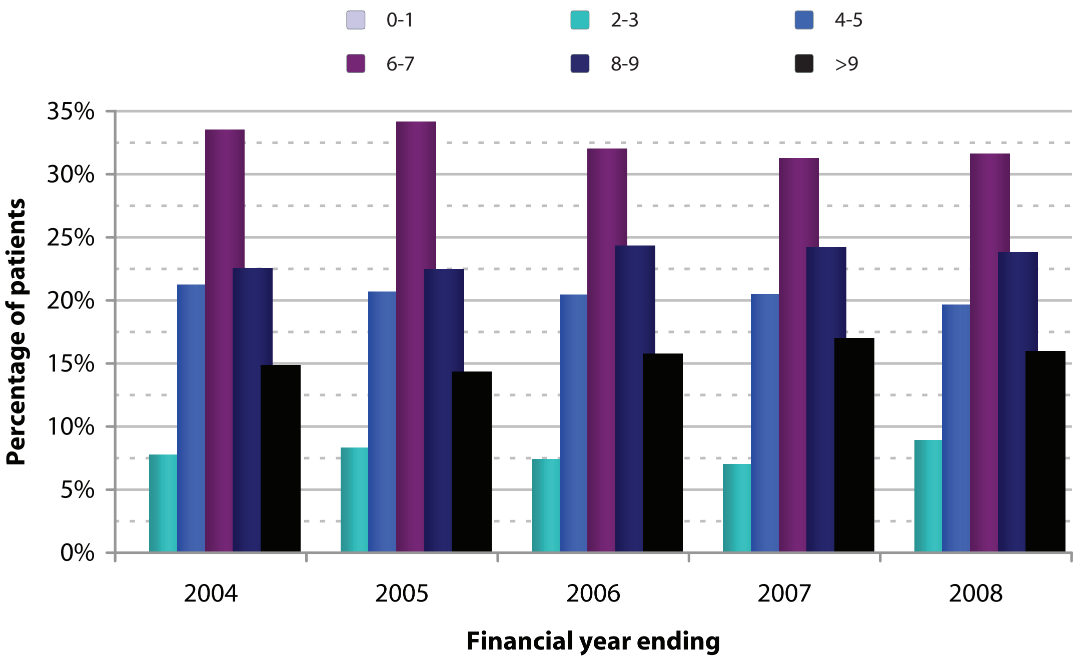
Isolated AVR: Additive *EuroSCORE* distributions (n=17,797)



Additive ***EuroSCORE*** distributions; combined aortic valve & CABG surgery; financial years 2004-2008

		Additive *EuroSCORE* groupings						
		0-1	2-3	4-5	6-7	8-9	>9	**All**
Financial year	2004	0	157	429	677	455	300	**2,018**
	2005	0	182	453	747	492	314	**2,188**
	2006	0	181	499	782	594	385	**2,441**
	2007	0	203	592	903	699	492	**2,889**
	2008	0	277	611	984	741	497	**3,110**
	All	**0**	**1,000**	**2,584**	**4,093**	**2,981**	**1,988**	**12,646**

Combined AVR & CABG: Additive *EuroSCORE* distributions (n=12,646)



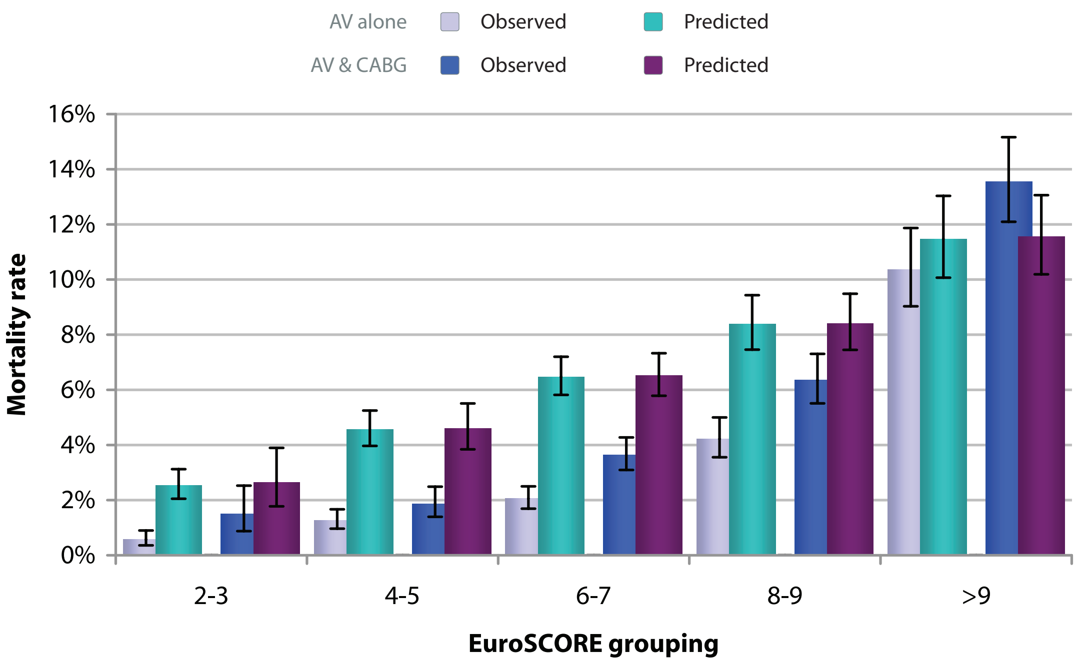
EuroSCORE and mortality

As for coronary artery bypass surgery, the additive ***EuroSCORE*** consistently and significantly over-predicts observed mortality in all but the highest risk patients.

Observed mortality according to the **additive *EuroSCORE*** groupings; all entries are scored irrespective of missing risk factor data; financial years 2004-2008; the upper numbers represent the crude mortality rate and the lower numbers the procedure count within the sub-group

		Post-operative mortality			
		Aortic valve alone		Aortic valve and CABG	
		Observed	Predicted	Observed	Predicted
Additive *EuroSCORE* grouping	2-3	0.6% 3,500	2.5%	1.5% 998	2.6%
	4-5	1.3% 4,247	4.6%	1.9% 2,571	4.6%
	6-7	2.1% 5,009	6.5%	3.6% 4,067	6.5%
	8-9	4.2% 3,129	8.4%	6.3% 2,961	8.4%
	>9	10.4% 1,843	11.5%	13.6% 1,977	11.5%
	All	**1.9%** **17,728**	**6.1%**	**5.3%** **12,574**	**7.1%**

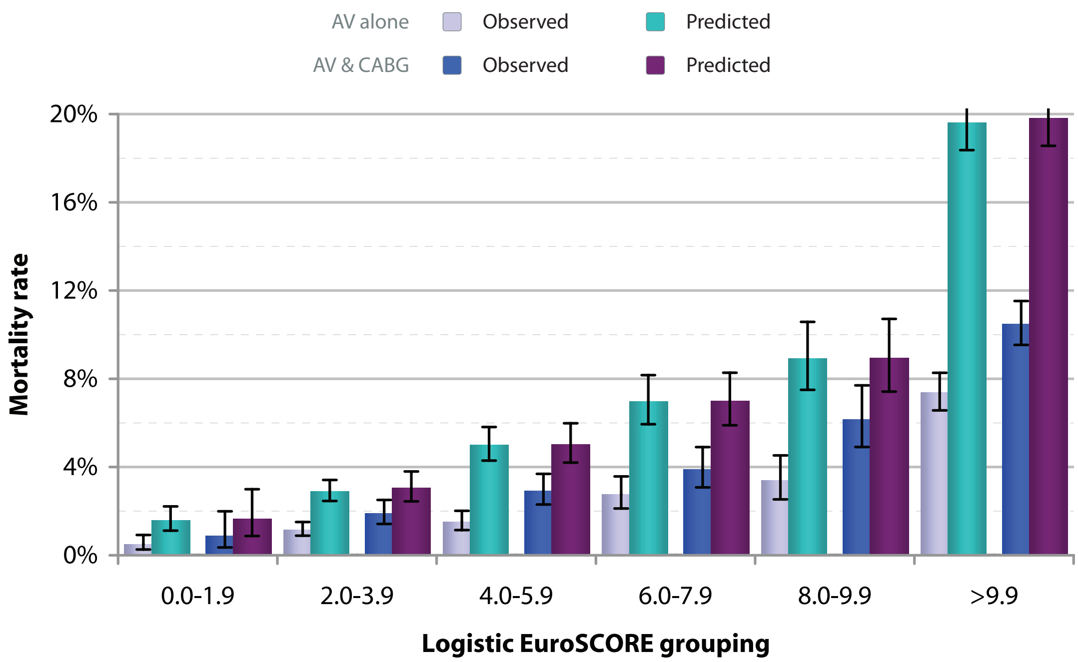
All AV surgery: Observed and predicted mortality rates according to the additive *EuroSCORE*; financial years 2004-2008 (n=30,302)



Observed mortality according to the **logistic *EuroSCORE*** groupings; all entries are scored irrespective of missing risk factor data; financial years 2004-2008; the upper numbers represent the crude mortality rate and the lower numbers the procedure count within the sub-group

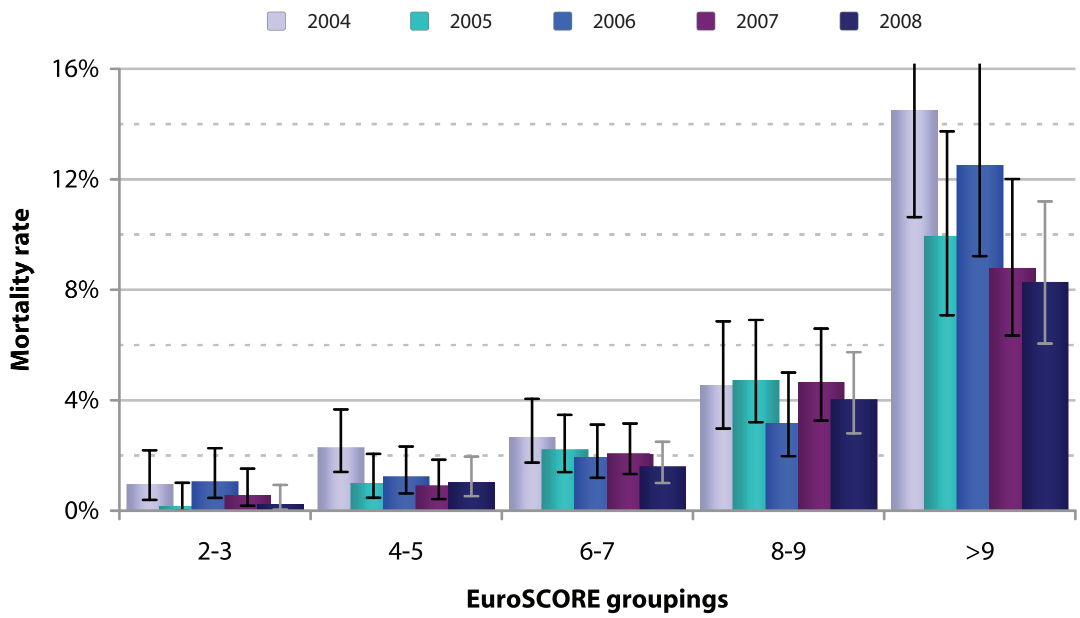
		Post-operative mortality			
		Aortic valve alone		Aortic valve and CABG	
		Observed	Predicted	Observed	Predicted
Logistic *EuroSCORE* grouping	0.0-1.9	0.5% 2,206	1.6%	0.9% 686	1.6%
	2.0-3.9	1.2% 5,002	2.9%	1.9% 2,642	3.1%
	4.0-5.9	1.5% 3,290	5.0%	2.9% 2,432	5.0%
	6.0-7.9	2.8% 2,103	7.0%	3.9% 1,850	7.0%
	8.0-9.9	3.4% 1,384	8.9%	6.2% 1,217	8.9%
	>9.9	7.4% 3,743	19.6%	10.5% 3,747	19.8%
	All	**1.9%** **17,728**	**7.6%**	**5.3%** **12,574**	**9.5%**

All AV surgery: Observed and predicted mortality rates according to the logistic *EuroSCORE*; financial years 2004-2008 (n=30,302)

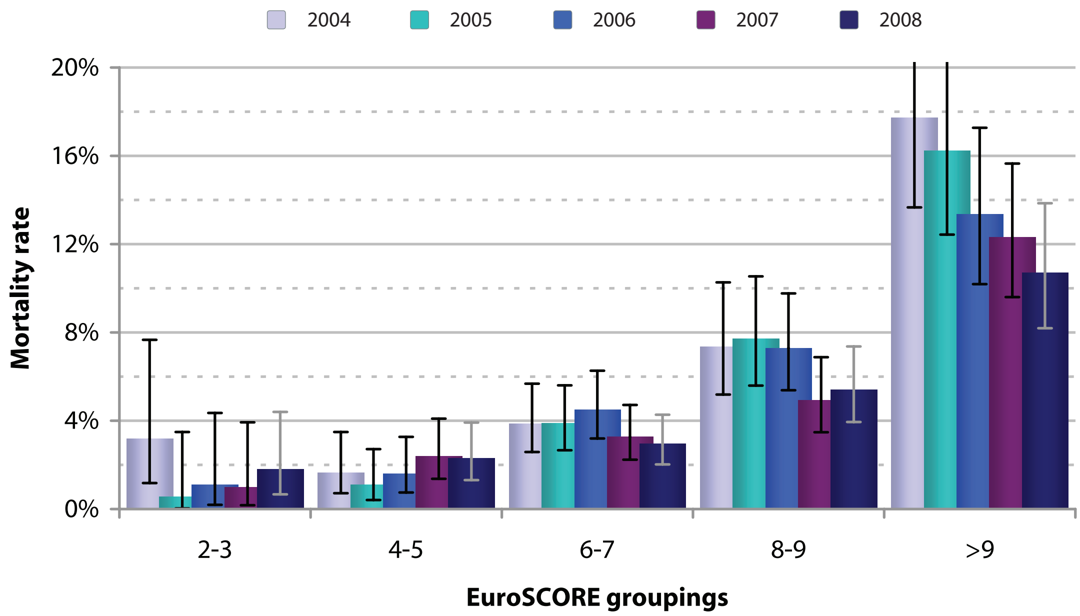


Mortality rates have decreased over time for most additive ***EuroSCORE*** groupings, suggesting better quality of post-operative care for patients. This apples to both isolated AVR surgery and combined AVR & CABG surgery (χ^2 trends through time: for isolated aortic valve surgery ***EuroSCORE*** grouping 2-3, p=0.204; 4-5, p=0.037; 6-7, p=0.100; 8-9, p=0.697; >9, p=0.010 and for combined aortic valve surgery and CABG ***EuroSCORE*** grouping 2-3, p=0.600; 4-5, p=0.154; 6-7, p=0.202; 8-9, p=0.033; >9, p=0.001).

Isolated AVR: Mortality and additive *EuroSCORE* through time (n=17,728)



Combined AVR & CABG: Mortality & additive *EuroSCORE* through time (n=12,574)



Mitral valve surgery

Mitral valve surgery

An independent commentary

This ten-year analysis of mitral valve operations reported to the SCTS database between 1999 and 2008 is very informative and provides a wealth of information regarding the status and provision of mitral valve surgery in the United Kingdom and Ireland. The report mirrors that from published series in terms of a lower crude mortality rate for mitral valve repair (2.0%) compared to mitral valve replacement (6.1%), a mortality benefit that exists in all sub-groups examined and at all time-periods through the study period.

The overall mitral valve repair rate, including patients who had concurrent coronary artery bypass surgery, was 51.7%. This differed amongst etiologies with the highest repair rate in the ischemic subgroup (74.1%). For the degenerative group, the repair rate was 64.6%. Valve repair was infrequent for rheumatic heart disease (8.5%) and active endocarditis (27%). There may, however, be some overlap as etiological distinctions may sometimes be blurred. For example, the distinction between functional *versus* ischemic; calcific degeneration *versus* degenerative; and active endocarditis *versus* previous endocarditis may not have been consistent over centres and across time, resulting in a potential for inconsistent coding. Without clear and reproducible definitions and accurate etiological classification it becomes difficult to robustly measure outcomes of mitral valve surgery [1].

The accuracy of the data is difficult to verify as the SCTS database is not currently subject to rigorous validation, and there are hints at possible mis-coding or incompleteness of data, particularly in the earlier years. For example, in 1999 only 328 operations for degenerative valve disease were reported, which seems too small a number. Some degenerative operations may have been mis-coded to another etiological category, or some operations may not have been reported with diagnostic data.

Nonetheless, there are indications from this analysis that the United Kingdom population is indeed under-served by mitral valve surgery. There was certainly more surgery being performed for mitral valve disease in the latter half of the decade, which may hint at a changing attitude towards indications for mitral valve surgery. In the reported data, 24.7% had depressed left ventricular function and 42% were reported as being in class III or IV heart failure at time of surgery. This suggests that many patients were not being offered surgery until they developed advanced symptoms. One has to conclude that selected patients with minimal symptoms but advancing left ventricular dysfunction (a Class I indication for surgery [2,3]) were either not identified by appropriate echocardiographic follow up, or were not referred or operated on in a timely fashion. Such a high percentage of patients with advanced left ventricular dysfunction implicates the need for better surveillance protocols and also mechanisms that would facilitate earlier surgery for appropriate patients with severe mitral regurgitation in the United Kingdom.

Another concerning observation in this database analysis is the high incidence of mitral valve replacement in asymptomatic patients. Of the 709 patients in NYHA Class I with degenerative etiology, 177 (24.9%) had a valve replacement. Valve replacement surgery is not recommended for treatment of asymptomatic mitral regurgitation [2,3] and does not have proven benefit over watchful waiting in this sub-group and likely results in worse short- to medium-term survival. This effect may be particularly pronounced in the United Kingdom considering the ten-fold higher operative mortality risk for replacement compared with repair noted in asymptomatic patients in the SCTS database (mortality rate for NHYA I patients: repair 0.6%, replacement 6.2%). The 6 % mortality risk of mitral valve replacement means 1 in 17 asymptomatic patients would die having surgery if the valve were replaced. Additionally, these patients are likely subjected to a higher medium-term rate of mortality and stroke if they have a replacement. For these reasons, North American guidelines recommend that surgery should only be undertaken in asymptomatic patients if there is a very high probability of repair, and that surgery on asymptomatic patients be only undertaken in designated reference repair centres [3]. In fact the European Guidelines do not endorse intervention in asymptomatic patients [2]. For asymptomatic patients, therefore, a repair rate well above 95% is desirable. The importance of avoiding unnecessary valve replacements in this patient sub-group was recognized in a recent UK consensus statement, which recommends that centres undertaking repair in asymptomatic patients be subject to close scrutiny to ensure that recommended high standards of practice are achieved [4].

In order to clarify the reasons for the relatively high frequency of valve replacement in the United Kingdom, future iterations of the database should be broadened to collect information on the type of degenerative disease (Barlow's *versus* non-Barlow's), the leaflet involvement (anterior, posterior, bileaflet) and lesions (calcification) as this will help categorize centres based on complexity of repairs that are undertaken. This categorization is critical to matching individual patients to surgeons and centres most likely to effect a repair [5]. It has indeed been argued that repair of Barlow valves in the United Kingdom be limited to a few super-specialized, high-volume centres [4]. With current NHS policy allowing patients to move out of their locality for treatment, referral to regional repair centres, where appropriate, should not only be possible, but be a stated goal to improve access to the highest available level of care. Clearly, some centres are more versed at mitral valve repair than others and as for cardiothoracic transplantation and congenital heart surgery, having several designated NHS complex mitral repair centres in the United Kingdom may be preferable to the current scenario where all heart hospitals provide mitral valve surgery for cases in their catchment area. Additionally, concentrating complex mitral valve repair in fewer centres will help build experience and expertise; over the current reported period, the majority of United Kingdom centres performed less than 20 procedures annually for degenerative disease, which is probably not sufficient to allow development of expertise, reproducibility and predictability of repair. A multi-disciplinary consensus group in the United Kingdom has suggested that surgeons undertaking mitral repair surgery should be doing more than 25 repairs each year and hospitals should be doing more than 50 repairs each year [4]. This is clearly not the case currently; implementation of these recommendations across the United Kingdom will likely result in much higher valve repair rates, which is particularly relevant in the sub-group of patients with degenerative disease.

The most notable observation raised by this analysis is the marked variation in healthcare provision that occurs with mitral valve surgery. This is well depicted on page 217 where centres are ranked by repair rate: the top centre repaired almost 90% of all valves while the bottom ranking centre repaired 20% of valves. The reasons for this variation, and the names of the individual centres, are less important especially as the data have not been rigorously validated; what is important is what is illustrated by the data, which is the vexed problem of variation in national healthcare provision faced in many countries. Regional and local variations in repair rates are pronounced. For example, a patient in Scotland with degenerative mitral valve disease has a 57% chance of having a valve repair in Glasgow, with lower rates in the other centres. The chances of having a repair in England were highest in Coventry with an 98.4% repair rate, with lower rates being reported in nearby cities.

Looking specifically at centres doing more than 30 procedures per year, high-volume centres did not, as one might expect, consistently deliver higher repair rates and there remained great variability. The repair rate ranged from 36% to 98% in the high-volume centres. Presumably multiple surgeons undertook procedures in each centre so the repair rates do not reflect individual surgeon practice, but rather centre philosophy, logistics and practice (*i.e.*, the degree to which all surgeons in a centre were committed to a *repair first* philosophy, even if it meant surgeon-surgeon referral of selected cases). Regardless, these data strongly suggest a *postcode lottery* in access to mitral valve repair in the United Kingdom, with one's chances of repair depending heavily on the hospital in which one is treated. Only three of the high volume centres – James Cook University Hospital, Walsgrave Hospital and Wythenshawe Hospital – had a repair rate above 85%, while the median repair rate for all high-volume centres was 67.5%. These high-volume centres performed 61% of all procedures for degenerative disease. Repair rates amongst the low- and medium-volume centres were variable, but only one medium-volume centre (New Cross Hospital) had a repair rate over 85%.

The mortality rate for an isolated degenerative mitral valve repair was 1.3% and stroke rate 0.8% compared to 4.3% and 3.0% respectively for isolated valve replacement with a higher mortality if concurrent CABG or other procedures were undertaken (approximately 4% with repair and 8% with replacement). Isolated valve repair also had a substantially better medium-term survival (90.0% *versus* 83.6% for isolated valve replacement). Although these data are not risk-adjusted, they are consistent with previously published data that show superiority of valve repair. This implies that some patients, by virtue of the hospitals they attend, will be less likely to survive the medium-term, and more likely to have a stroke, because of a higher use of valve replacement in those centres. There was to some degree a tendency to use valve replacement in higher-risk patients; for example, the repair rate was 70% below age 65 but 60% above 80 years. However, it must be emphasized that even in the elderly age group, mitral valve repair did confer a survival advantage (the mortality rate for valve repair patients aged 80 years and above was 5.5% *versus* 15.6% for replacement); indeed the absolute incremental risk in mortality for valve replacement compared with repair was greatest in elderly patients contradicting conventional thinking that a *quick* valve replacement is safer in elderly patients.

These data are unique as they provide exciting insight into mitral valve repair from a complete national perspective & the observations seem likely apply to many other countries, including the United States. This analysis provides an imperative for reorganization of healthcare provision for mitral valve disease, within the United Kingdom and beyond, with regionalization of services and national quality standards and guidelines to streamline care with a view to reducing variations in care. The SCTS database is an incredible resource and repository of data on mitral valve surgery and will remain central to future quality improvement initiatives in the NHS and beyond.

Ani C Anyanwu and David H Adams, Mount Sinai Medical Center, New York, United States of America

For references please see page 319.

Mitral valve surgery

Key points from mitral valve analyses

- There has been a doubling in the number of mitral valve repairs between 2001 & 2008.
- There has been no change in the number of mitral valve replacements.
- Many patients referred for mitral valve repair have significant damage to left ventricular function or severe symptoms and will not derive optimum benefit from surgery.
- The overall mortality for isolated mitral valve repair is around 2%, the mortality from mitral valve replacement remains high at 6.1%.
- 63% of all isolated repairs & 34% of all isolated replacements are for degenerative valve disease.
- There has been an increase in the proportion of patients with degenerative mitral valve disease who undergo mitral valve repair from 52% in 1999 to 67% in 2008.
- Whether patients with degenerative mitral valve disease undergo mitral repair or replacement varies significantly between hospitals.

Introduction

Patients need mitral valve surgery when the mitral valve is either narrowed (mitral stenosis) or leaking (mitral regurgitation). The commonest cause of mitral stenosis is rheumatic disease, which is now a rare problem in the United Kingdom, but there are still a number of patients with mitral valve disease as a result of suffering rheumatic disease in the past. The commonest causes of mitral regurgitation are degenerative valve disease, ischaemic heart disease and infective endocarditis.

The majority of patients with mitral stenosis who require surgery will require a mitral valve replacement (MVR), but a small proportion may be treated by mitral valve repair (MV repair) or open commissurotomy. Many patients who have mitral regurgitation can be treated by mitral valve repair, but some will undergo replacement, either because of the pathology of the valve, the complexity of the disease or because the expertise to repair the valve is not available locally. Some patients who need coronary artery bypass surgery for ischaemic heart disease also have mitral regurgitation due to damage or malfunction of the heart muscle, but there is no consensus between surgeons about when mitral repair is necessary in this group. Some patients with degenerative or rheumatic valve disease will have co-existent coronary artery disease, which requires coronary artery bypass surgery at the time of their valve operation. These issues can make the analysis of a mitral valve registry somewhat complex.

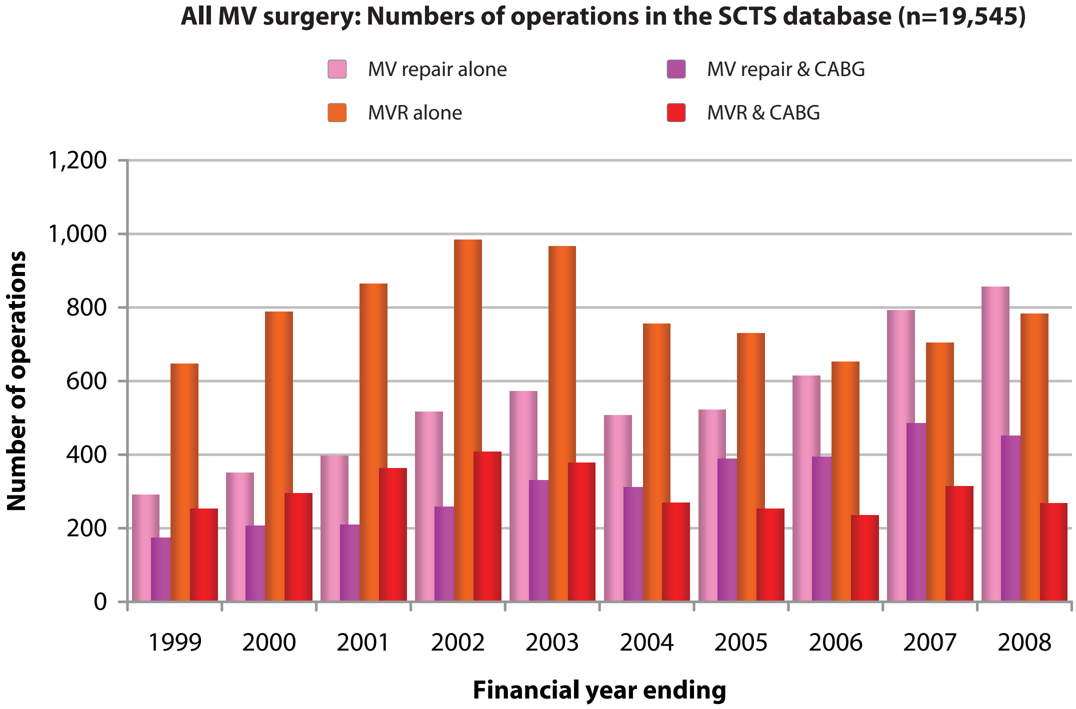
We have analysed all patients in the database who have undergone either mitral valve replacement or repair, with or without concomitant coronary surgery. Patients undergoing concomitant tricuspid valve surgery have been included in a separate section, but other combinations of surgery including mitral plus aortic valve surgery are excluded from this analysis, and are included in the section on page 342.

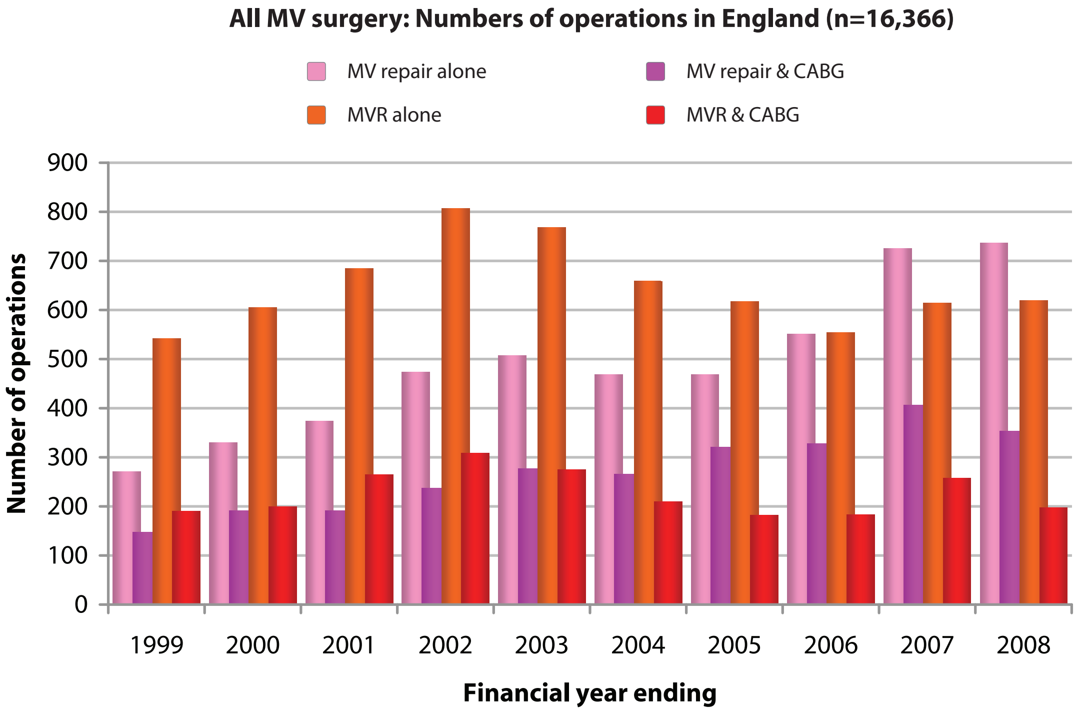
There is a huge amount of data on mitral surgery in the database, and in line with the structure of the analysis on aortic valve surgery we have not presented each risk factor in detail. Initially, we have examined the number and type of operations for mitral valve disease, to track changes over time, and we have analysed the pathology for which valve surgery was needed. The most common aetiology recorded was degenerative valve disease and we have analysed this group in detail first, looking at the incidence, variations and influence of changes in procedures and various risk factors. We have also performed a sub-group analysis of the particularly controversial group of patients who have degenerative mitral regurgitation with no symptoms and *normal* left ventricular function. We have then reported the results for all mitral surgery, subdivided by mitral repair and replacement, with and without coronary artery bypass surgery.

Changes in number of mitral operations

There was an increase in the number of mitral valve replacements between 1999 and 2002, but since then the numbers have reduced again. There has been a persistent increase in the volume of mitral repair operations over time, both with and without coronary artery bypass surgery. These changes probably reflect a number of issues, including an increase in the availability of cardiological and surgical expertise for diagnosing and treating patients with mitral regurgitation and changing indications for surgical intervention.

The data from just the English centres, where the data are more complete over time, essentially show a similar pattern, with a consistent increase in the number of patients undergoing isolated mitral repair since 2005 and no real change in the total number of patients having mitral valve replacement.





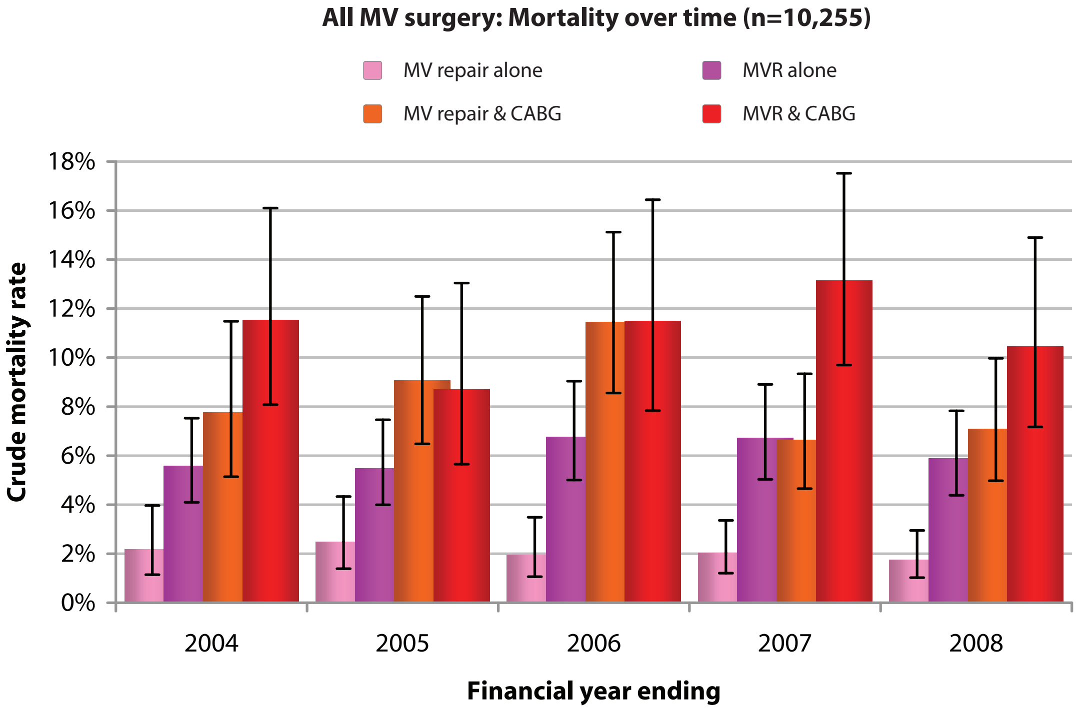
i The data from Aberdeen Royal Infirmary, Edinburgh Royal Infirmary & Glasgow Jubilee Hospital for the financial year 2007 were not included in this report. The data were collected locally & successfully transferred to CCAD. However, due to a CCAD systems error with data transfer, they were not transferred to the analytical unit at Dendrite Clinical Systems.

An overview of outcomes in mitral valve surgery

The in-hospital mortality rate for all mitral valve repairs (irrespective of pathology) is lower than for replacements, and this finding is consistent over time. The mortality for combined mitral valve repair & CABG surgery is higher than for isolated mitral valve repair and, again, combined mitral valve replacement & CABG has a higher mortality rate than isolated mitral valve replacement.

Mortality; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

	Procedure			
	Isolated MV		Combined MV & CABG	
Financial year	Repair	Replacement	Repair	Replacement
2004	2.2% 507	5.6% 753	7.8% 309	11.5% 269
2005	2.5% 522	5.5% 729	9.1% 386	8.7% 253
2006	2.0% 614	6.8% 651	11.5% 393	11.5% 235
2007	2.0% 786	6.7% 699	6.6% 482	13.1% 312
2008	1.8% 854	5.9% 782	7.1% 451	10.4% 268
All	**2.0% 3,283**	**6.1% 3,614**	**8.3% 2,021**	**11.1% 1,337**

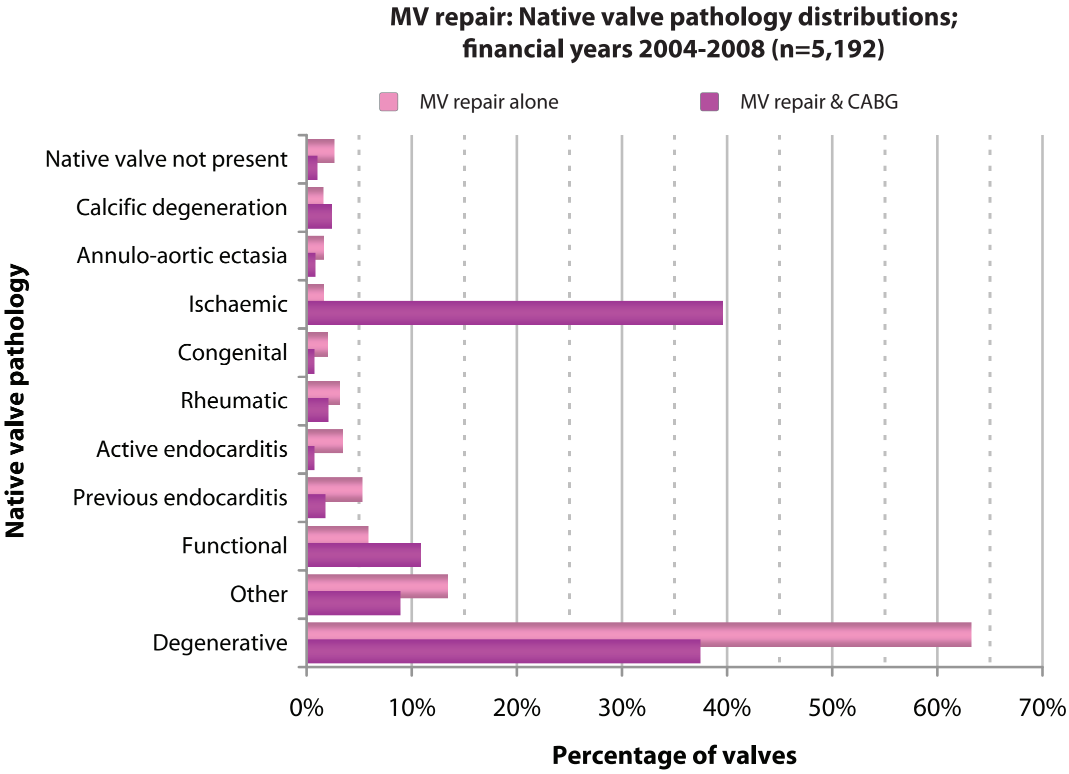


Native valve pathology

Mitral valve repair is performed for many different pathologies, but the dominant one is degenerative valve disease, which comprises 62% of the total. Combined mitral valve repair & CABG is undertaken for degenerative valve disease in conjunction with coronary artery disease and ischaemic mitral regurgitation in approximately equal measure.

Mitral valve repair: native valve pathology distributions; financial years 2004-2008

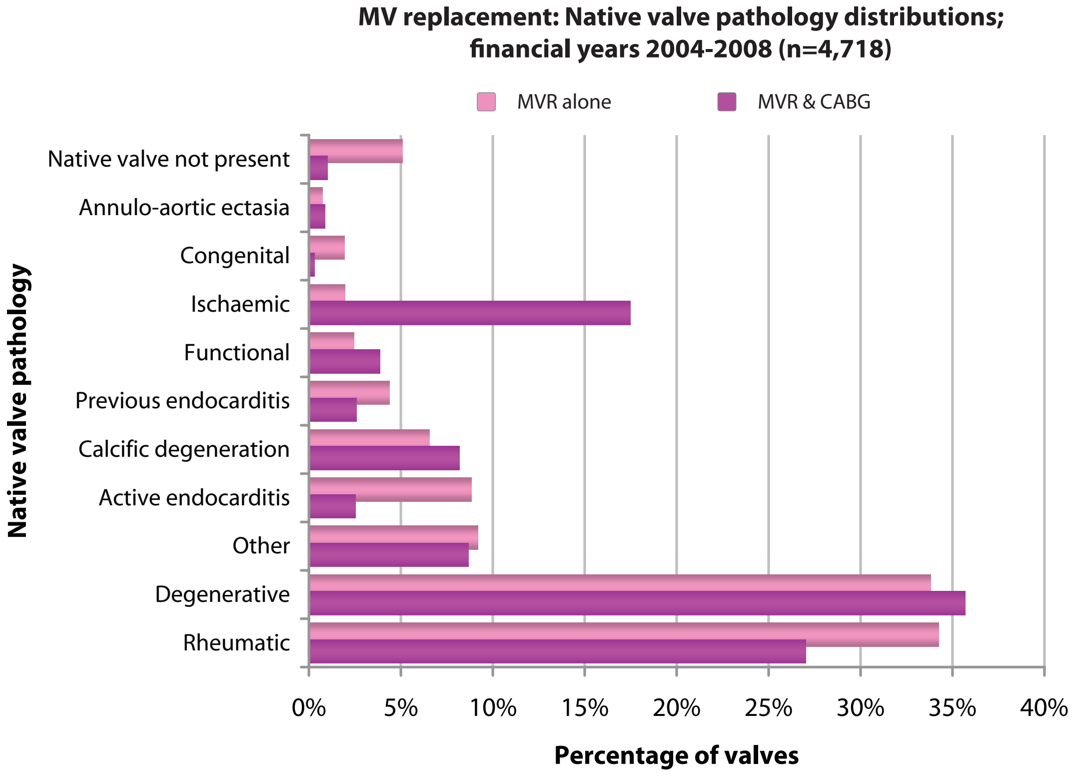
		Procedure		
		Isolated MV repair	Combined MV repair & CABG	**All MV repairs**
Native valve pathology	Native valve not present	85	20	**105**
	Congenital	64	14	**78**
	Degenerative	2,038	737	**2,775**
	Active endocarditis	111	14	**125**
	Previous endocarditis	171	35	**206**
	Rheumatic	102	40	**142**
	Annulo-aortic ectasia	52	16	**68**
	Calcific degeneration	51	47	**98**
	Ischaemic	53	779	**832**
	Functional	189	214	**403**
	Other	432	175	**607**
	Unspecified	69	63	**132**
	Valve denominator	**3,292**	**2,032**	**5,324**



Degenerative and rheumatic valve disease, in similar numbers, are the pathologies seen in patients undergoing isolated mitral valve replacement. The commonest pathology in patients undergoing combined mitral valve replacement & CABG is degenerative valve disease. Overall one-third of all mitral valve replacements are performed for degenerative valve disease.

Mitral valve replacement: native valve pathology distributions; financial years 2004-2008

		Procedure		
		MVR	Combined MVR & CABG	**All MV repairs**
Native valve pathology	Native valve not present	176	13	**189**
	Congenital	67	4	**71**
	Degenerative	1,166	453	**1,619**
	Active endocarditis	305	32	**337**
	Previous endocarditis	151	33	**184**
	Rheumatic	1,181	343	**1,524**
	Annulo-aortic ectasia	26	11	**37**
	Calcific degeneration	226	104	**330**
	Ischaemic	68	222	**290**
	Functional	85	49	**134**
	Other	317	110	**427**
	Unspecified	177	70	**247**
	Valve denominator	**3,626**	**1,339**	**4,965**



Focus on degenerative mitral valve disease

Replacement or repair?

Changes in treatment approaches over time

The commonest cause of mitral valve disease leading to mitral valve surgery is degenerative valve disease. It is generally accepted that mitral valve repair is a better treatment than replacement, giving lower in-hospital mortality and better long-term survival. On occasion, either due to the complex pathology of the valve or lack of availability of local mitral valve repair expertise, it may be treated by mitral valve replacement.

It is also possible that degenerative mitral valve disease can occur in conjunction with coronary artery disease. The valve pathology may be identical in two different patients, one with no coronary disease may be treated by isolated mitral valve repair and the other with concomitant disease may undergo combined mitral valve replacement & CABG. A further potential confounding factor in analysing the mitral surgery data in the database has been the development of surgery for atrial fibrillation. This has come into surgical practice in recent years, but there is no widespread consensus on when AF surgery should be performed, and it seems to be applied quite variably. We have no field in the database to capture data specifically for AF surgery, but patients undergoing mitral surgery and AF ablation should be recorded as *mitral plus other* (see page 244).

The data show that there has been a marked increase in the proportion of patients undergoing *mitral plus other* surgery for degenerative mitral valve pathology (this is the commonest cause of surgical mitral valve disease; see page 210). This operation was very unusual in 1999, but has increased over time. *Valve plus other* now comprises over 15% of all isolated single mitral valve repairs, and most of these *other* operations are probably AF ablations.

Also of interest, in 1999 only 328 operations for degenerative mitral valve disease were reported in the database, and 52% of these underwent mitral repair; in 2008 there were 1,381 operations and 67% underwent repair.

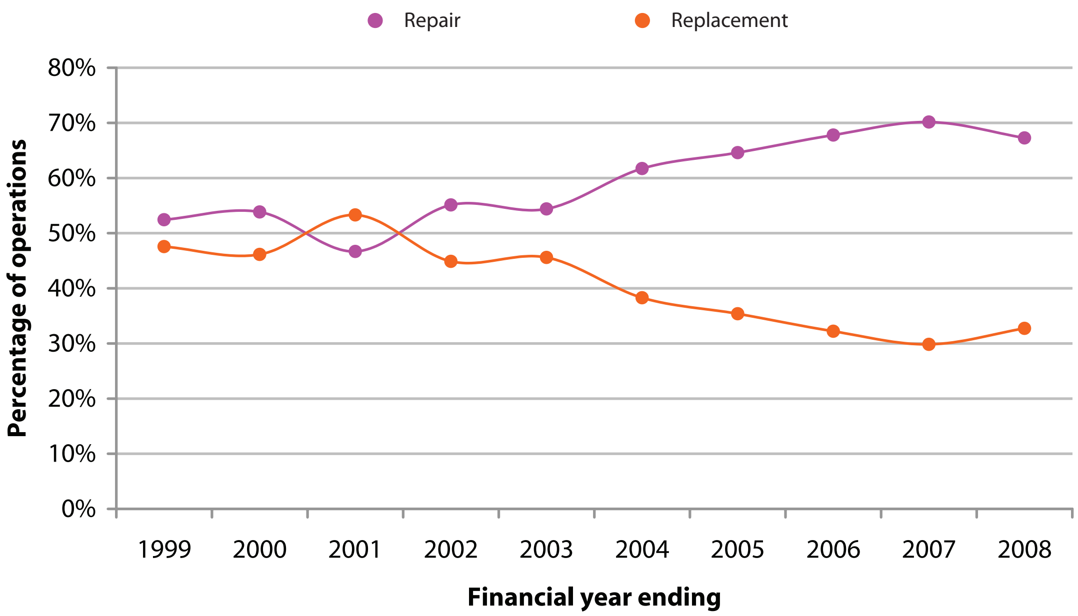
Patients treated surgically for degenerative mitral valve disease; the incidence of other cardiac procedures associated with the mitral valve surgery

	Cardiac procedure grouping							
	Repair				Replacement			
Financial year	No other cardiac procedures	One or more other cardiac procedures	Other procedures not listed	Unspecified / data inconsistent	No other cardiac procedures	One or more other cardiac procedures	Other procedures not listed	Unspecified / data inconsistent
1999	170	2	1	0	153	3	2	0
2000	159	9	8	0	134	10	5	0
2001	165	11	9	0	199	2	0	0
2002	223	30	24	0	198	8	3	0
2003	269	40	33	0	246	13	7	0
2004	395	62	55	33	253	27	17	24
2005	453	94	83	39	273	34	27	14
2006	523	131	111	32	259	46	37	21
2007	574	136	120	40	283	28	22	8
2008	706	181	159	42	365	55	45	32

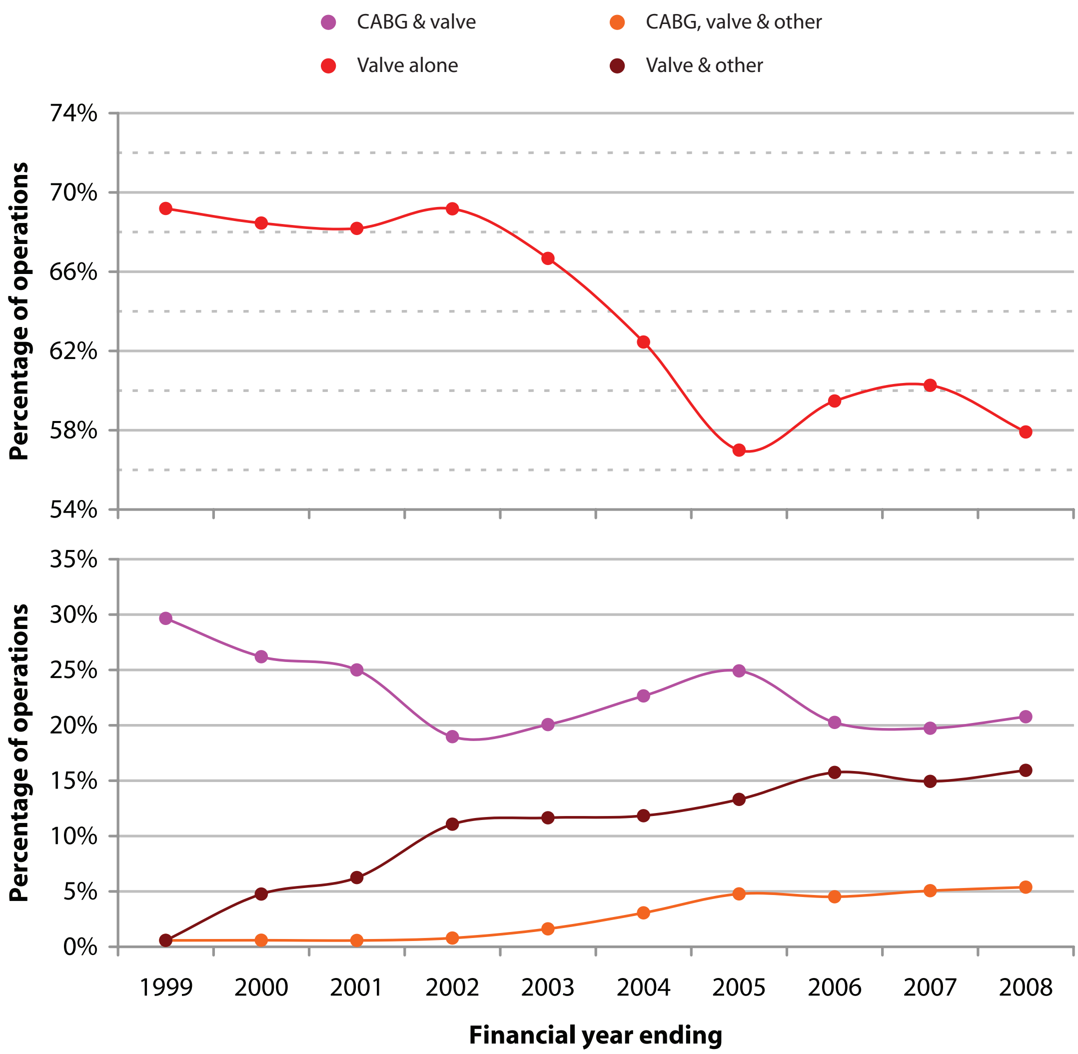
Patients treated surgically for degenerative mitral valve disease

Financial year	Cardiac procedure grouping							
	Repair				Replacement			
	CABG & valve	CABG, valve & other	Valve alone	Valve & other	CABG & valve	CABG, valve & other	Valve alone	Valve & Other
1999	51	1	119	1	51	0	101	4
2000	44	1	115	8	43	5	91	5
2001	44	1	120	11	54	2	144	1
2002	48	2	175	28	69	2	127	8
2003	62	5	206	36	69	3	177	10
2004	111	15	306	58	83	7	191	23
2005	146	28	334	78	82	8	203	28
2006	139	31	408	108	95	14	184	33
2007	148	38	452	112	93	8	195	23
2008	193	50	538	148	100	14	293	45

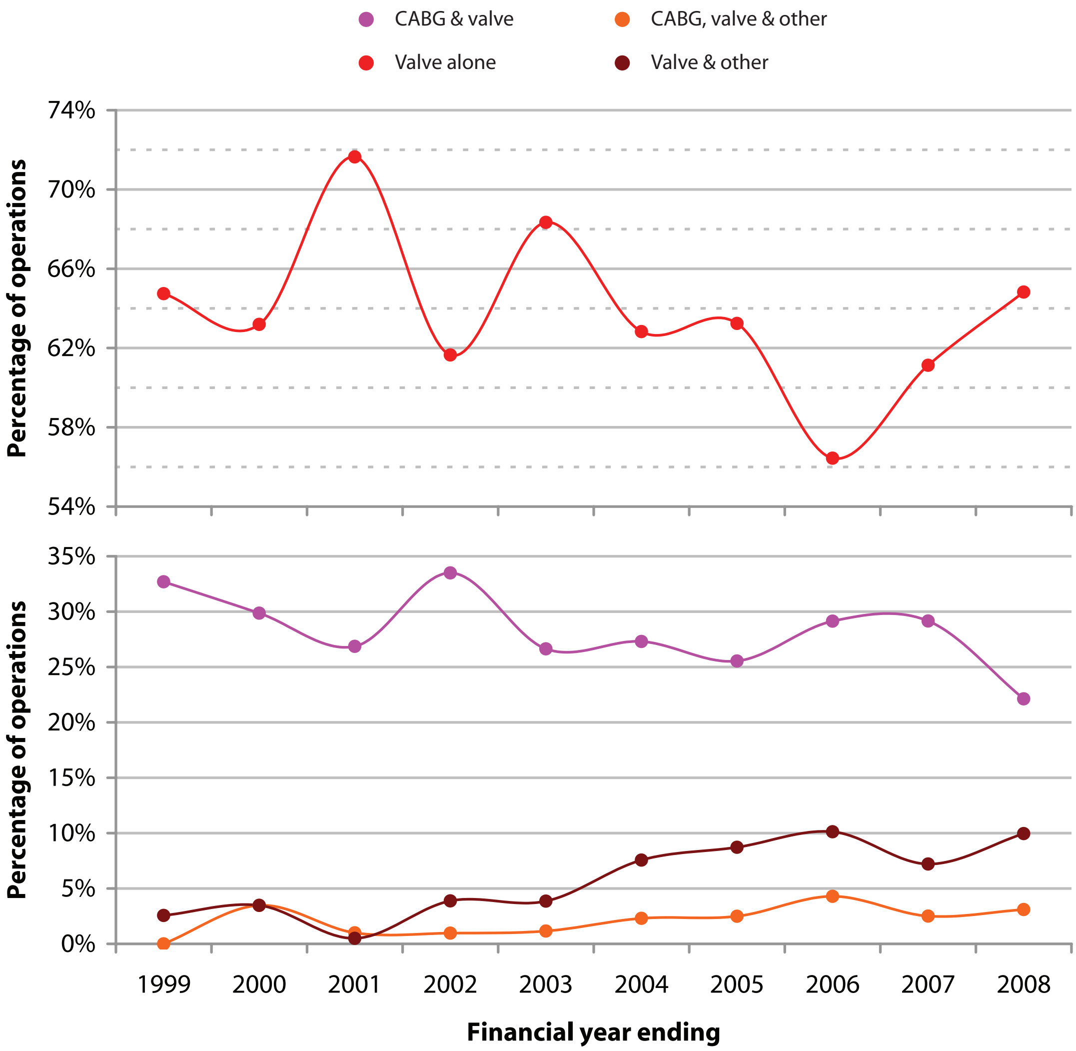
Degenerative mitral valve disease: Changes in treatment over time; all operation classes included (n=7,207)



All single MV repairs for degenerative disease: Procedure groupings over time (n=4,519)



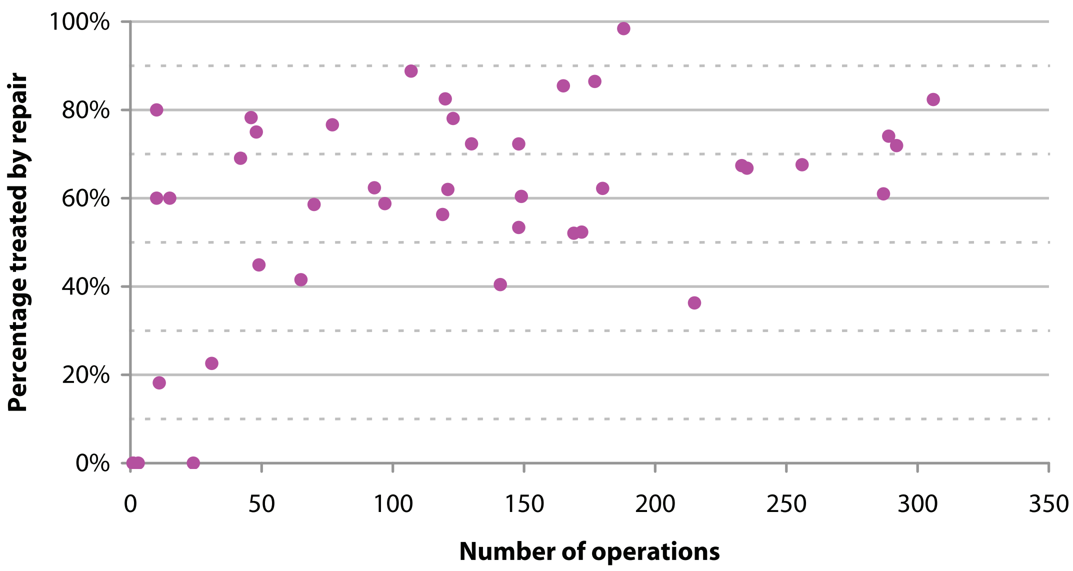
All single MVRs for degenerative disease: Procedure groupings over time (n=2,688)



Inter-hospital variation in treatment approach

The following graph shows the proportion of patients undergoing mitral valve procedures that are repairs, for a diagnosis of degenerative valve disease, for all centres submitting data to the database; the linear regression line through these points has an r^2 value of 0.23.

All single mitral valve procedures for degenerative disease: Treatment approach at the contributing hospitals (n=5,163)



In the following table we have looked at all patients who have been categorised as having degenerative mitral valve disease and who have undergone any mitral procedure, with or without any other concomitant type of surgical procedure. If, from any centre, there are issues with collection, categorization or appropriate transmission of these data, it is possible that centre will not be accurately represented in this analysis.

The mitral dataset was agreed in 2003 and has not been analysed in detail since. The definitions included in the dataset are complex and do not necessarily always lend themselves to accurate classification of diagnosis and procedure, and because of a lack of regular & rigorous analysis and feedback, units will not always have been able to learn from shortcomings in their data quality for these procedures; the following table needs to be seen in this context. We would hope that units will use the data in the table to understand issues about their quality, and about the comparative type of care currently given to patients with degenerative mitral disease.

i The data from Aberdeen Royal Infirmary, Edinburgh Royal Infirmary & Glasgow Jubilee Hospital for the financial year 2007 were not included in this report. The data were collected locally & successfully transferred to CCAD. However, due to a CCAD systems error with data transfer, they were not transferred to the analytical unit at Dendrite Clinical Systems.

Mitral valve procedures for degenerative disease; all procedure classes; financial years 2004-2008

		Mitral valve procedure			
		Repair	Replace	All	% repairs
Hospital	Aberdeen Royal Infirmary	2	9	**11**	18.2%
	Bart's & the London	175	112	**287**	61.0%
	Blackpool Victoria Hospital	90	82	**172**	52.3%
	Bristol Royal Infirmary	173	83	**256**	67.6%
	Castle Hill Hospital, Hull	79	69	**148**	53.4%
	Derriford Hospital, Plymouth	112	68	**180**	62.2%
	Edinburgh Royal Infirmary	0	24	**24**	0.0%
	Freeman Hospital, Newcastle	88	81	**169**	52.1%
	Galway Clinic	0	1	**1**	0.0%
	Glasgow Royal Infirmary	0	3	**3**	0.0%
	Glasgow Western Infirmary	57	40	**97**	58.8%
	Glenfield Hospital, Leicester	210	82	**292**	71.9%
	Golden Jubilee Hospital, Glasgow	0	1	**1**	0.0%
	Guys & St Thomas's Hospital, London	214	75	**289**	74.0%
	Hammersmith Hospital, London	41	29	**70**	58.6%
	Harefield Hospital, Middlesex	90	59	**149**	60.4%
	Harley Street Clinic, London	7	24	**31**	22.6%
	James Cook University Hospital, Middlesbrough	153	24	**177**	86.4%
	John Radcliffe Hospital, Oxford	75	46	**121**	62.0%
	King's College Hospital, London	96	27	**123**	78.0%
	Leeds General Infirmary	78	137	**215**	36.3%
	Liverpool Heart & Chest Hospital	59	18	**77**	76.6%
	London Bridge Hospital	29	13	**42**	69.0%
	Mater Misericordiae Hospital, Dublin	36	12	**48**	75.0%
	Morriston Hospital, Swansea	22	27	**49**	44.9%
	New Cross Hospital, Wolverhampton	95	12	**107**	88.8%
	N Staffordshire Royal Infirmary, Stoke-on-Trent	99	21	**120**	82.5%
	Northern General Hospital, Sheffield	157	78	**235**	66.8%
	Nottingham City Hospital	57	84	**141**	40.4%
	Papworth Hospital, Cambridge	157	76	**233**	67.4%
	Queen Elizabeth Hospital, Birmingham	107	41	**148**	72.3%
	Royal Brompton Hospital, London	252	54	**306**	82.4%
	Royal Sussex County Hospital, Brighton	8	2	**10**	80.0%
	Royal Victoria Hospital, Belfast	27	38	**65**	41.5%
	St Anthony's Hospital, London	9	6	**15**	60.0%
	St George's Hospital, London	6	4	**10**	60.0%
	St Mary's Hospital, London	36	10	**46**	78.3%
	The Heart Hospital, London	67	52	**119**	56.3%
	University Hospital of Wales, Cardiff	94	36	**130**	72.3%
	Walsgrave Hospital, Coventry	185	3	**188**	98.4%
	Wellington Hospital, London	58	35	**93**	62.4%
	Wythenshawe Hospital, Manchester	141	24	**165**	85.5%
	All	**3,441**	**1,722**	**5,163**	**66.6%**

Risk factor overview

In general, patients undergoing isolated mitral valve repair for degenerative valve disease are more likely to be younger, male, have good ejection fraction and undergoing an elective procedure than those treated by isolated replacement. They are, however, also more likely to fall in NYHA class 3 or 4. As the casemix is different, comparisons between the outcomes of those having repair or replacement should be made with caution. Robust conclusions can only come from a more comprehensive analysis, which is outside the scope of this report.

In the past it has been clearly reported that patients with good left ventricular function and NYHA class I or II symptoms who undergo mitral valve repair do very well following the operation (Tribouilloy 1999, Enriquez Sarano 1994). A high proportion of the patients coming to isolated mitral valve surgery for degenerative disease in Great Britain and Ireland have impaired left ventricular function (24.7%), and / or severe symptoms (NYHA 3-4; 42%). These patients will not derive optimum benefit from surgery.

Risk factors for patients with degenerative mitral valve disease; financial years 2004-2008; the upper numbers represent the crude percentage rate and the lower numbers the count of known data

			Risk factor				
			Age > 70	Female	Poor / fair ejection fraction	Priority	Dyspnoea NYHA3-4
Procedure	Repair	Valve alone	33.2% 2,035	31.3% 2,038	24.7% 1,966	10.5% 2,037	41.9% 1,966
		Valve and other	35.1% 504	35.3% 504	31.6% 493	9.3% 504	46.9% 497
		Valve and CABG	53.5% 735	22.3% 737	44.6% 716	21.9% 736	46.8% 714
		Valve, CABG and other	51.9% 160	29.0% 162	50.0% 160	23.5% 162	59.6% 161
	Replacement	Valve alone	40.6% 1,061	44.4% 1,066	30.5% 1,024	15.4% 1,066	15.4% 1,066
		Valve and other	37.1% 151	44.1% 152	32.2% 149	10.5% 152	54.3% 151
		Valve and CABG	57.3% 450	29.6% 453	41.4% 442	19.6% 453	53.0% 447
		Valve, CABG and other	49.0% 51	31.4% 51	56.0% 50	33.3% 51	59.2% 49

i Enriquez-Sarano M, Tajik AJ, Schaff HV, Orszulak TA, Bailey KR, Frye RL. Echocardiographic prediction of survival after surgical correction of organic mitral regurgitation. *Circulation.* 1994; **90(2):** 830-7.

ii Tribouilloy CM, Enriquez-Sarano M, Schaff HV, Orszulak TA, Bailey KR, Tajik AJ, Frye RL. Impact of preoperative symptoms on survival after surgical correction of organic mitral regurgitation: rationale for optimizing surgical indications. *Circulation.* 1999; **99(3):** 400-5.

Outcome overview

In-hospital mortality and medium-term survival rates are better after repair than replacement (but please see the qualifying comments on the previous page). The mortality rate is higher when concomitant coronary artery bypass surgery is performed with either repair or replacement. The mortality rate is also higher for *valve plus other*. All post-operative complication rates are higher in the mitral replacement group than the repair group.

Outcomes for patients with degenerative mitral valve disease; financial years 2004-2008; the upper numbers represent the crude percentage outcome rate and the lower numbers the count of known data

			Outcome					
			Crude mortality rate	Re-operation for bleeding rate	New post-operative stroke rate	New post-operative HF / dialysis rate	Average post-operative stay / days	5-year survival rate
Procedure	Repair	Valve alone	1.3% 2,032	4.0% 1,094	0.8% 1,795	1.4% 1,793	9.6% 1,986	90.0% 1,658
		Valve and other	4.0% 503	4.2% 476	0.9% 464	2.4% 466	10.3% 499	86.5% 442
		Valve and CABG	3.8% 1,064	6.4% 674	2.5% 635	4.3% 634	12.7% 706	79.7% 823
		Valve, CABG and other	4.3% 161	4.5% 156	1.3% 154	4.6% 152	17.3% 160	79.8% 133
	Replacement	Valve alone	4.3% 1,064	5.4% 946	3.0% 895	4.3% 894	12.5% 1,020	83.6% 609
		Valve and other	5.9% 152	9.0% 144	4.4% 135	6.6% 136	15.0% 148	80.9% 127
		Valve and CABG	8.2% 731	9.6% 397	4.4% 383	7.1% 382	16.0% 431	71.9% 380
		Valve, CABG and other	7.8% 51	6.8% 44	2.2% 45	16.3% 43	20.9% 48	65.8% 38

i Within these groups are a small number of cases where the operation included surgery on the aorta: 13 mitral valve repairs and 5 mitral valve replacements. The mortality rate for these high risk procedures were 7.7% and 20.0% respectively.

Risk factors in patients with degenerative mitral valve disease

The following risk factor analyses are for all patients undergoing either mitral valve repair or replacement where the valve pathology is *degenerative*. All patients undergoing concomitant CABG or non-specified *other* operations have been included.

Age

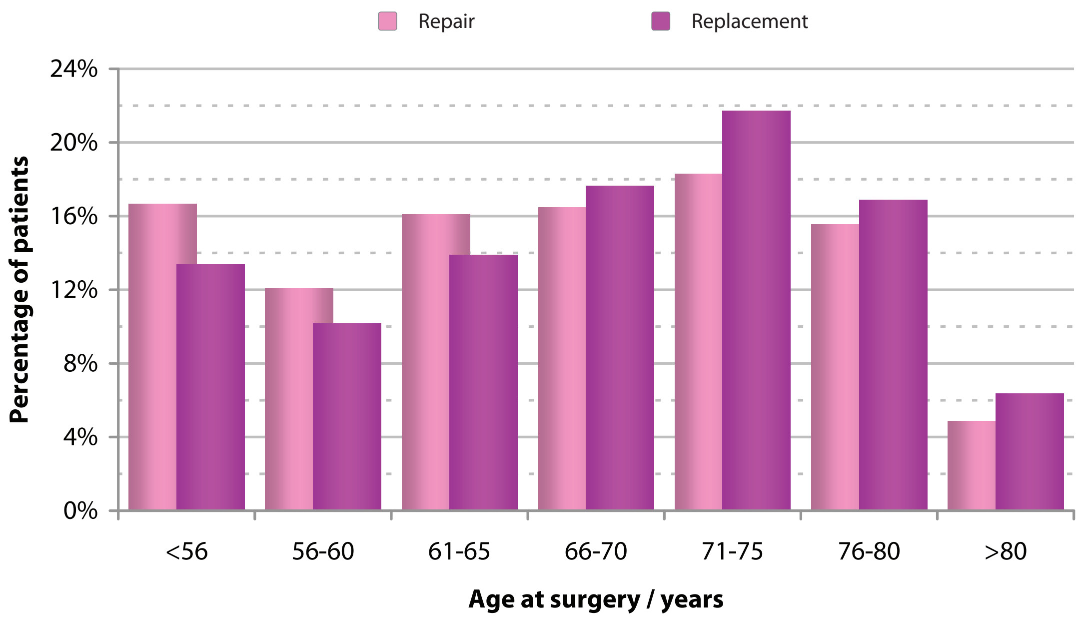
Age distributions

Patients undergoing mitral repair are younger than those undergoing replacement. The proportion of patients who are under 60 & undergo mitral repair is 28%, which is considerably less than that seen in the United States of America (Gammie *et al*. 2006).

Degenerative mitral valve disease; age distributions; financial years 2004-2008

Age at surgery / years	Procedure: Repair	Replacement	Unspecified	All
<56	572	229	4	**805**
56-60	414	174	3	**591**
61-65	553	238	3	**794**
66-70	566	302	2	**870**
71-75	628	372	4	**1,004**
76-80	534	289	2	**825**
>80	167	109	4	**280**
Unspecified	7	9	0	**16**
All	**3,441**	**1,722**	**22**	**5,185**

Degenerative mitral valve disease: Age at surgery (n=5,147)



i Gammie JS, O'Brien SM, Griffith BP, Ferguson TB, Peterson ED. Influence of hospital procedural volume on care process and mortality for patients undergoing elective surgery for mitral regurgitation. *Circulation.* 2007; **115(7):** 881-7.

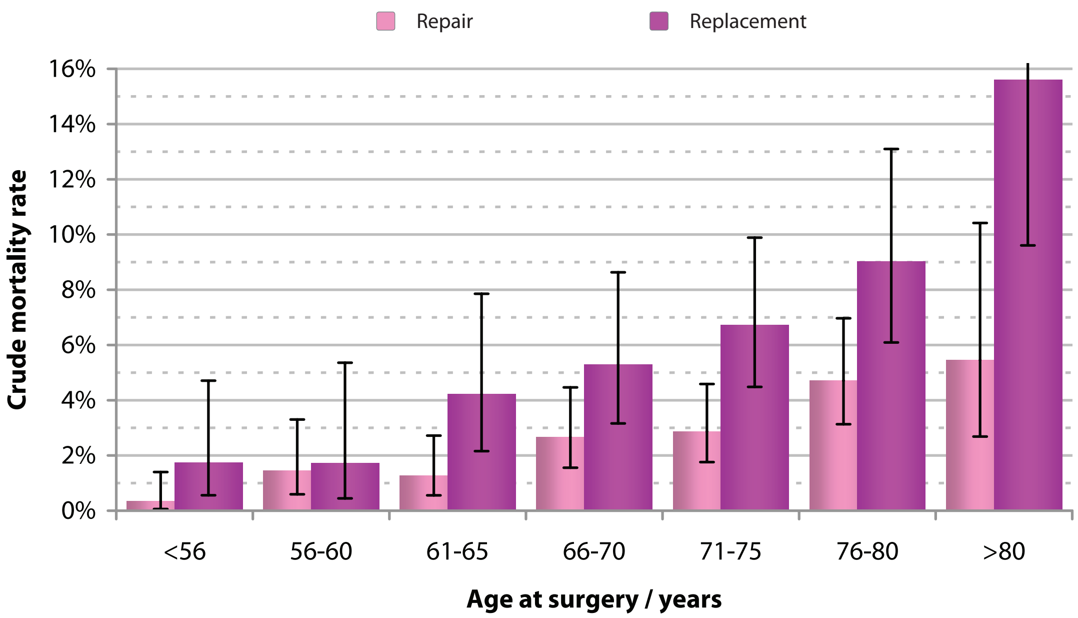
Mortality and age

The mortality rate is higher for patients undergoing mitral valve replacement than repair for all age groups. For both groups the mortality rate increases with increasing age.

Degenerative mitral valve disease; mortality and age; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the count in the sub-group

Age at surgery / years	Procedure: Repair	Procedure: Replacement	Procedure: All
<56	0.3% 572	1.7% 229	**0.9%** **805**
56-60	1.5% 412	1.7% 174	**1.5%** **589**
61-65	1.3% 551	4.2% 237	**2.1%** **791**
66-70	2.7% 562	5.3% 302	**3.6%** **866**
71-75	2.9% 627	6.7% 372	**4.4%** **1003**
76-80	4.7% 531	9.0% 288	**6.2%** **821**
>80	5.5% 165	15.6% 109	**9.4%** **278**
Unspecified	0.0% 7	0.0% 9	**0.0%** **16**
All	**2.4%** **3,427**	**5.9%** **1,720**	**3.6%** **5,169**

Degenerative mitral valve disease: Crude mortality and age (n=5,131)



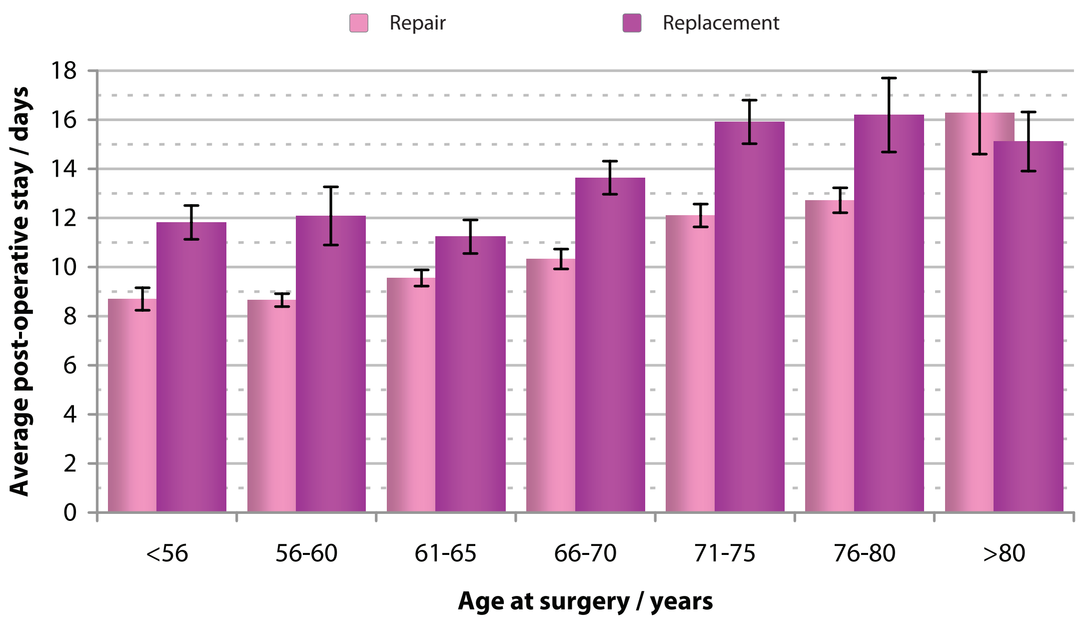
Post-operative stay and age

Post-operative length-of-stay is greater following replacement than repair, for all age groups. Generally, length-of-stay increases as age increases.

Degenerative mitral valve disease; post-operative stay and age; financial years 2004-2008; the upper numbers represent the average stay in days and the lower numbers the count in the sub-group

Age at surgery / years	Procedure: Repair	Procedure: Replacement	Procedure: All
<56	8.7 558	11.8 220	**9.6** **782**
56-60	8.7 409	12.1 168	**9.7** **580**
61-65	9.6 540	11.2 224	**10.0** **767**
66-70	10.3 547	13.6 292	**11.5** **841**
71-75	12.1 612	15.9 353	**13.5** **968**
76-80	12.7 516	16.2 275	**13.9** **793**
>80	16.3 162	15.1 106	**15.8** **271**
Unspecified	12.3 7	9.4 9	**10.7** **16**
All	**10.7** **3,351**	**13.9** **1,647**	**11.8** **5,018**

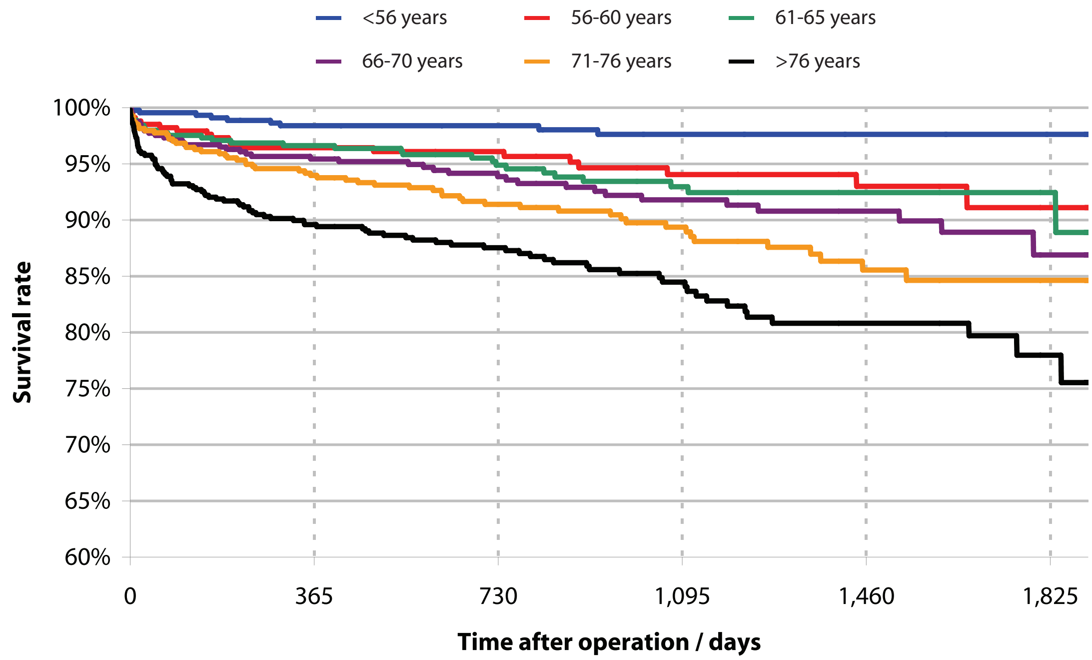
Degenerative mitral valve disease: Post-operative stay and age (n=4,982)



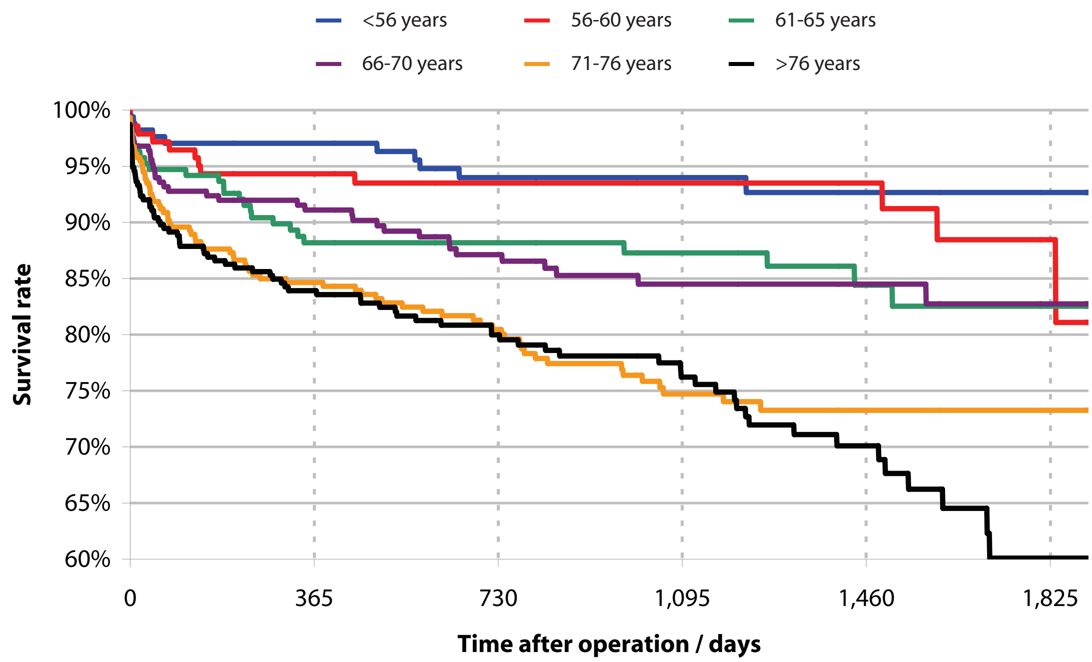
Survival and age

The medium-term survival rate for patients up to the age of 60 undergoing mitral valve repair is better than 90% five years after surgery. Survival is reduced in the older age groups, but following repair the Kaplan-Meier survival rate 5 years post-surgery is better than 75% in patients over the age of 76. Medium-term survival is worse following repair than replacement for all age groups.

Degenerative mitral valve disease: Medium-term survival and age at surgery; valve repair procedures; financial years 2004-2008 (n=2,837)



Degenerative mitral valve disease: Medium-term survival and age at surgery; valve replacement procedures; financial years 2004-2008 (n=1,368)



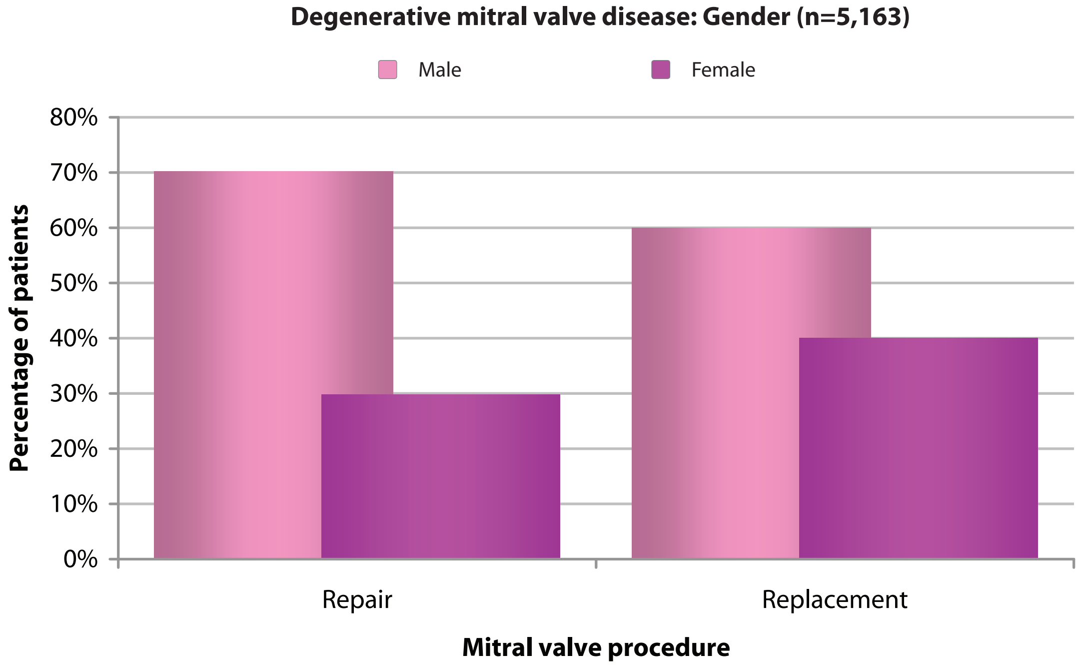
Gender

Gender distributions

Male patients make up the majority (70%) of patients treated with mitral valve repair for degenerative valve disease, compared to 60% of those undergoing mitral valve replacement surgery.

Degenerative mitral valve disease; gender distributions; financial years 2004-2008

		Procedure			
		Repair	Replacement	Unspecified	All
Gender	Male	2,415	1,032	12	**3,459**
	Female	1,026	690	10	**1,726**
	Unspecified	0	0	0	**0**
	All	**3,441**	**1,722**	**22**	**5,185**



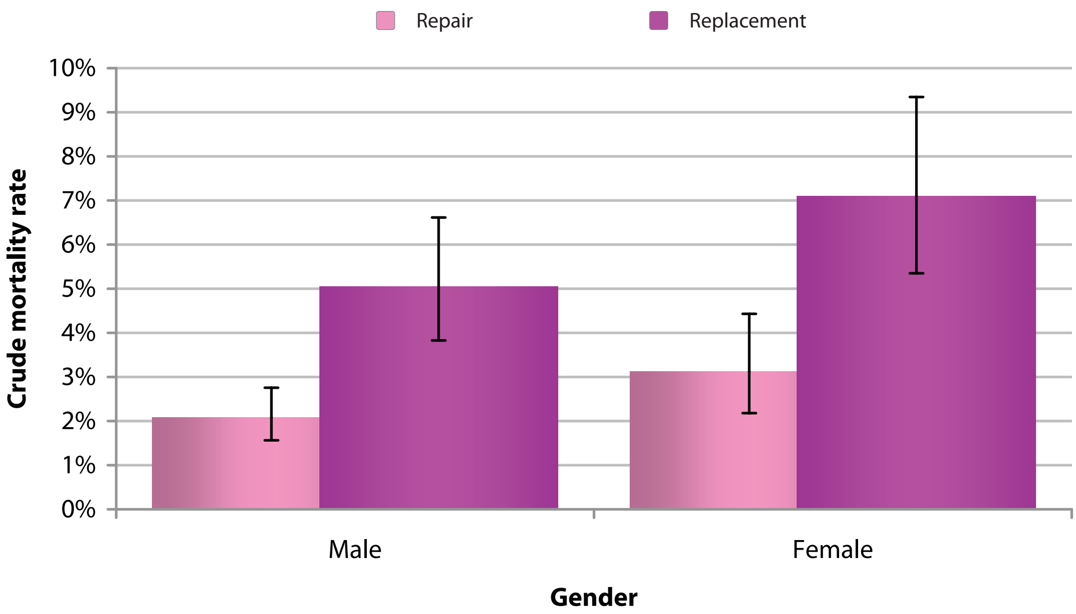
Mortality and gender

As with coronary artery bypass surgery and with aortic valve replacement surgery, the mortality rate after surgery for degenerative mitral valve disease appears higher for women, but this difference is not statistically significant.

Degenerative mitral valve disease; mortality and gender; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the count in the sub-group

		Procedure		
		Repair	Replacement	**All**
Gender	Male	2.1% 2,402	5.0% 1,030	**3.0%** **3,444**
	Female	3.1% 1,025	7.1% 690	**4.8%** **1,725**
	Unspecified	NA 0	NA 0	**NA** **0**
	All	**2.4%** **3,427**	**5.9%** **1,720**	**3.6%** **5,169**

Degenerative mitral valve disease: Crude mortality and gender (n=5,147)



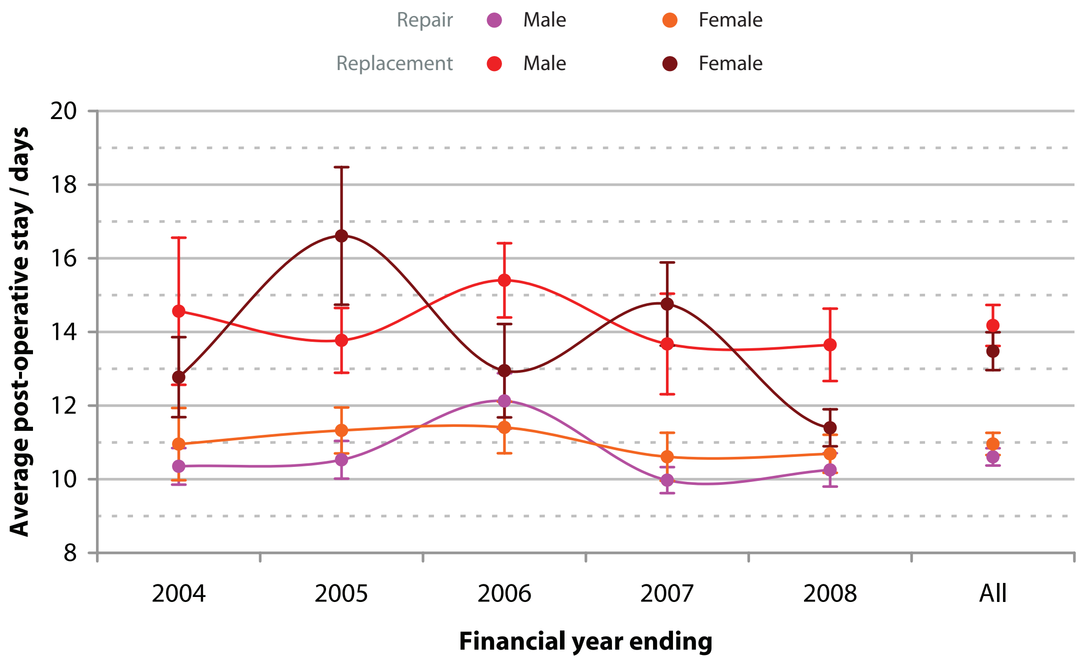
Post-operative stay and gender

As shown above, post-operative length-of-stay is greater following replacement than repair, but is not substantially different for men and women.

Degenerative mitral valve disease; mortality and gender; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the count in the sub-group

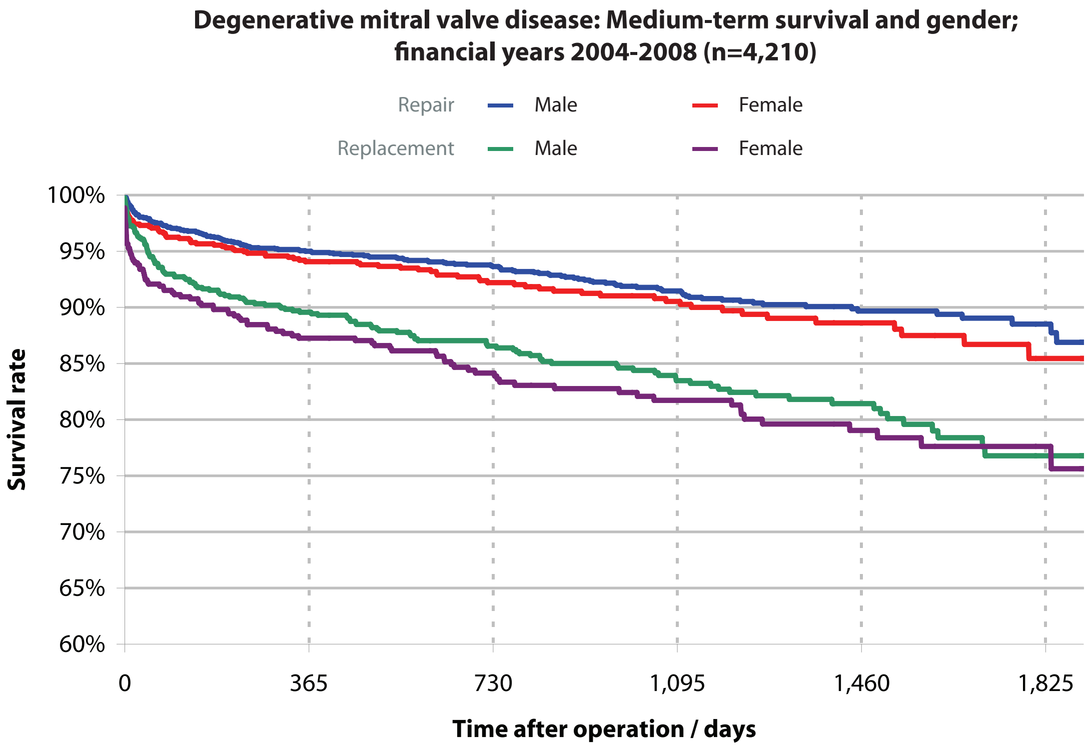
		Procedure	
		Repair	Replacement
Gender	Male	10.6 2,354	14.2 988
	Female	11.0 997	13.5 659
	Unspecified	NA 0	NA 0
	All	**10.7** **3,351**	**13.9** **1,647**

Degenerative mitral valve disease: Post-operative stay and gender; bars denote standard errors (n=4,998)



Survival and gender

Medium-term survival is better following repair than replacement, but there is no real difference between survival rates for the two sexes.



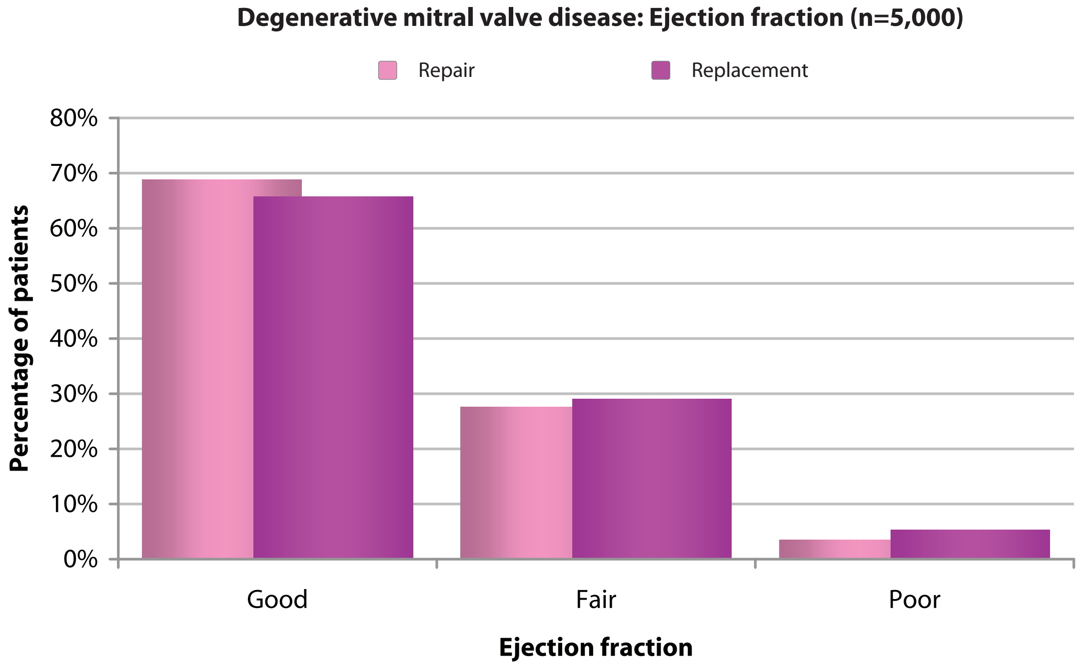
Ejection fraction

Ejection fraction distributions

A high proportion of patients coming to surgery for degenerative mitral valve disease have impaired ejection fraction. Patients with severe mitral regurgitation show an over-estimate of ejection fraction according to the criteria used in our database. For haemodynamic reasons, impaired left ventricular function in this setting can still be associated with an ejection fraction in excess of 50% (recorded as *good* in our database), and so left ventricular function would be designated *good* even though it is not, in reality, good from the patient's perspective. The real proportion of patients coming to surgery for severe mitral regurgitation is therefore even higher than shown here. Patients with impaired ejection fraction are known to do less well following mitral valve repair (Enriquez-Sarano 1994).

Degenerative mitral valve disease; ejection fraction distributions; financial years 2004-2008

		Procedure			
		Repair	Replacement	Unspecified	All
Ejection fraction	Good	2,295	1,094	13	**3,402**
	Fair	922	483	8	**1,413**
	Poor	118	88	1	**207**
	Unspecified	106	57	0	**163**
	All	**3,441**	**1,722**	**22**	**5,185**



ii Enriquez-Sarano M, Tajik AJ, Schaff HV, Orszulak TA, Bailey KR, Frye RL. Echocardiographic prediction of survival after surgical correction of organic mitral regurgitation. *Circulation.* 1994; **90(2):** 830-7.

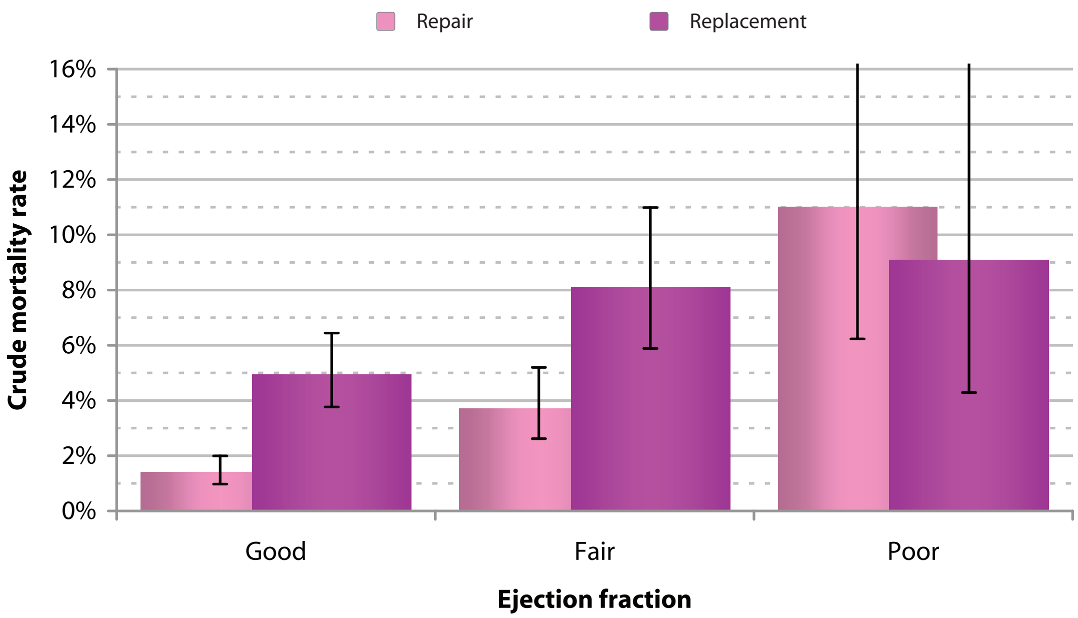
Mortality and ejection fraction

The operative mortality rate increases with increasing impairment of left ventricular function. The mortality rate for patients with *poor* ejection fraction is really quite high, in excess of 8% for both repair and replacement. For patients with good and moderate ejection fraction the mortality rate is lower for repair than it is for replacement.

Degenerative mitral valve disease; mortality and ejection fraction; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the count in the sub-group

		Procedure		
		Repair	Replacement	**All**
Ejection fraction	Good	1.4% 2,286	4.9% 1,093	**2.6%** **3,392**
	Fair	3.7% 917	8.1% 482	**5.2%** **1,407**
	Poor	11.0% 118	9.1% 88	**10.1%** **207**
	Unspecified	2.8% 106	0.0% 57	**1.8%** **163**
	All	**2.4%** **3,427**	**5.9%** **1,720**	**3.6%** **5,169**

Degenerative mitral valve disease: Crude mortality and ejection fraction (n=4,984)

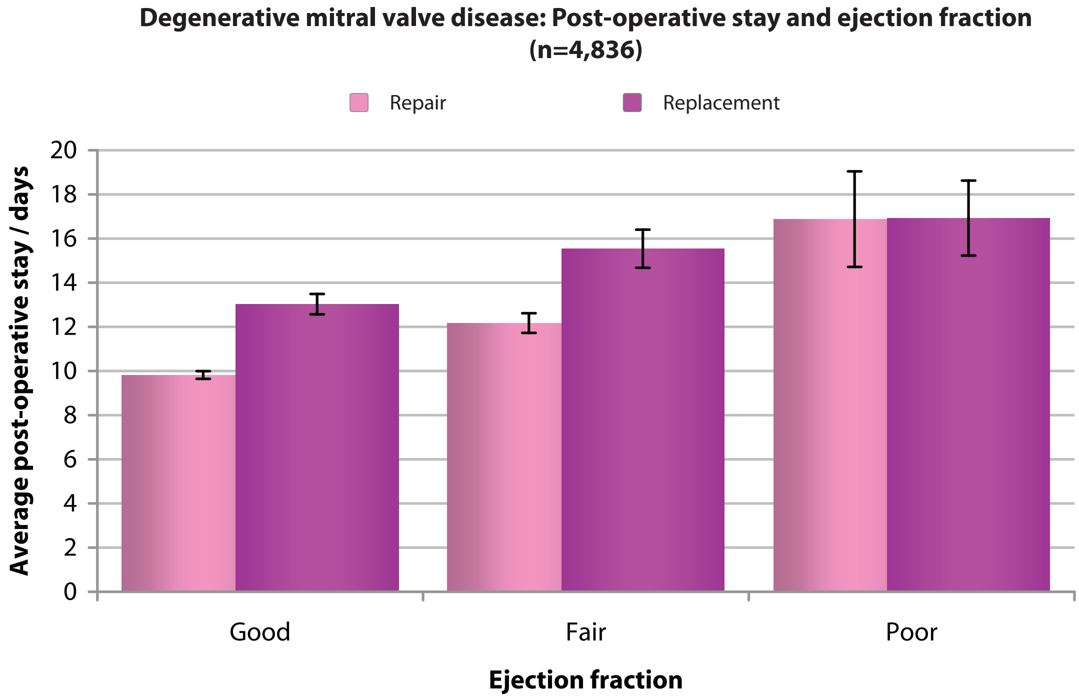


Post-operative stay and ejection fraction

Increasing impairment of left ventricular function is associated with increasing length-of-stay. For patients with good and moderate left ventricular function hospital stay is shorter for repair than it is for replacement.

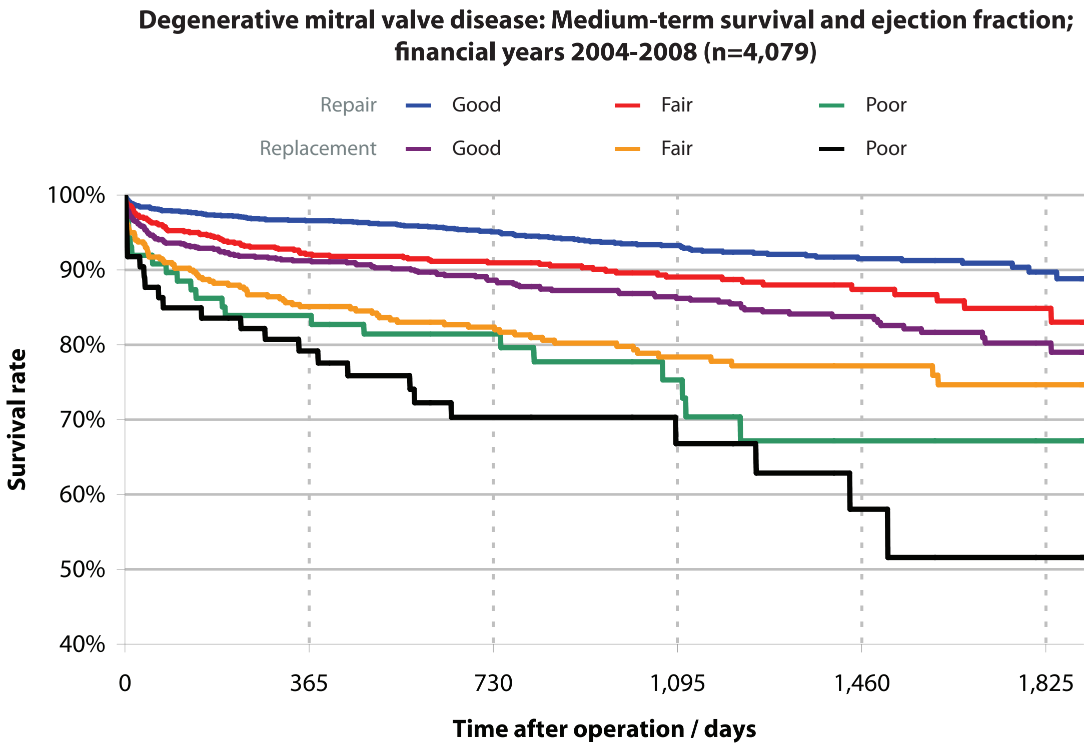
Degenerative mitral valve disease; post-operative stay and ejection fraction; financial years 2004-2008; the upper numbers represent the average stay in days and the lower numbers the count in the sub-group

		Procedure		
		Repair	Replacement	**All**
Ejection fraction	Good	9.8 2,244	13.0 1,045	**10.8 3,301**
	Fair	12.2 887	15.5 461	**13.3 1,355**
	Poor	16.9 115	16.9 84	**16.9 200**
	Unspecified	10.7 105	12.0 57	**11.2 162**
	All	**10.7 3,351**	**13.9 1,647**	**11.8 5,018**



Survival and ejection fraction

Survival is better after repair than it is after replacement. Deteriorating left ventricular function is associated with worse survival.



Angina

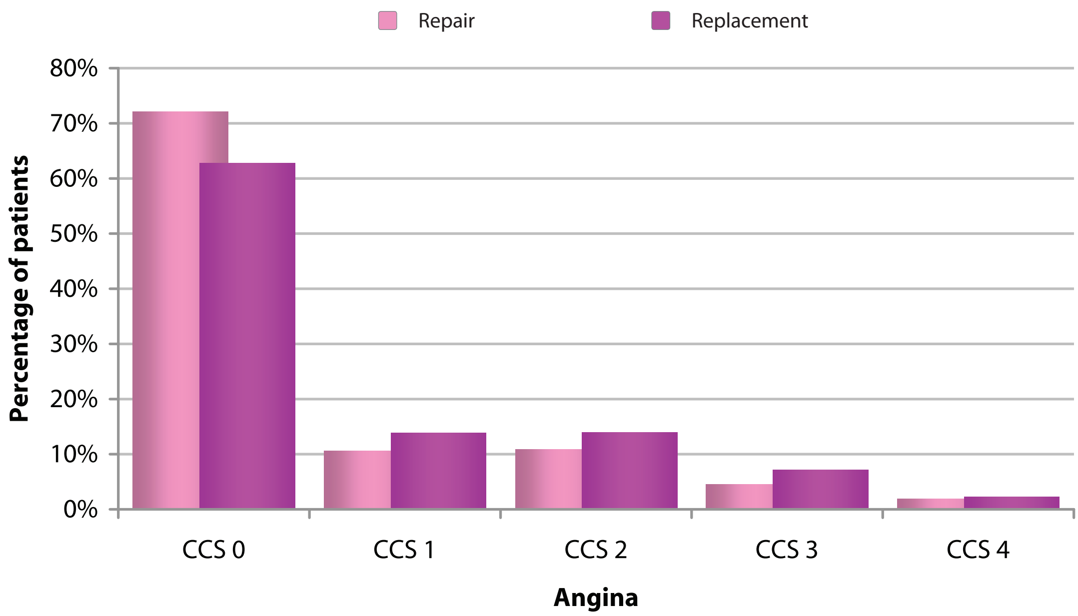
Angina distributions

The patients analysed in this section all had surgery for degenerative mitral valve disease, but some had concomitant coronary artery disease. This may have been because they had *occult* coronary artery disease identified on pre-operative screening coronary angiography, or because they had overt angina. Thirty percent of patients undergoing mitral repair had some degree of angina. Angina symptoms were severe (CCS class 3 or 4) in less than 10% . The proportion of patients with angina undergoing mitral replacement was slightly higher.

Degenerative mitral valve disease; angina distributions; financial years 2004-2008

		Procedure			
		Repair	Replacement	Unspecified	All
Angina	CCS 0	2,317	1,014	14	**3,345**
	CCS 1	341	224	2	**567**
	CCS 2	350	226	2	**578**
	CCS 3	145	115	3	**263**
	CCS 4	61	37	0	**98**
	Unspecified	227	106	1	**334**
	All	**3,441**	**1,722**	**22**	**5,185**

Degenerative mitral valve disease: Angina (n=4,830)

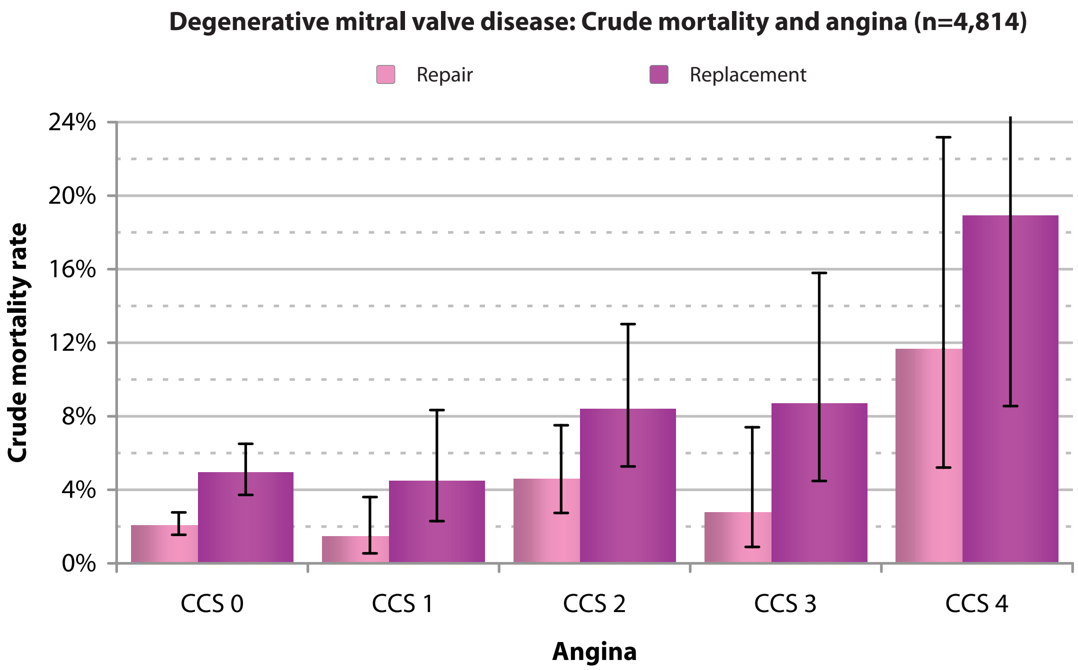


Mortality and angina

The most severe category of angina (class 4) was associated with an elevated mortality rate.

Degenerative mitral valve disease; mortality and angina; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the count in the sub-group

		Procedure		
		Repair	Replacement	**All**
Angina	CCS 0	2.1% 2,309	4.9% 1,013	**3.0%** **3,322**
	CCS 1	1.5% 339	4.5% 223	**2.7%** **562**
	CCS 2	4.6% 348	8.4% 226	**6.1%** **574**
	CCS 3	2.8% 144	8.7% 115	**5.4%** **259**
	CCS 4	11.7% 60	18.9% 37	**14.4%** **97**
	Unspecified	0.9% 227	4.7% 106	**2.1%** **333**
	All	**2.4%** **3,427**	**5.9%** **1,720**	**3.6%** **5,147**



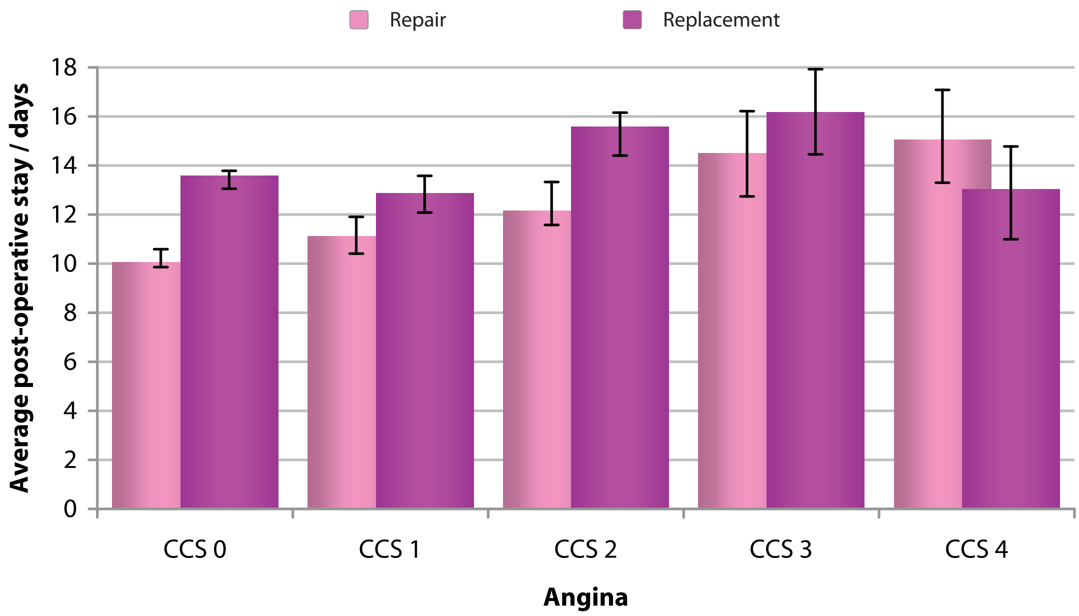
Post-operative stay and angina

The presence of angina was generally associated with an increased length of post-operative in-hospital stay.

Degenerative mitral valve disease; post-operative stay and angina; financial years 2004-2008; the upper numbers represent the average stay in days and the lower numbers the count in the sub-group

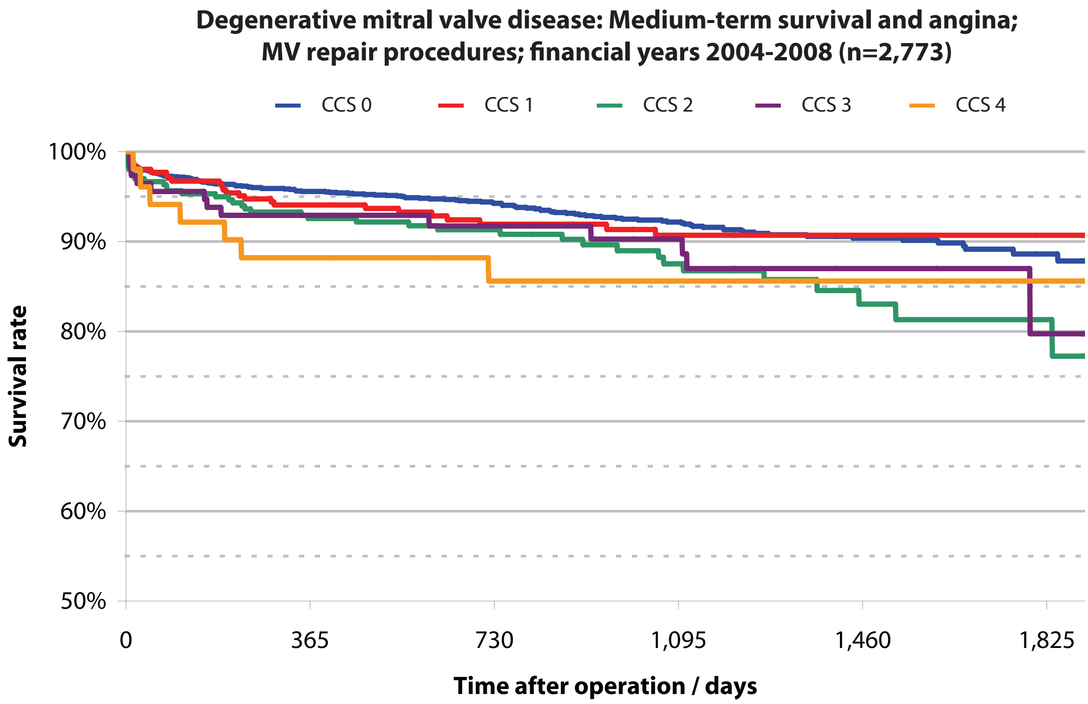
		Procedure		
		Repair	Replacement	**All**
Angina	CCS 0	10.1 2,262	13.6 975	**11.1** **3,250**
	CCS 1	11.1 334	12.9 211	**11.8** **547**
	CCS 2	12.1 340	15.6 215	**13.5** **557**
	CCS 3	14.5 141	16.2 110	**15.2** **253**
	CCS 4	15.1 60	13.0 36	**14.3** **96**
	Unspecified	11.0 214	13.2 100	**11.7** **315**
	All	**10.7** **3,351**	**13.9** **1,647**	**11.8** **5,018**

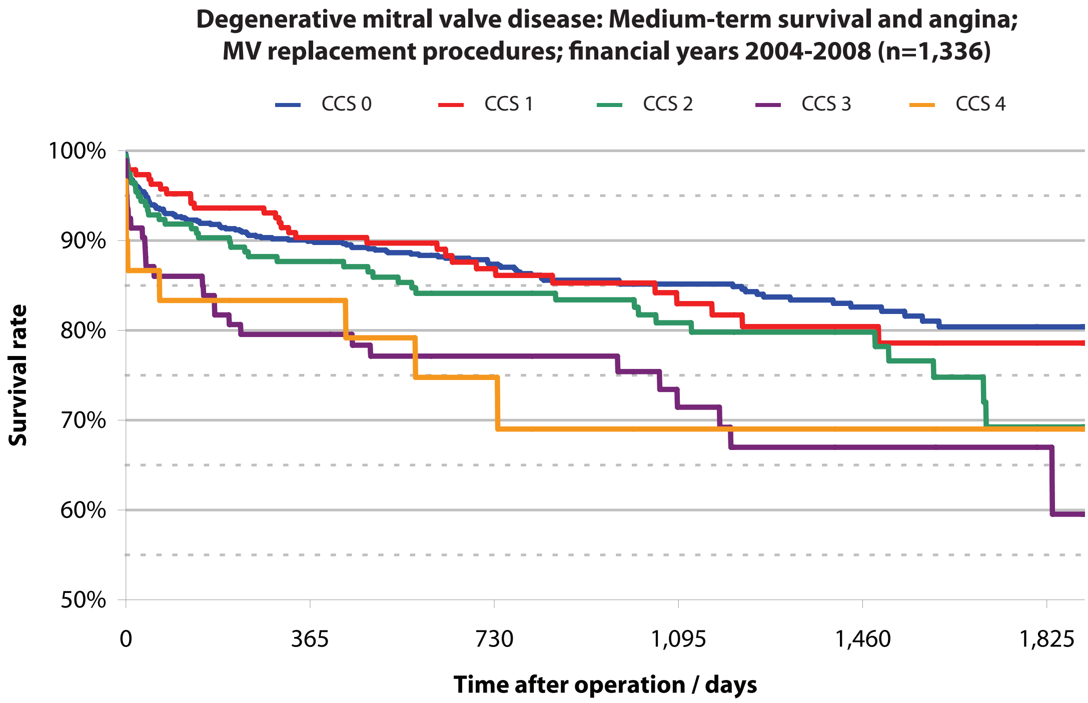
Degenerative mitral valve disease: Post-operative stay and angina (n=4,684)



Survival and angina

Mild angina (CCS class 1) does not seem to be associated with worse survival rate. The number of patients with the most severe angina (CCS class 4) was small.





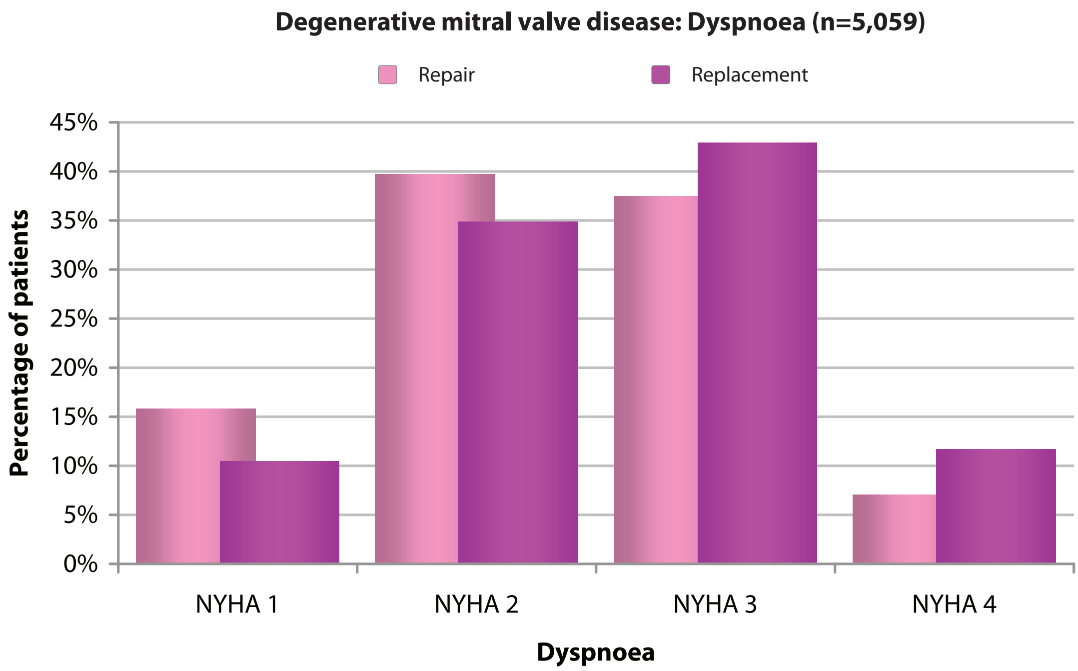
Dyspnoea

Dyspnoea distributions

These finding are worrying. More than 40% of patients undergoing mitral valve repair for degenerative mitral valve disease have NYHA class 3 or 4 symptoms. As described previously these patients do not derive optimum benefit from surgery (see page 218).

Degenerative mitral valve disease; dyspnoea distributions; financial years 2004-2008

		Procedure			
		Repair	Replacement	Unspecified	**All**
Dyspnoea	NYHA 1	532	177	0	**709**
	NYHA 2	1,337	590	5	**1,932**
	NYHA 3	1,262	726	14	**2,002**
	NYHA 4	237	198	2	**437**
	Unspecified	73	31	1	**105**
	All	**3,441**	**1,722**	**22**	**5,185**



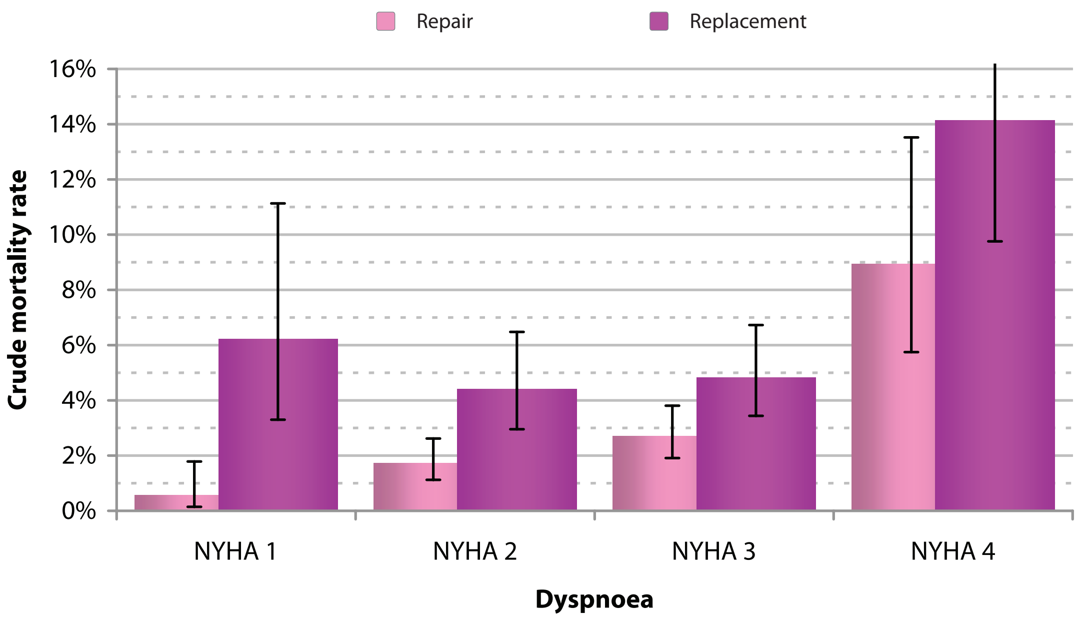
Mortality and dyspnoea

The general picture is one where the mortality rate is higher in patients with more severe symptoms. The mortality rates for those undergoing mitral repair and replacement with NYHA class 4 symptoms are 9% and 14% respectively.

Degenerative mitral valve disease; mortality and dyspnoea; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the count in the sub-group

		Procedure		
		Repair	Replacement	All
Dyspnoea	NYHA 1	0.6% 531	6.2% 177	**2.0%** **708**
	NYHA 2	1.7% 1,334	4.4% 590	**2.5%** **1,924**
	NYHA 3	2.7% 1,255	4.8% 724	**3.5%** **1,979**
	NYHA 4	8.9% 235	14.1% 198	**11.3%** **433**
	Unspecified	1.4% 72	3.2% 31	**1.9%** **103**
	All	**2.4%** **3,427**	**5.9%** **1,720**	**3.6%** **5,147**

Degenerative mitral valve disease: Crude mortality and dyspnoea (n=5,044)



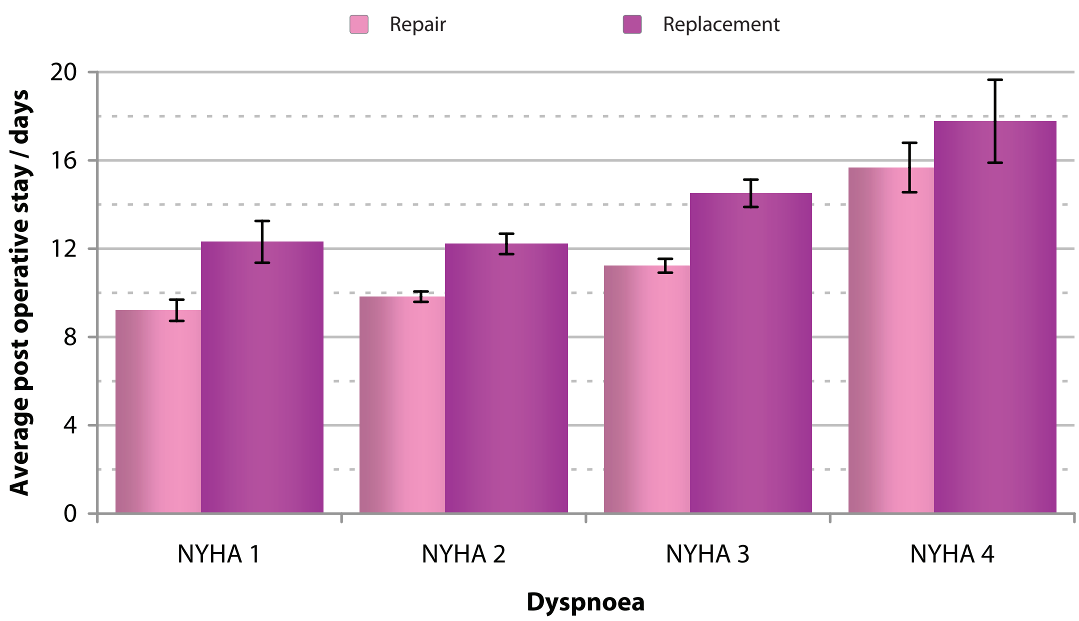
Post-operative stay and dyspnoea

Increasing symptoms of dyspnoea are associated with increased post-operative length-of-stay.

Degenerative mitral valve disease; post-operative stay and dyspnoea; financial years 2004-2008; the upper numbers represent the average stay in days and the lower numbers the count in the sub-group

		Procedure		
		Repair	Replacement	**All**
Dyspnoea	NYHA 1	9.2 524	12.3 175	**10.0** **699**
	NYHA 2	9.8 1,298	12.2 562	**10.6** **1,865**
	NYHA 3	11.2 1,239	14.5 702	**12.4** **1,953**
	NYHA 4	15.7 232	17.8 185	**16.6** **419**
	Unspecified	13.2 58	17.1 23	**14.2** **82**
	All	**10.7** **3,351**	**13.9** **1,647**	**11.8** **5,018**

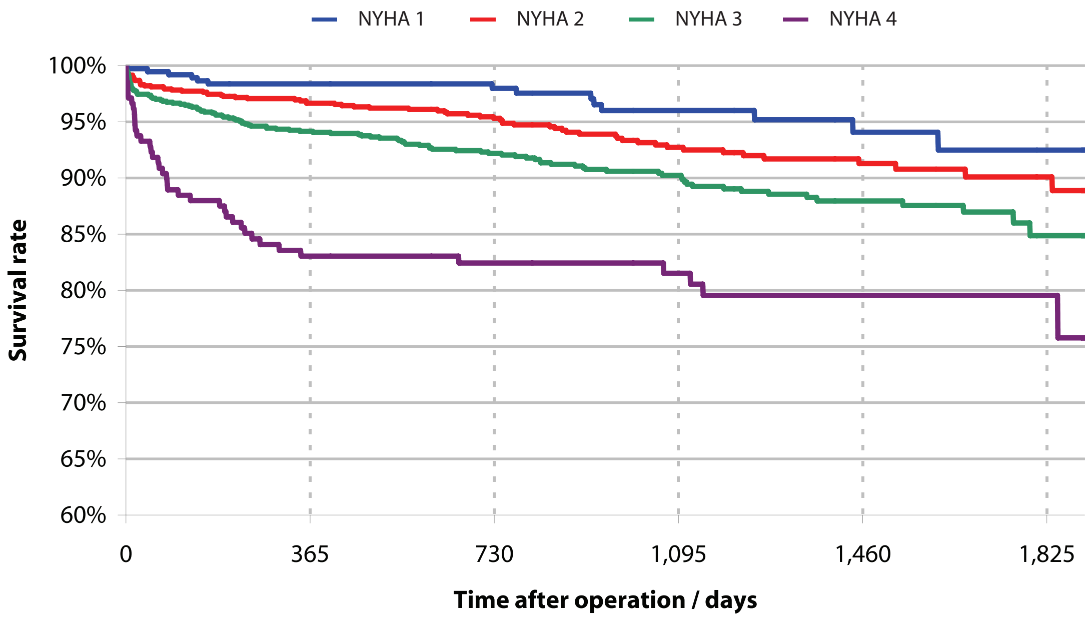
Degenerative mitral valve disease: Post-operative stay and dyspnoea (n=4,917)



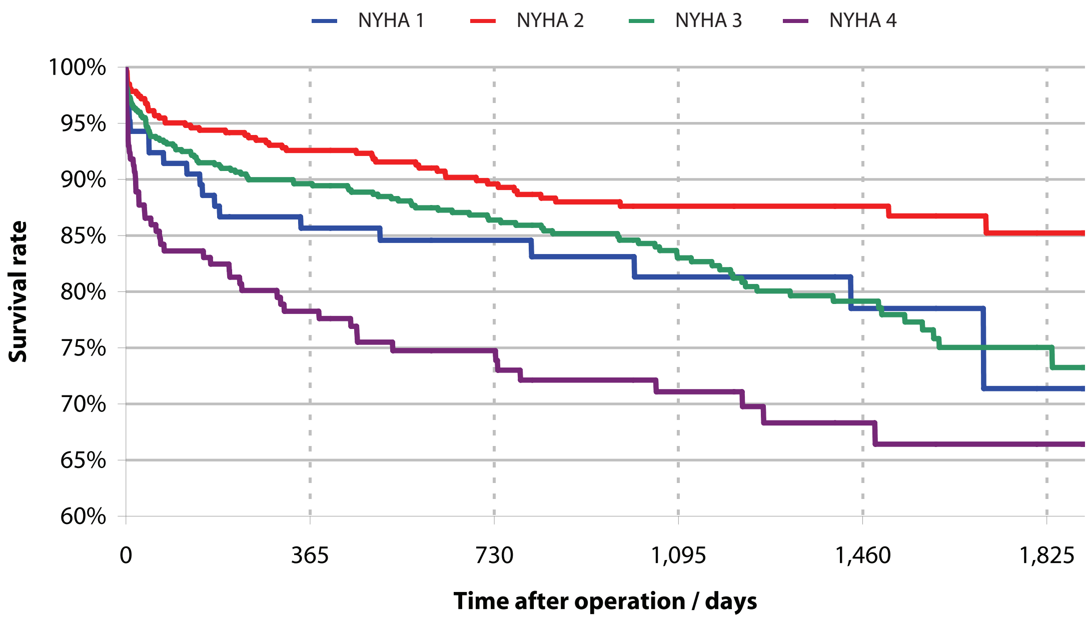
Survival and dyspnoea

Medium-term survival is clearly associated with pre-operative symptoms of dyspnoea (Tribouilloy 1999).

Degenerative mitral valve disease: Medium-term survival and dyspnoea; valve repair procedures; financial years 2004-2008 (n=2,771)



Degenerative mitral valve disease: Medium-term survival and dyspnoea; valve replacement procedures; financial years 2004-2008 (n=1,338)



i Tribouilloy CM, Enriquez-Sarano M, Schaff HV, Orszulak TA, Bailey KR, Tajik AJ, Frye RL. Impact of preoperative symptoms on survival after surgical correction of organic mitral regurgitation: rationale for optimizing surgical indications. *Circulation.* 1999; **99(3):** 400-5.

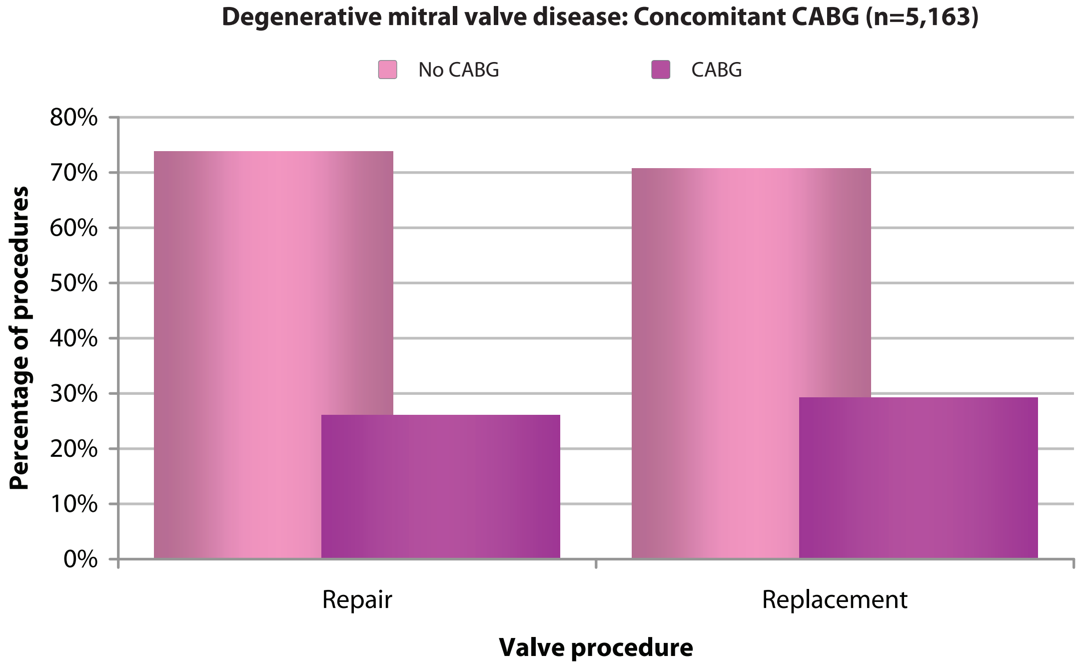
Concomitant CABG

Distributions

Twenty-five percent of patients with degenerative mitral valve disease having mitral repair and 30% of those undergoing replacement have concomitant coronary artery bypass surgery. This proportion is high, reflecting the high incidence of underlying coronary artery disease in patients in Great Britain and Ireland.

Degenerative mitral valve disease; the occurrence of concomitant CABG; financial years 2004-2008

		Procedure			
		Repair	Replacement	Unspecified	**All**
Concomitant CABG	No	899	504	7	**1,410**
	Yes	2,542	1,218	15	**3,775**
	Unspecified	0	0	0	**0**
	All	**3,441**	**1,722**	**22**	**5,185**



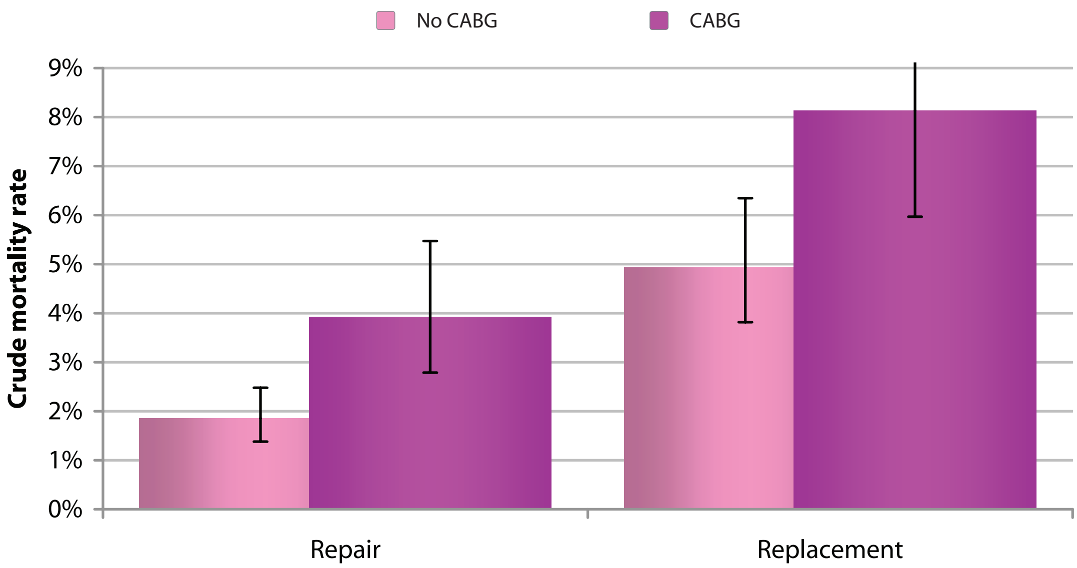
Mortality and concomitant CABG

Concomitant coronary artery bypass surgery is associated with an elevated mortality rate, for both repair and replacement.

Degenerative mitral valve disease; mortality and concomitant CABG; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the count in the sub-group

		Procedure		
		Repair	Replacement	All
Concomitant CABG	No	1.9% 2,535	4.9% 1,216	**2.9%** **3,766**
	Yes	3.9% 892	8.1% 504	**5.5%** **1,403**
	Unspecified	NA 0	NA 0	**NA** **0**
	All	**2.4%** **3,427**	**5.9%** **1,720**	**3.6%** **5,169**

Degenerative mitral valve disease: Crude mortality and concomitant CABG (n=5,147)



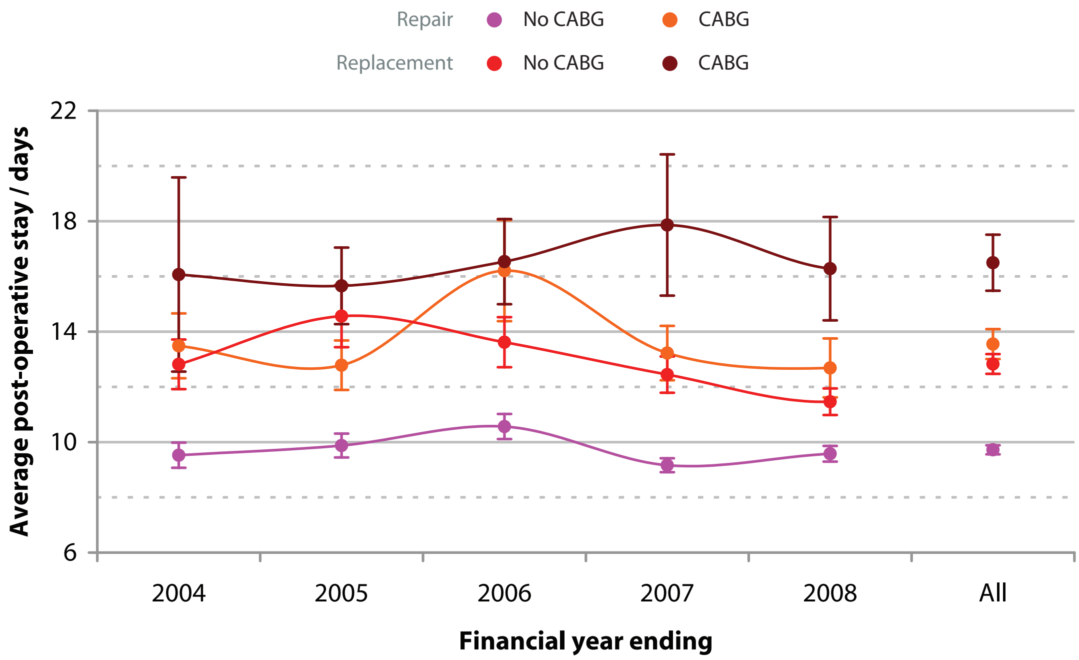
Post-operative stay and concomitant CABG

Concomitant coronary artery bypass surgery is associated with an increase in post-operative length-of-stay for both mitral repair and replacement.

Degenerative mitral valve disease; post-operative stay and concomitant CABG; financial years 2004-2008; the upper numbers represent the average stay in days and the lower numbers the count in the sub-group

		Procedure			
		Repair		Replacement	
		No CABG	CABG	No CABG	CABG
Financial year	2004	9.5 352	13.5 121	12.8 202	16.1 88
	2005	9.9 401	12.8 172	14.6 227	15.7 85
	2006	10.6 492	16.2 153	13.6 191	16.5 97
	2007	9.2 555	13.2 178	12.4 211	17.9 95
	2008	9.6 685	12.7 242	11.5 337	16.3 114
	All	**9.7** **2,485**	**13.6** **866**	**12.8** **1,168**	**16.5** **479**

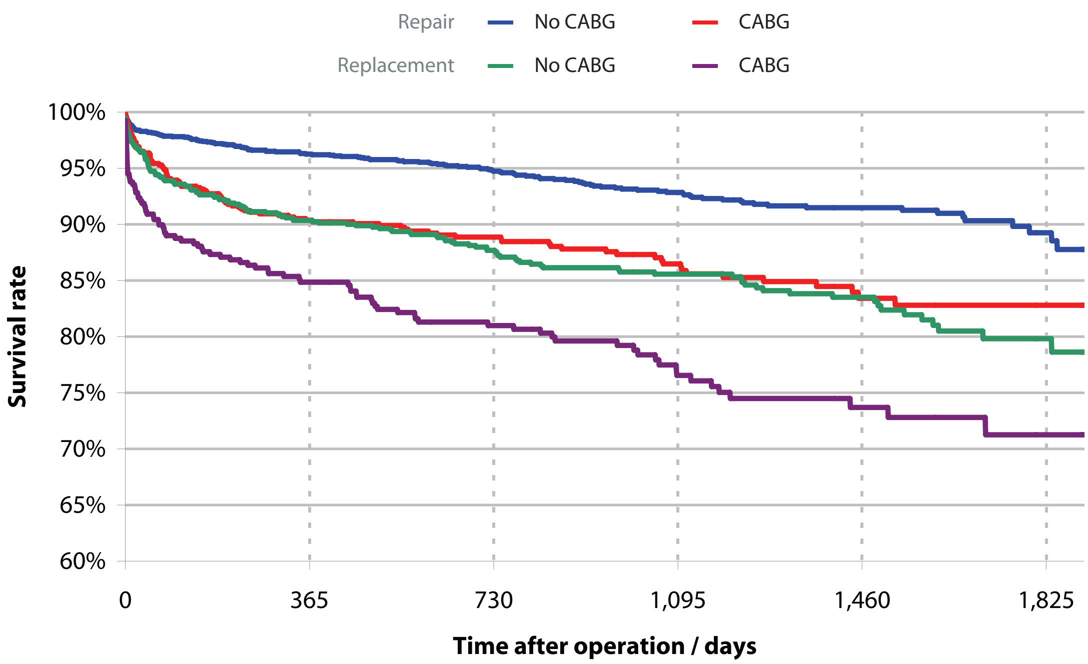
Degenerative mitral valve disease: Post-operative stay and concomitant CABG; bars denote standard errors (n=4,998)



Survival and concomitant CABG

Concomitant coronary artery bypass surgery is associated with worse medium-term survival, for both repair and replacement.

Degenerative mitral valve disease: Medium-term survival & concomitant CABG; financial years 2004-2008 (n=4,210)



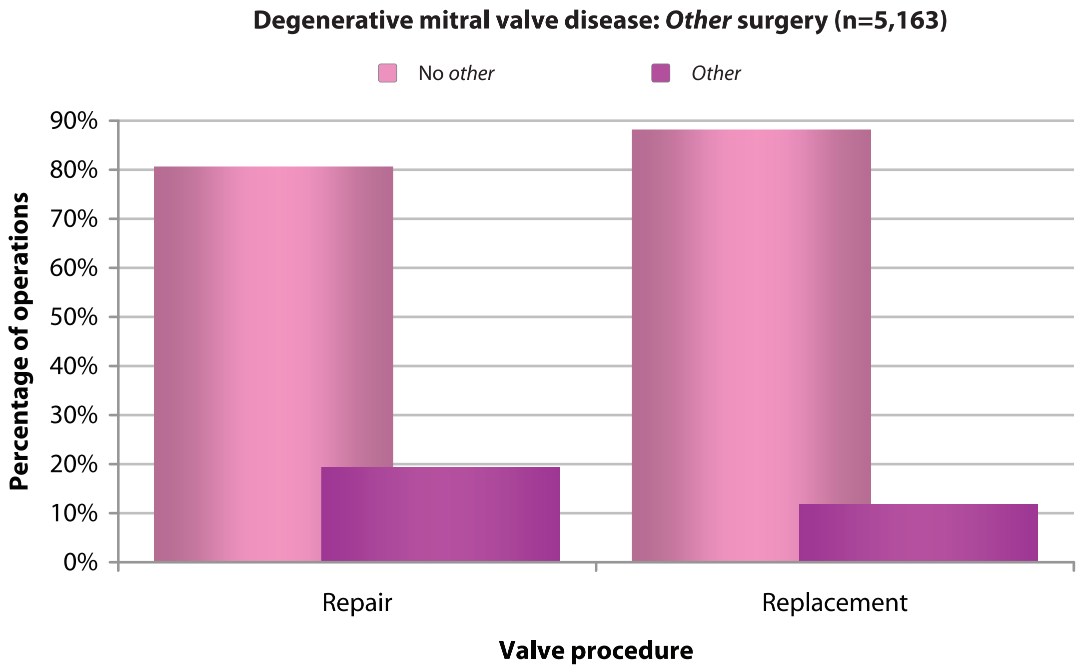
Other concomitant surgery

Distributions

Just under 20% of patient undergoing mitral valve repair for degenerative mitral valve disease have concomitant unspecified *other* operations. We suspect that the majority of these are AF ablations.

Degenerative mitral valve disease; the occurrence of *other* surgery; financial years 2004-2008

		Procedure			
		Repair	Replacement	Unspecified	All
Other surgery	No	2,775	1,519	18	**4,312**
	Yes	666	203	4	**873**
	Unspecified	0	0	0	**0**
	All	**3,441**	**1,722**	**22**	**5,185**



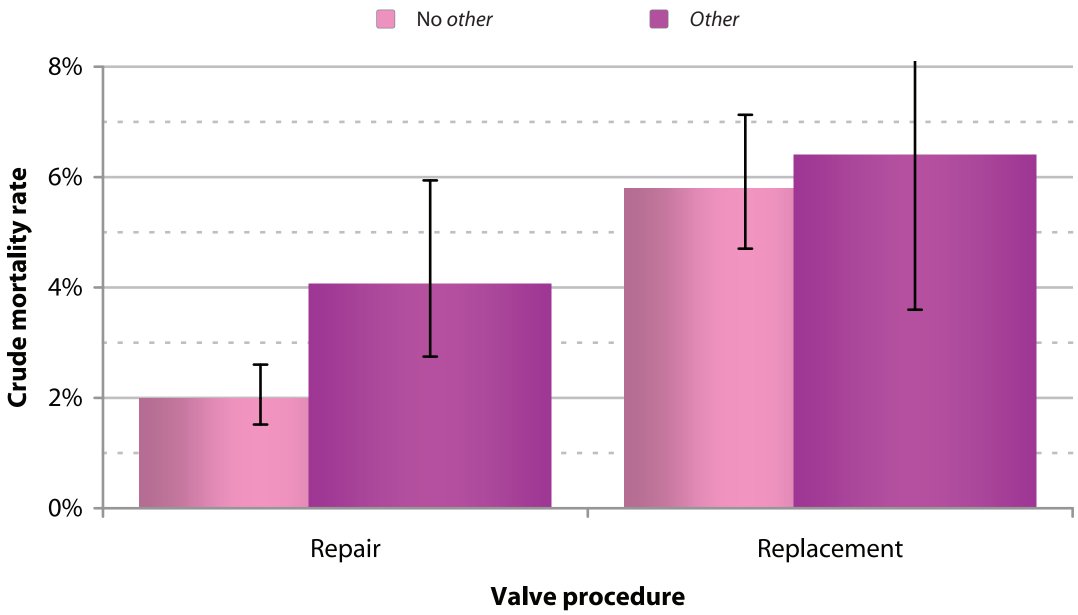
Mortality and *other* surgery

Concomitant *other* surgery is associated with a significantly higher mortality for repair, but not for replacement. Whilst we suspect that the majority of these patient have undergone AF ablation, we do not have robust evidence to that effect, and so it should not be assumed that concomitant AF ablation with mitral valve repair is associated with an increased mortality. A recent large database analysis from the United States of America showed that just over 50% of patients undergoing mitral surgery underwent concomitant AF ablation and there was no increase in operative risk associated with the AF surgery, after adjusting for patient risk factors (Gammie *et al.* 2008).

Degenerative mitral valve disease; mortality and *other* surgery; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the count in the sub-group

		Procedure		
		Repair	Replacement	**All**
***Other* surgery**	No	2.0% 2,763	5.8% 1,517	**3.3%** **4,280**
	Yes	4.1% 664	6.4% 203	**4.6%** **867**
	Unspecified	NA 0	NA 0	**NA** **0**
	All	**2.4%** **3,427**	**5.9%** **1,720**	**3.6%** **5,147**

Degenerative mitral valve disease: Crude mortality and *other* surgery (n=5,147)



i Gammie JS, Haddad M, Milford-Beland S, Welke KF, Ferguson TB Jr, O'Brien SM, Griffith BP, Peterson ED. Atrial fibrillation correction surgery: lessons from the Society of Thoracic Surgeons National Cardiac Database. *Ann Thorac Surg.* 2008; **85(3):** 909-14.

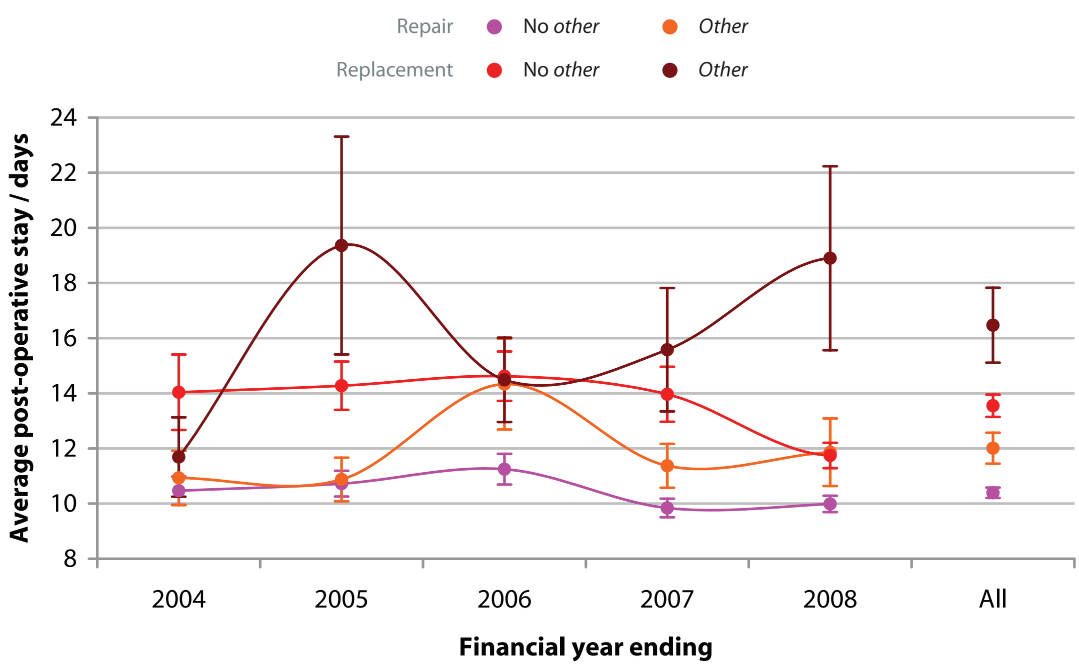
Post-operative stay and *other* concomitant surgery

Concomitant *other* surgery is associated with a greater post-operative length-of-stay.

Degenerative mitral valve disease; post-operative stay and *other* surgery; financial years 2004-2008; the upper numbers represent the average stay in days and the lower numbers the count in the sub-group

	Procedure			
	Repair		Replacement	
Financial year	No *other*	*Other*	No *other*	*Other*
2004	10.5 401	10.9 72	14.0 261	11.7 29
2005	10.7 469	10.9 104	14.3 276	19.4 36
2006	11.2 508	14.3 137	14.6 247	14.5 41
2007	9.8 585	11.4 148	14.0 275	15.6 31
2008	10.0 729	11.9 198	11.7 392	18.9 59
All	**10.4** **2,692**	**12.0** **659**	**13.5** **1,451**	**16.5** **196**

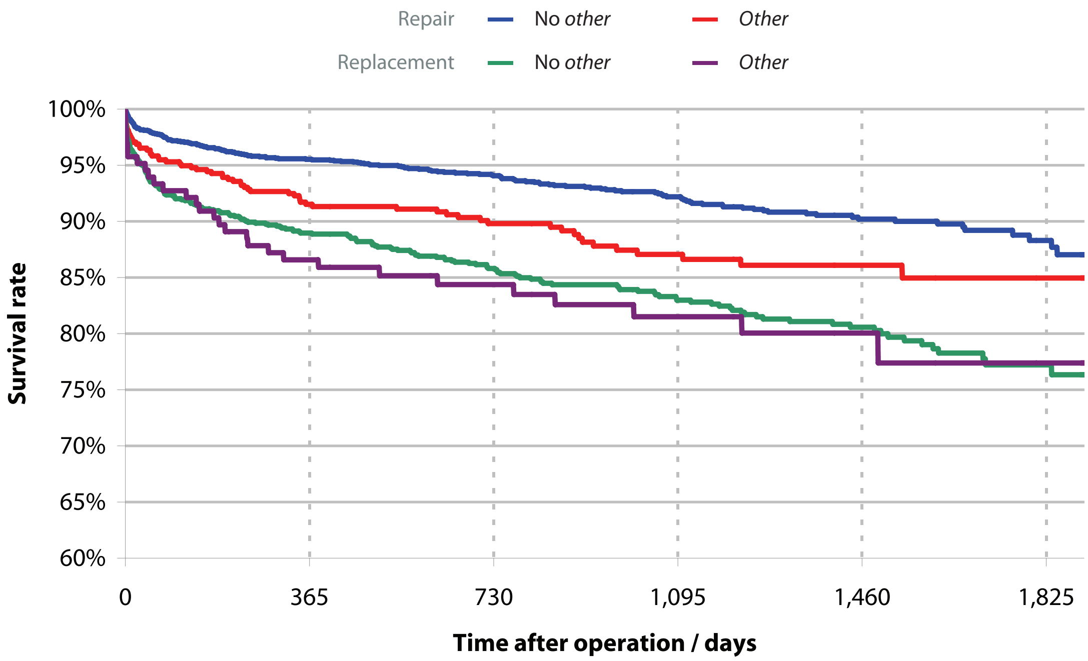
Degenerative mitral valve disease: Post-operative stay and concomitant *Other* surgery; bars denote standard errors (n=4,998)



Survival and *other* surgery

Patients having concomitant *other* surgery along with mitral repair have a worse medium-term survival rate.

Degenerative mitral valve disease: Medium-term survival and *other* surgery; financial years 2004-2008 (n=4,210)



We appreciate that it is difficult to form robust conclusions from the data on mitral & *other* surgery presented here. Surgery for atrial fibrillation is a relatively new development and our current data set is not optimally configured to capture useful information for these procedures. We are currently in the process of undertaking a radical revision of the dataset, which will leave us in a better position to analyse this group of patients in the future.

Mitral valve surgery

Isolated mitral valve repair for degenerative valve disease

Distributions and outcome rates for major risk factors not reported in detail; financial years 2004-2008

Risk factor		Count	Mortality rate (count; 95% CI)
Body mass index	Underweight	193	5.2% (192; 2.7-9.6%)
	Normal	1,324	2.4% (1,320; 1.7-3.4%)
	Overweight	1,330	2.3% (1,322; 1.6-3.4%)
	Obese	413	1.2% (412; 0.4-3.0%)
	Morbidly obese	60	3.3% (60; 0.6-12.5%)
	Unspecified	121	
LMS disease	No	2,784	2.4% (2,774; 1.9-3.1%)
	Yes	112	4.5% (112; 1.7-10.6%)
	Unspecified	545	
Previous cardiac surgery	No	3,353	2.3% (3,339; 1.8-2.9%)
	Yes	69	8.7% (69; 3.6-18.6%)
	Unspecified	19	
Diabetes	No	3,191	2.2% (3,178; 1.7-2.8%)
	Yes	200	6.0% (199; 3.3-10.5%)
	Unspecified	50	
Hypertension	No	1,886	1.3% (1,880; 0.8-1.9%)
	Yes	1,504	3.8% (1,496; 2.9-4.9%)
	Unspecified	51	
Extra-cardiac arteriopathy	No	3,226	2.2% (3,212; 1.8-2.8%)
	Yes	159	6.3% (159; 3.2-11.6%)
	Unspecified	56	
Renal disease	No	3,329	2.2% (3,316; 1.8-2.8%)
	Yes	49	14.6% (48; 6.5-28.4%)
	Unspecified	63	

Post-operative stay / days (count; SE)	Post-operative stroke rate (count; 95% CI)	Re-op for bleeding rate (count; 95% CI)	Survival rate at 5 years
10.6 (188; 0.57)	0.6% (170; 0.0-3.7%)	4.4% (180; 2.1-8.9%)	81.6%
11.1 (1,292; 0.32)	1.5% (1,172; 0.9-2.5%)	4.6% (1,230; 3.5-5.9%)	88.4%
10.3 (1,296; 0.27)	0.8% (1,186; 0.4-1.6%)	4.8% (1,263; 3.7-6.1%)	87.7%
10.8 (399; 0.61)	1.6% (368; 0.7-3.7%)	3.1% (384; 1.7-5.5%)	85.3%
13.1 (59; 1.90)	1.7% (58; 0.1-10.5%)	7.1% (56; 2.3-18.1%)	87.5%
10.7 (2,756; 0.21)	1.2% (2,667; 0.9-1.8%)	4.1% (2,681; 3.4-4.9%)	87.4%
13.7 (109; 1.18)	1.9% (107; 0.3-7.2%)	7.4% (108; 3.5-14.5%)	79.3%
10.6 (3,266; 0.19)	1.1% (2,967; 0.8-1.6%)	4.5% (3,132; 3.8-5.3%)	88.0%
14.3 (67; 2.10)	4.8% (63; 1.2-14.2%)	6.3% (64; 2.0-16.0%)	71.6%
10.5 (3,104; 0.19)	1.1% (2,847; 0.8-1.6%)	4.3% (3,000; 3.6-5.1%)	88.2%
13.5 (198; 0.93)	2.7% (188; 1.0-6.4%)	6.2% (195; 3.4-10.8%)	75.6%
9.8 (1,846; 0.20)	1.1% (1,714; 0.7-1.8%)	3.7% (1,775; 2.9-4.7%)	89.9%
11.8 (1,454; 0.34)	1.4% (1,320; 0.8-2.2%)	5.3% (1,419; 4.2-6.6%)	84.4%
10.5 (3,142; 0.19)	1.1% (2,884; 0.8-1.6%)	4.3% (3,039; 3.7-5.1%)	88.1%
15.2 (153; 1.04)	3.4% (145; 1.3-8.3%)	6.7% (149; 3.4-12.3%)	75.2%
10.6 (3,243; 0.18)	1.2% (2,992; 0.8-1.6%)	4.4% (3,139; 3.7-5.2%)	88.2%
19.8 (45; 3.78)	2.3% (43; 0.1-13.8%)	13.6% (44; 5.7-28.0%)	71.8%

Isolated mitral valve replacement for degenerative valve disease

Distributions and outcome rates for major risk factors not reported in detail; financial years 2004-2008

Risk factor		Count	Mortality rate (count; 95% CI)
Body mass index	Underweight	126	15.1% (126; 9.6-9.6%)
	Normal	615	5.0% (614; 3.4-3.5%)
	Overweight	619	4.5% (619; 3.4-3.1%)
	Obese	246	5.3% (245; 3.0-3.0%)
	Morbidly obese	54	9.3% (54; 12.5-3.5%)
	Unspecified	62	
LMS disease	No	1,336	5.8% (1,335; 3.1-4.7%)
	Yes	49	10.2% (49; 10.6-3.8%)
	Unspecified	337	
Previous cardiac surgery	No	1,494	5.3% (1,492; 2.9-4.2%)
	Yes	197	10.7% (197; 18.6-6.9%)
	Unspecified	31	
Diabetes	No	1,543	5.6% (1,541; 2.8-4.5%)
	Yes	158	8.9% (158; 10.5-5.1%)
	Unspecified	21	
Hypertension	No	858	4.8% (856; 1.9-3.5%)
	Yes	835	6.9% (835; 4.9-5.4%)
	Unspecified	29	
Extra-cardiac arteriopathy	No	1,595	5.6% (1,593; 2.8-4.5%)
	Yes	101	11.9% (101; 11.6-6.6%)
	Unspecified	26	
Renal disease	No	1,638	5.5% (1,637; 2.8-4.5%)
	Yes	45	25.0% (44; 28.4-13.7%)
	Unspecified	39	

Post-operative stay / days (count; SE)	Post-operative stroke rate (count; 95% CI)	Re-op for bleeding rate (count; 95% CI)	Survival rate at 5 years
13.3 (120; 1.15)	4.9% (102; 3.7-1.8%)	8.4% (107; 8.9-4.2%)	62.3%
12.9 (580; 0.47)	2.7% (523; 2.5-1.5%)	7.7% (547; 5.9-5.7%)	81.0%
13.8 (595; 0.74)	4.1% (533; 1.6-2.7%)	6.6% (564; 6.1-4.7%)	77.0%
15.4 (239; 1.23)	3.3% (212; 3.7-1.5%)	4.1% (220; 5.5-2.0%)	78.6%
18.6 (54; 2.11)	2.3% (44; 10.5-0.1%)	2.1% (47; 18.1-0.1%)	71.2%
14.0 (1,295; 0.46)	3.5% (1,231; 1.8-2.6%)	6.8% (1,230; 4.9-5.5%)	77.4%
14.1 (49; 1.49)	4.3% (46; 7.2-0.8%)	10.9% (46; 14.5-4.1%)	66.3%
13.7 (1,431; 0.42)	3.0% (1,267; 1.6-2.2%)	6.9% (1,323; 5.3-5.6%)	77.5%
15.6 (188; 1.15)	7.9% (164; 14.2-4.5%)	6.1% (180; 16.0-3.2%)	70.5%
13.3 (1,473; 0.38)	3.4% (1,321; 1.6-2.5%)	6.6% (1,385; 5.1-5.4%)	78.3%
19.5 (154; 2.06)	4.6% (131; 6.4-1.9%)	8.6% (140; 10.8-4.7%)	65.1%
12.7 (818; 0.44)	2.9% (726; 1.8-1.8%)	6.6% (763; 4.7-4.9%)	78.8%
14.9 (801; 0.65)	4.0% (720; 2.2-2.8%)	7.0% (758; 6.6-5.3%)	75.3%
13.4 (1,523; 0.37)	3.4% (1,355; 1.6-2.5%)	6.8% (1,428; 5.1-5.6%)	78.1%
20.1 (100; 2.76)	5.4% (92; 8.3-2.0%)	7.6% (92; 12.3-3.4%)	59.4%
13.7 (1,568; 0.40)	3.5% (1,400; 1.6-2.6%)	6.7% (1,470; 5.2-5.5%)	77.8%
17.7 (42; 2.69)	5.0% (40; 13.8-0.9%)	15.0% (40; 28.0-6.2%)	49.8%

Mitral valve repair

In line with the other analyses presented in the book, the following section on mitral valve repair and mitral valve replacement are based around the specific procedures undertaken. The groups therefore contain *pooled* patients with a variety of pathologies as described in the earlier section .

Risk factor analyses

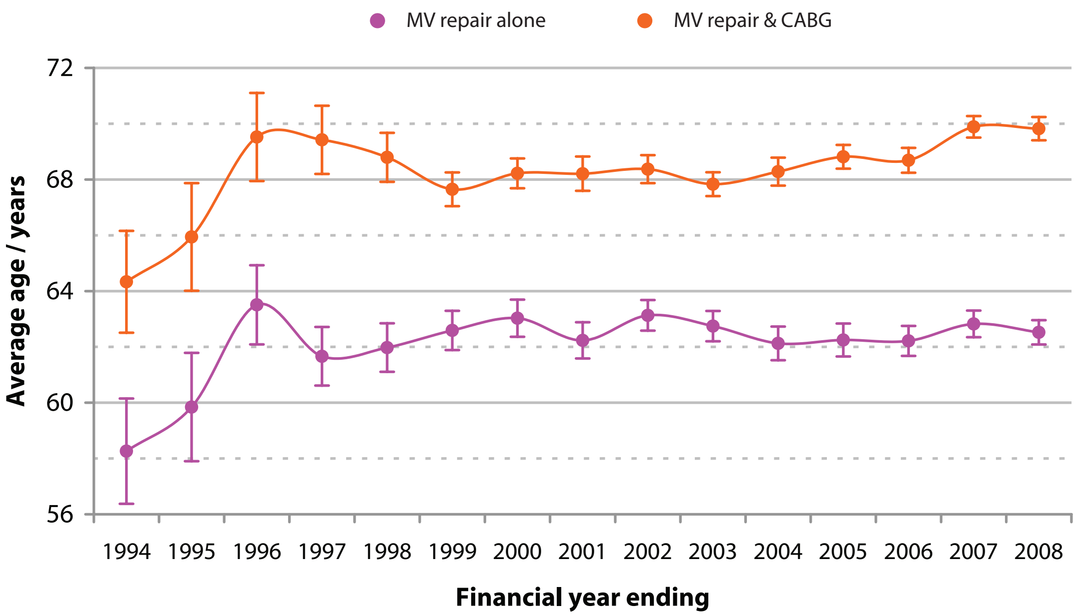
Age

Average age

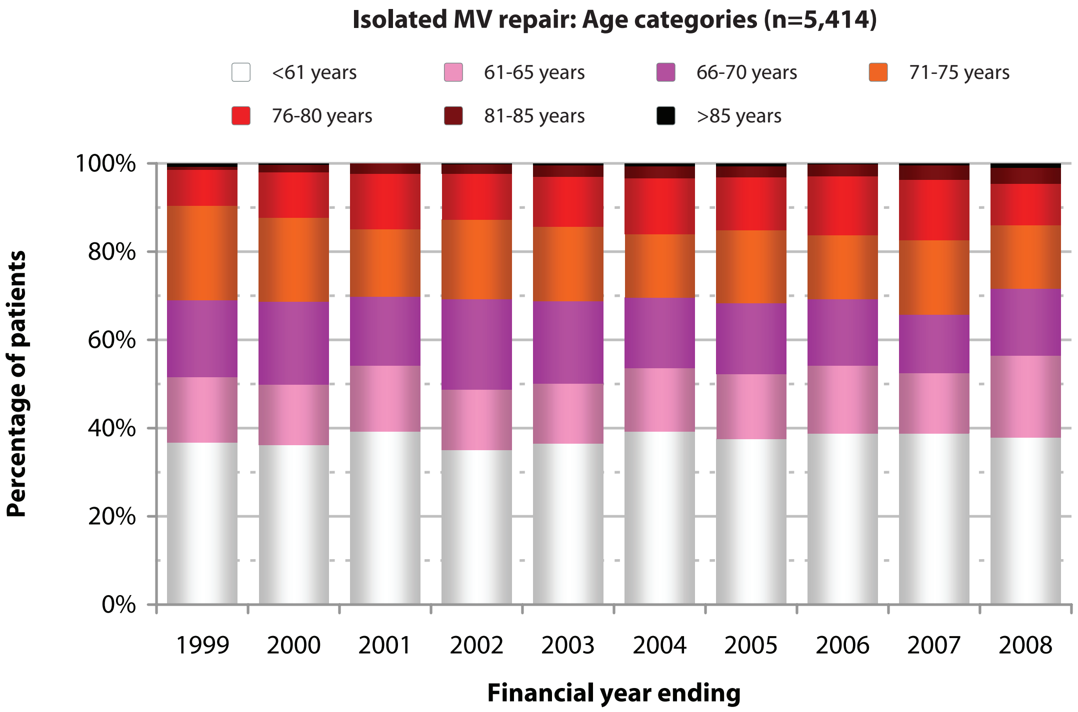
Unlike the analyses for isolated CABG and aortic valve surgery, there has been no increase in average age for patients undergoing mitral valve repair over the last 12 years.

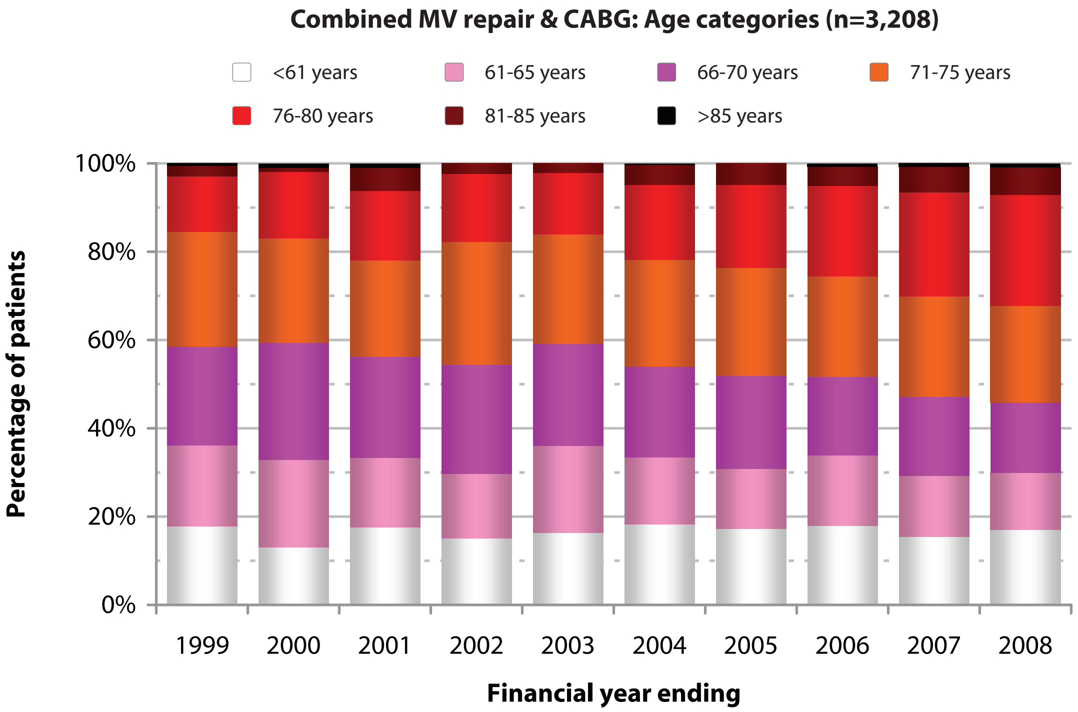
The average age for patients coming to isolated mitral repair and combined mitral valve repair & CABG in 2008 were 62.5 years and 69.8 years respectively, which should be compared with those for isolated AVR (65.6 years) and combined AVR & CABG (73.4 years).

MV repair: Average age; bars denote standard error (n=9,279)



The age groupings for patients undergoing mitral repair surgery are again quite different from those undergoing AVR surgery (see page 167). Nearly 40% of patients undergoing isolated mitral valve repair are under the age of 61 years; for isolated AVR it is only 25%. Similarly more than 10% of patients undergoing isolated AVR surgery in 2008 were over the age of 80, compared to less than 5% for isolated mitral valve repair.





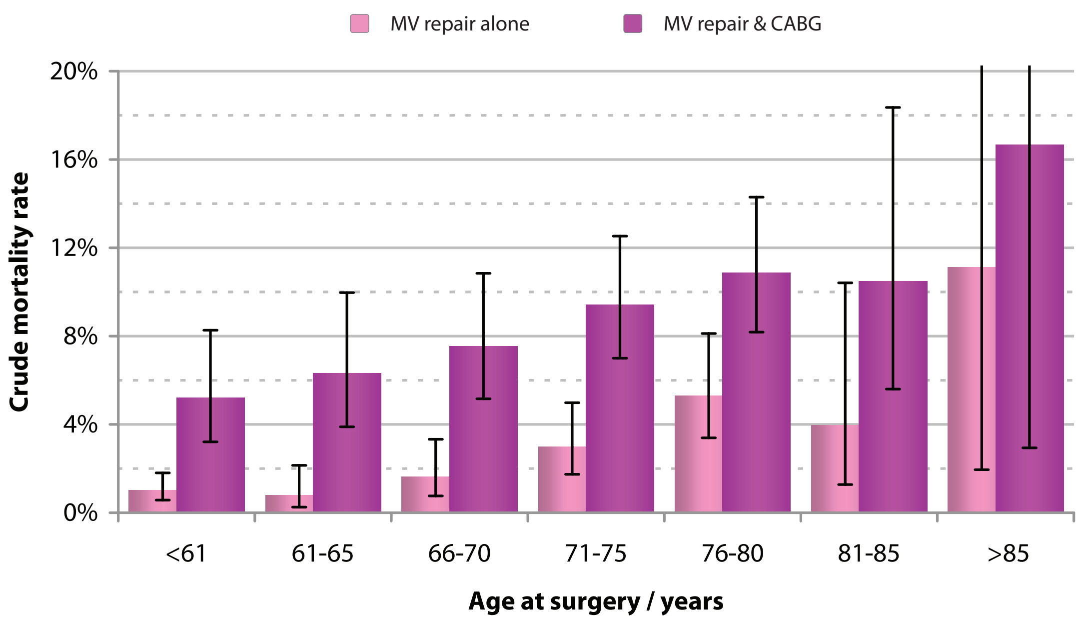
Mortality and age

The mortality rate for combined mitral repair & CABG is consistently and significantly higher than for isolated mitral valve repair. There is a an over-arching relationship between increasing age and increased mortality rate, as there is for both isolated CABG and aortic valve surgery.

Mortality and age; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MV repair	Combined MV repair & CABG	**All MV repairs**
Age at surgery / years	<61	1.0% 1,261	5.2% 345	**1.9%** **1,606**
	61-65	0.8% 508	6.3% 285	**2.8%** **793**
	66-70	1.6% 489	7.5% 371	**4.2%** **860**
	71-75	3.0% 503	9.4% 467	**6.1%** **970**
	76-80	5.3% 396	10.9% 432	**8.2%** **828**
	81-85	4.0% 101	10.5% 105	**7.3%** **206**
	>85	11.1% 18	16.7% 12	**13.3%** **30**
	Unspecified	0.0% 7	0.0% 4	**0.0%** **11**
	All	**2.0%** **3,283**	**8.3%** **2,021**	**4.4%** **5,304**

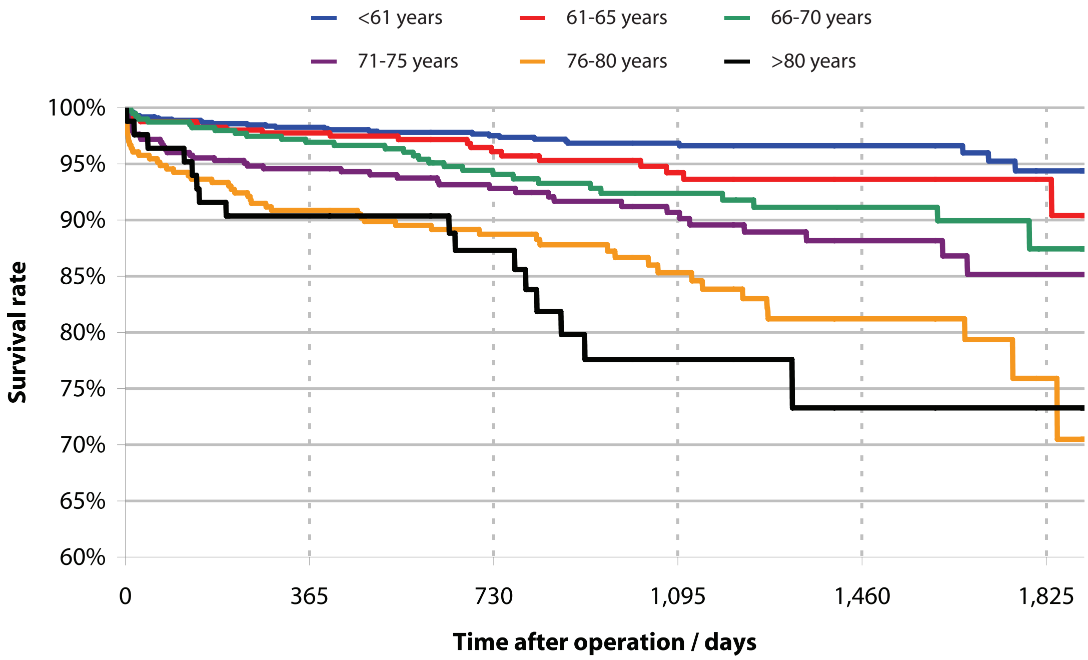
MV repair: Crude mortality and age (n=5,293)



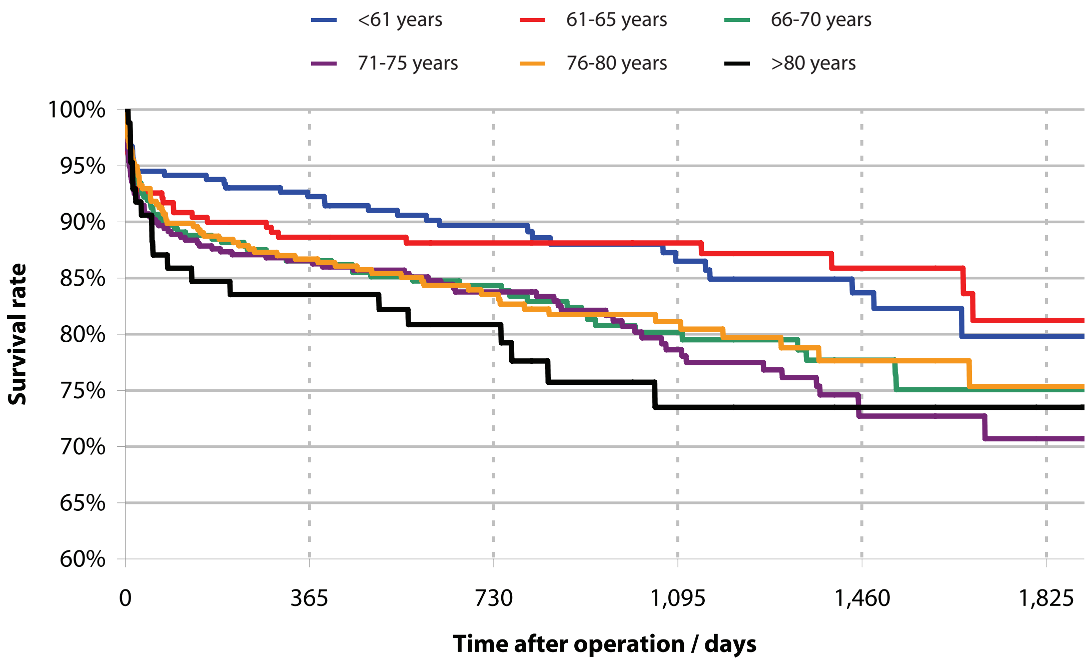
Survival and age

Medium-term survival is lower for patients undergoing combined mitral repair & CABG than it is for isolated mitral repair. The survival rates following isolated valve repair are very similar to those seen after isolated coronary artery bypass surgery, as shown on page 55, and somewhat better than those seen after isolated AVR surgery, right across the spectrum of age.

Isolated MV repair: Medium-term survival and age at surgery; financial years 2004-2008 (n=2,615)



Combined MV repair & CABG: Medium-term survival and age at surgery; financial years 2004-2008 (n=1,650)



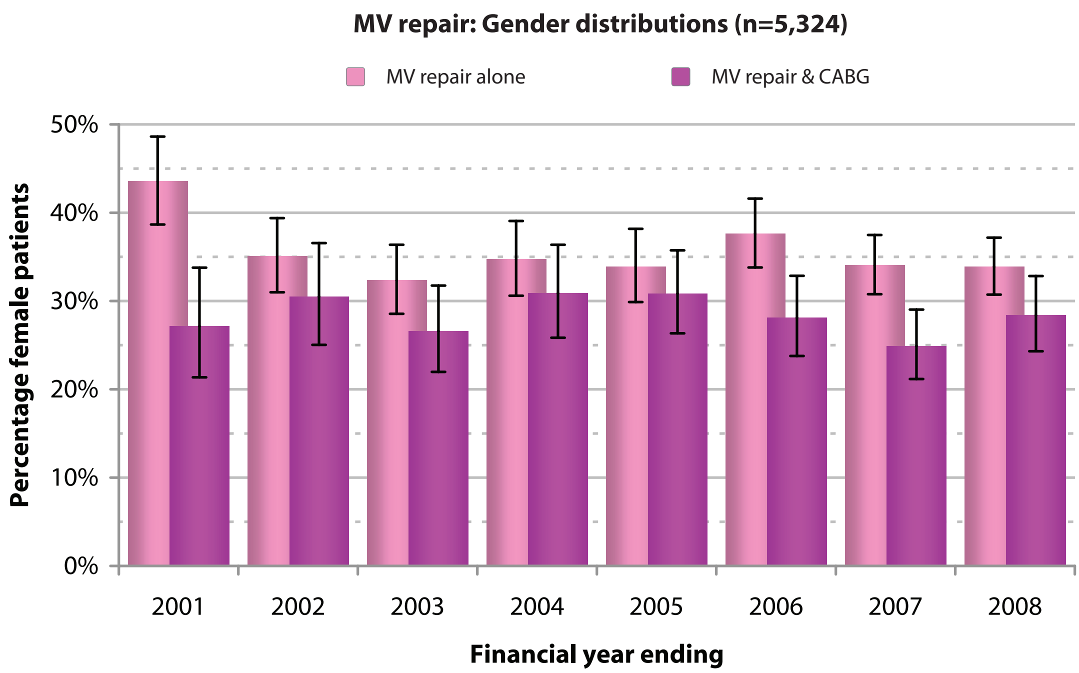
Gender

Gender distributions

Women comprise about one-third of all patients undergoing isolated mitral repair surgery, compared to about one-quarter of patients for isolated coronary artery bypass surgery and about two-fifths of patients for isolated AVR.

Gender distributions; financial years 2004-2008

		Procedure		
		Isolated MV repair	Combined MV repair & CABG	**All MV repairs**
Gender	Male	2,148	1,456	**3,604**
	Female	1,144	576	**1,720**
	Unspecified	0	0	**0**
	All	**3,292**	**2,032**	**5,324**



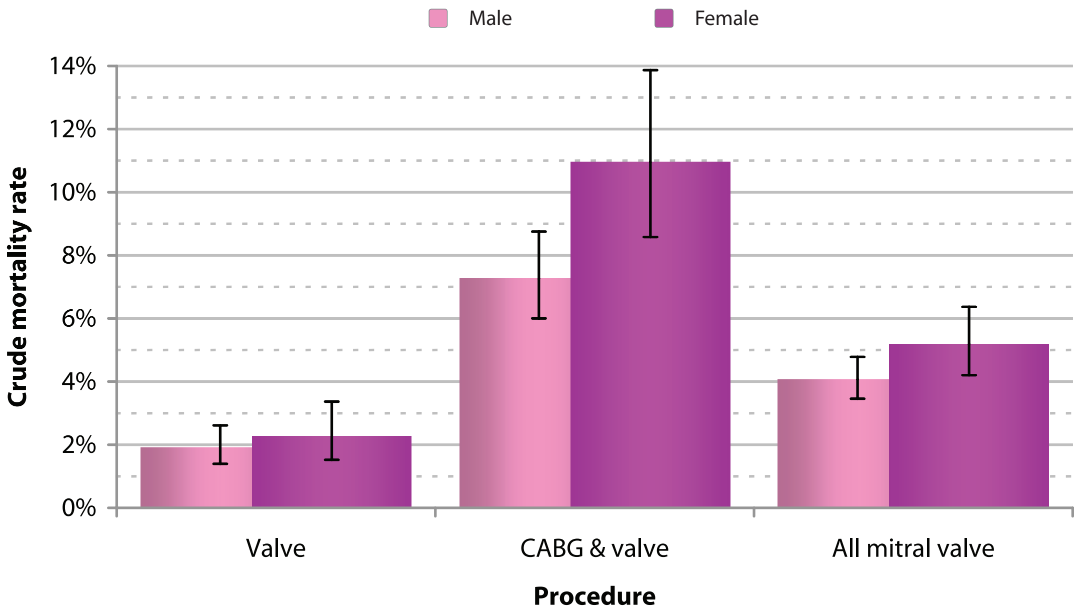
Mortality and gender

The in-hospital mortality rates after isolated mitral valve repair for women and men are approximately the same. This is in contrast to outcomes for isolated CABG surgery and aortic valve replacement surgery, where women have a higher mortality rate. The reasons for this are not fully understood.

Mortality and age; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MV repair	Combined MV repair & CABG	**All MV repairs**
Gender	Male	1.9% 2,141	7.3% 1,446	**4.1%** **3,587**
	Female	2.3% 1,142	11.0% 575	**5.2%** **1,717**
	All	**2.0%** **3,283**	**8.3%** **2,021**	**4.4%** **5,304**

MV repair: Mortality and gender; financial years 2004-2008 (n=5,304)



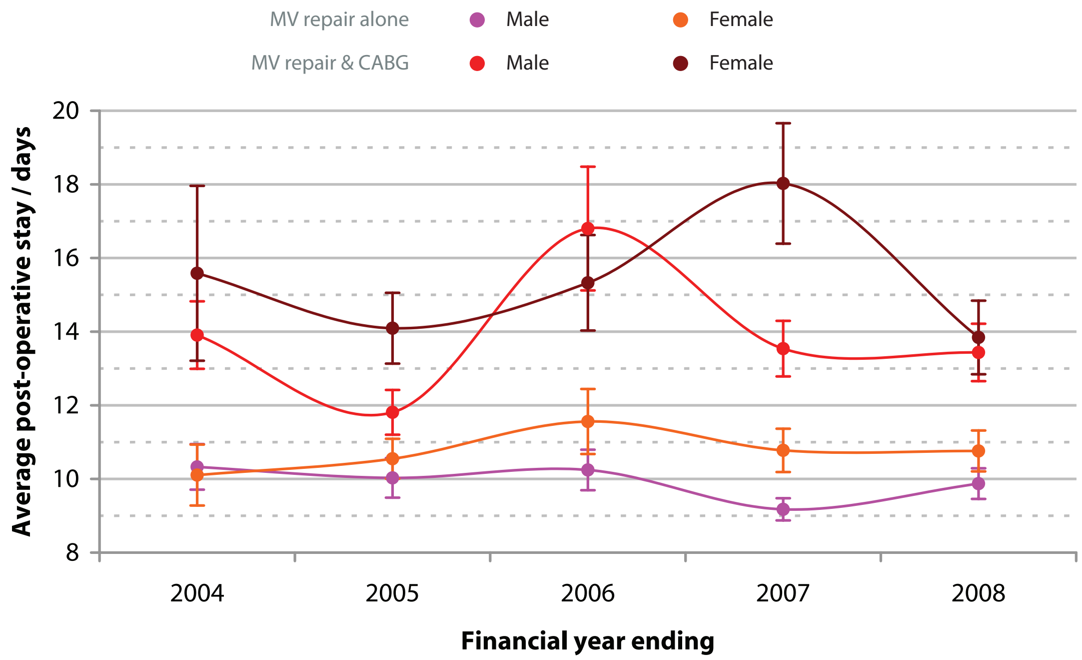
Post-operative stay and gender

The post-operative length-of-stay is greater for patients undergoing combined mitral valve repair & CABG surgery, but there are no sustained and systematic differences due to gender.

Post-operative stay and gender; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

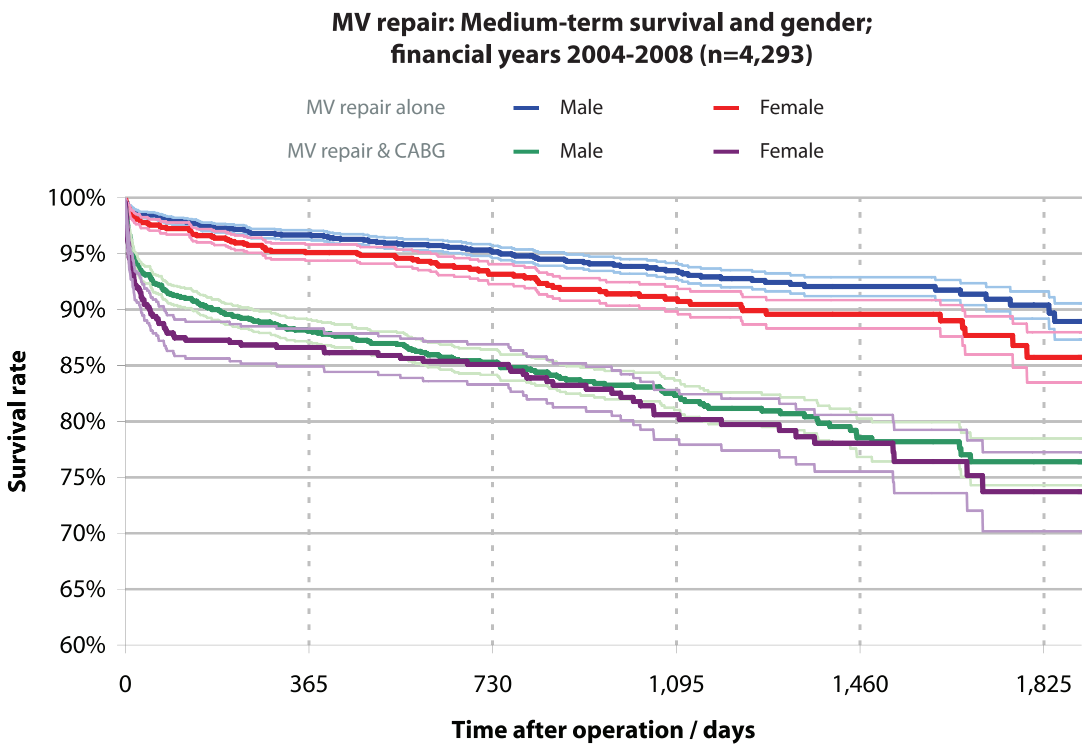
		Procedure			
		Isolated MV repair		Combined MV repair & CABG	
		Male	Female	Male	Female
Financial year	2004	10.3 311	10.1 171	13.9 204	15.6 94
	2005	10.0 336	10.5 175	11.8 262	14.1 118
	2006	10.2 364	11.6 214	16.8 250	15.3 104
	2007	9.2 508	10.8 268	13.5 350	18.0 118
	2008	9.9 561	10.8 288	13.4 317	13.8 127
	All	**9.9** **2,080**	**10.8** **1,116**	**13.8** **1,383**	**15.3** **561**

MV repair: Post-operative stay and gender; bars denote standard error (n=5,140)



Survival and gender

There are small differences in medium-term survival, with men having a greater survival rate than women, but the major difference is the difference in survival between patients undergoing isolated mitral repair and those undergoing combined mitral valve repair & CABG.



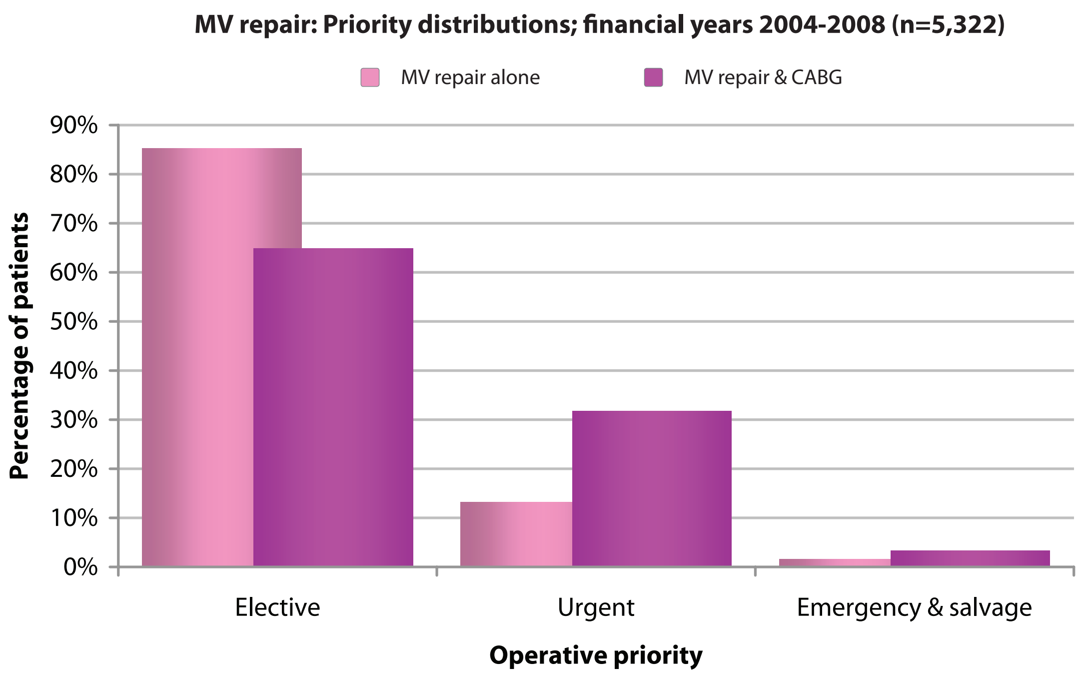
Priority

Priority distributions

Eighty-five percent of isolated mitral repairs are performed as elective operations, which is strikingly different from isolated coronary artery bypass surgery (68%) and isolated AVR (75%). The proportion of patients undergoing combined mitral valve repair & CABG as non-elective surgery is significantly higher, presumably reflecting those patients undergoing in-hospital coronary surgery who also have ischaemic mitral regurgitation. Emergency and salvage cases comprise a small proportion of the total population.

Priority distributions; financial years 2004-2008

		Procedure		
		Isolated MV repair	Combined MV repair & CABG	**All MV repairs**
Priority	Elective	2,805	1,318	**4,123**
	Urgent	433	646	**1,079**
	Emergency	49	62	**111**
	Salvage	4	5	**9**
	Unspecified	1	1	**2**
	All	**3,292**	**2,032**	**5,324**



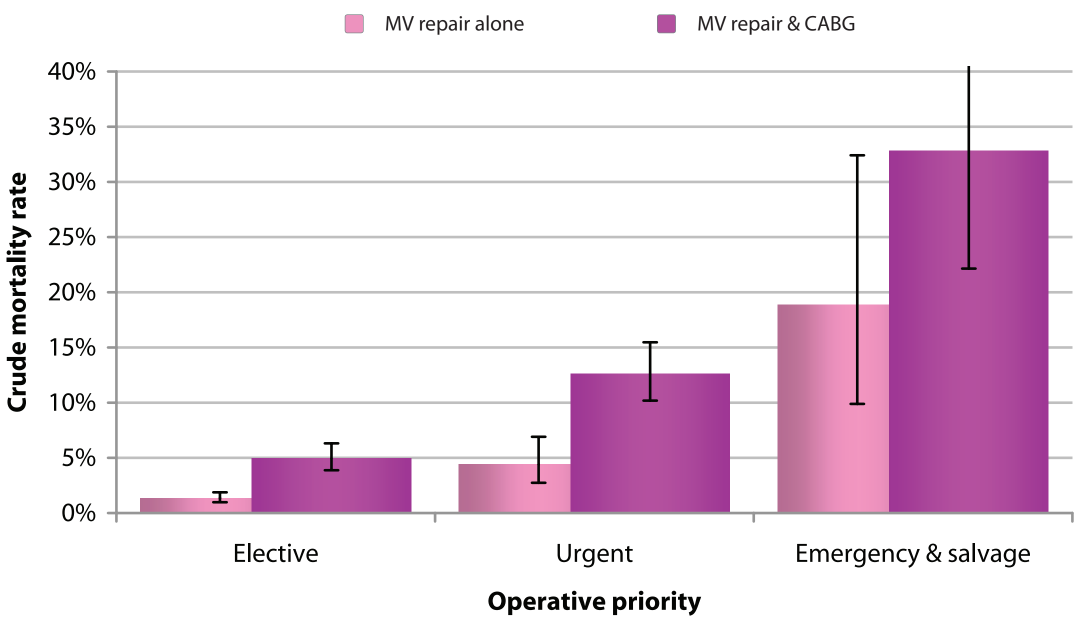
Mortality and priority

Operative mortality is strongly associated with operative priority, and of particular note is the high mortality rate (12.5%) associated with urgent combined mitral valve repair & CABG.

Mortality and priority; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MV repair	Combined MV repair & CABG	**All MV repairs**
Priority	Elective	1.4% 2,797	5.0% 1,310	**2.5%** **4,107**
	Urgent	4.4% 432	12.6% 643	**9.3%** **1,075**
	Emergency	14.3% 49	33.9% 62	**25.2%** **111**
	Salvage	75.0% 4	20.0% 5	**44.4%** **9**
	Unspecified	0.0% 1	0.0% 1	**0.0%** **2**
	All	**2.0%** **3,283**	**8.3%** **2,021**	**4.4%** **5,304**

MV repair: Mortality and priority; financial years 2004-2008 (n=5,302)



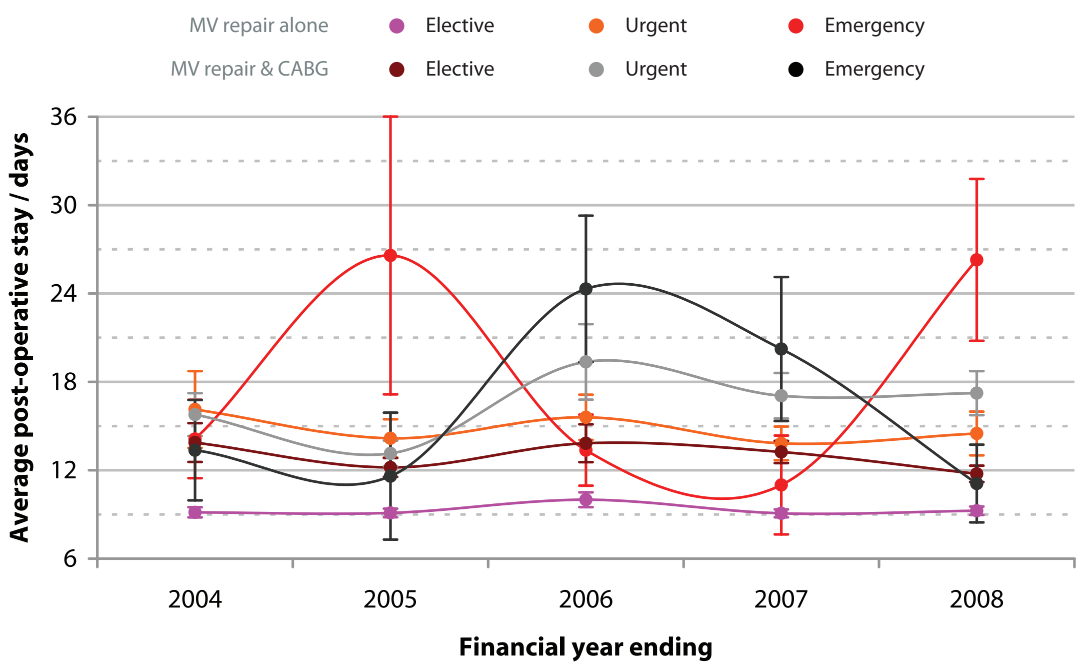
Post-operative stay and priority

There is a difference in post-operative length-of-stay overall, with emergency patients staying longer than those undergoing urgent surgery, who, in turn, stay longer than elective patients.

Post-operative stay and priority; financial years 2004-2008; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MV repair	Combined MV repair & CABG	**All MV repairs**
Priority	Elective	9.3 2,722	12.9 1,261	**10.4** **3,983**
	Urgent	14.7 420	16.7 617	**15.9** **1,037**
	Emergency	20.2 49	17.1 60	**18.5** **109**
	Salvage	8.3 4	30.8 5	**20.8** **9**
	Unspecified	6.0 1	9.0 1	**7.5** **2**
	All	**10.2** **3,196**	**14.3** **1,944**	**11.7** **5,140**

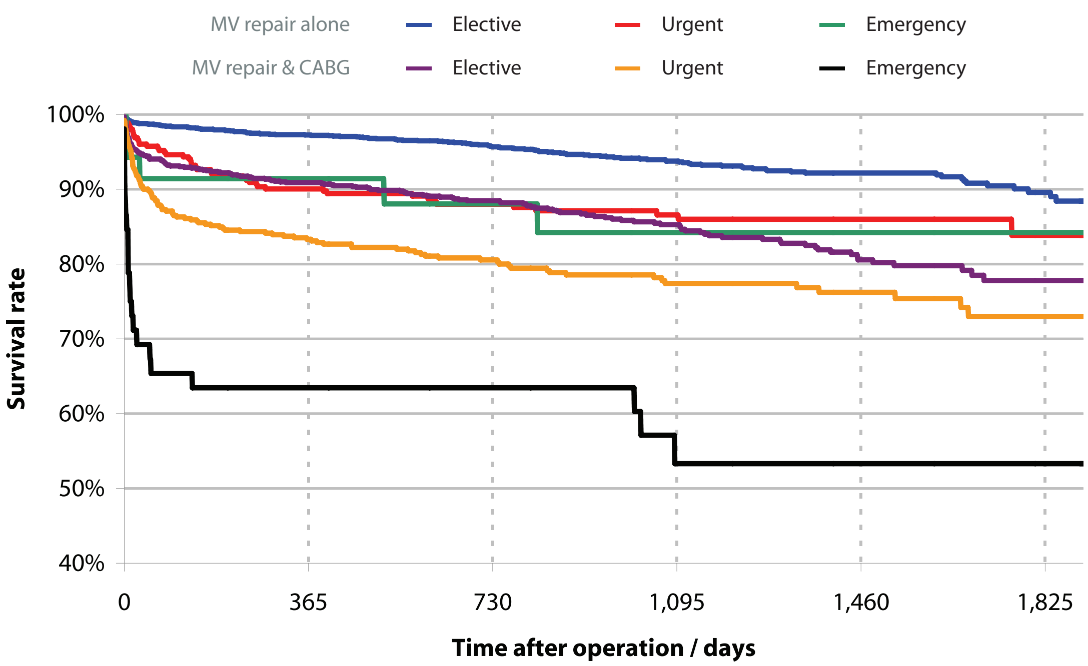
MV repair: Post-operative stay and priority; bars denote standard error (n=5,129)



Survival and priority

Isolated mitral repair is associated with good medium-term survival, irrespective of operative priority. The survival rates following combined mitral valve repair & CABG surgery are lower, and for the small group who undergo this operation as an emergency the survival rate at 5 years is only 50%.

MV repair: Medium-term survival and priority; financial years 2004-2008 (n=4,282)



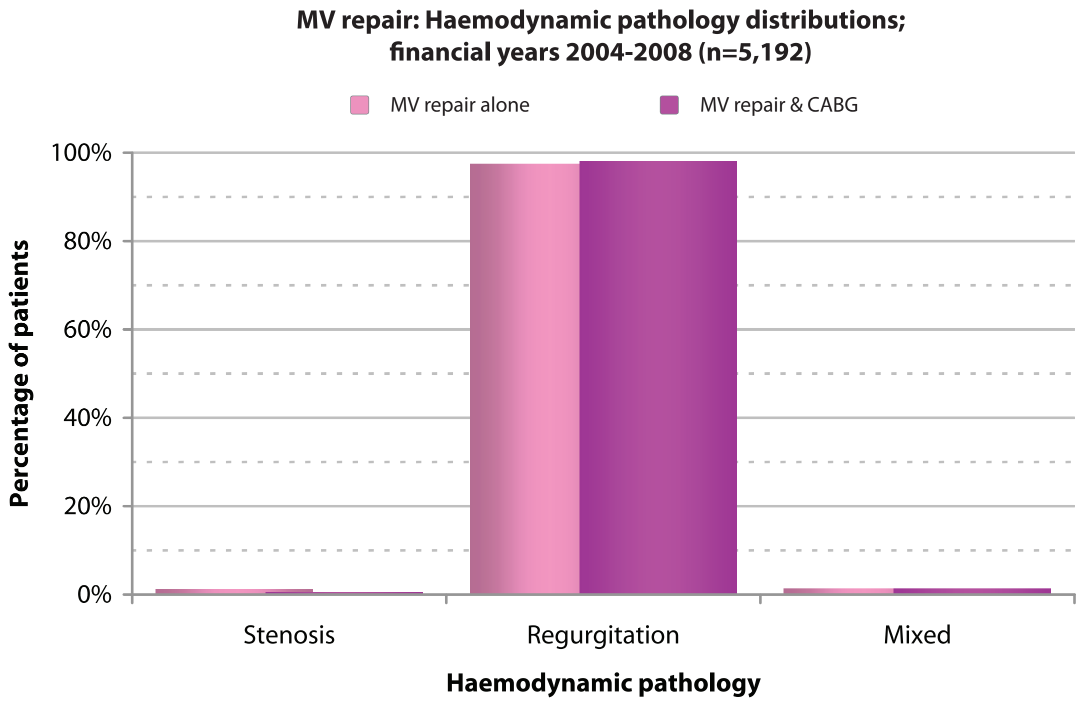
Haemodynamic pathology

Haemodynamic pathology distributions

The vast majority of mitral repairs were for mitral regurgitation. Only a tiny percentage were for stenosis or for mixed mitral valve disease.

Haemodynamic pathology distributions; financial years 2004-2008

		Procedure		
		Isolated MV repair	Combined MV repair & CABG	**All MV repairs**
Haemodynamic pathology	Stenosis	39	12	**51**
	Regurgitation	3,114	1,959	**5,073**
	Mixed	42	26	**68**
	Unspecified	97	35	**132**
	All	**3,292**	**2,032**	**5,324**

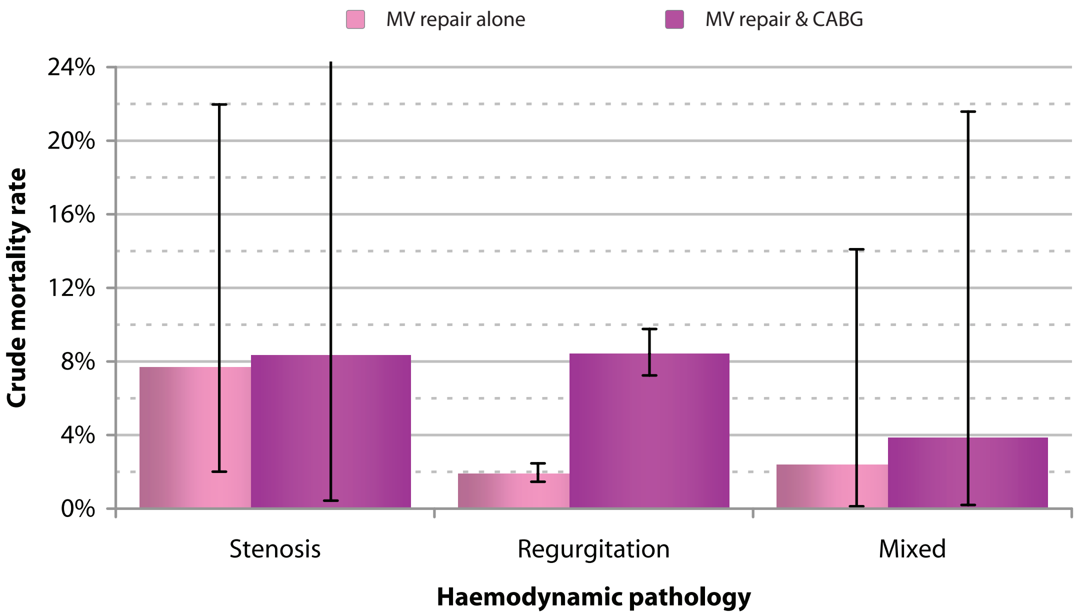


Mortality and haemodynamic pathology

Mortality and haemodynamic pathology; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

Haemodynamic pathology	Procedure: Isolated MV repair	Procedure: Combined MV repair & CABG	Procedure: **All MV repairs**
Stenosis	7.7% 39	8.3% 12	**7.8%** **51**
Regurgitation	1.9% 3,105	8.4% 1,948	**4.4%** **5,053**
Mixed	2.4% 42	3.8% 26	**2.9%** **68**
Unspecified	4.1% 97	5.7% 35	**4.5%** **132**
All	**2.0%** **3,283**	**8.3%** **2,021**	**4.4%** **5,304**

MV repair: Mortality and haemodynamic pathology; financial years 2004-2008 (n=5,172)



Isolated mitral valve repair

Distributions and outcome rates for major risk factors not reported in detail; financial years 2004-2008

Risk factor			Count	Mortality rate (count; 95% CI)
Risk factor	Body mass index	Underweight	226	2.2% (225; 0.8-5.4%)
		Normal	1,297	2.2% (1,293; 1.5-3.2%)
		Overweight	1,182	2.0% (1,178; 1.3-3.1%)
		Obese	376	1.6% (376; 0.7-3.6%)
		Morbidly obese	79	1.3% (79; 0.1-7.8)
		Unspecified	132	
	Ejection fraction	Good	2,342	1.4% (2,334; 1.0-2.0%)
		Fair	706	3.1% (706; 2.0-4.8%)
		Poor	112	7.1% (112; 3.4-14.0%)
		Unspecified	132	
	LMS disease	No	2,636	2.1% (2,632; 1.6-2.7%)
		Yes	17	5.9% (17; 0.3-30.8%)
		Unspecified	639	
	Previous cardiac surgery	No	3,066	1.7% (3,057; 1.3-2.2%)
		Yes	196	6.1% (196; 3.3-10.7%)
		Unspecified	30	
	Diabetes	No	3,093	1.9% (3,085; 1.4-2.4%)
		Yes	142	5.7% (141; 2.7-11.2%)
		Unspecified	57	
	Hypertension	No	1,973	1.5% (1,966; 1.5-2.4%)
		Yes	1,259	2.8% (1,257; 3.4-14.3%)
		Unspecified	60	
	Extra-cardiac arteriopathy	No	3,131	1.9% (3,122; 1.0-2.2%)
		Yes	110	7.3% (110; 3.4-14.3%)
		Unspecified	51	
	Renal disease	No	3,133	1.7% (3,124; 1.3-2.2%)
		Yes	65	20.0% (65; 11.5-32.1%)
		Unspecified	94	
	Angina	CCS0	2,419	1.9% (2,411; 1.5-2.6%)
		CCS1	312	2.6% (311; 1.2-5.2%)
		CCS2	179	3.4% (179; 1.4-7.5%)
		CCS3	60	1.7% (60; 0.1-10.1%)
		CC4	20	10.0% (20; 1.8-33.1%)
		Unspecified	302	
	Dyspnoea	NYHA 1	631	0.3% (6310.1-1.3%)
		NYHA 2	1,226	1.1% (1,223; 0.6-1.9%)
		NYHA 3	1,098	2.3% (1,094; 1.5-3.4%)
		NYHA 4	266	9.4% (265; 6.3-13.8%)
		Unspecified	71	

Post-operative stay / days (count; SE)	Post-operative stroke rate (count; 95% CI)	Re-op for bleeding rate (count; 95% CI)	Survival rate at 5 years
10.8 (223; 0.60)	1.5% (194; 0.4-4.8%)	2.6% (192; 1.0-6.3%)	83.0%
10.7 (1,267; 0.32)	1.8% (1,121; 1.1-2.8%)	3.7% (1,101; 2.7-5.1%)	89.5%
9.2 (1,158; 0.22)	1.0% (1,036; 0.5-1.8%)	4.2% (1,024; 3.1-5.7%)	88.6%
10.5 (363; 0.45)	1.3% (319; 0.4-3.4%)	4.4% (319; 2.5-7.4%)	88.4%
11.2 (78; 1.26)	1.4% (69; 0.1-8.9%)	1.6% (64; 0.1-9.5%)	91.1%
9.7 (2,281; 0.18)	1.5% (2,084; 1.0-2.1%)	3.7% (2,025; 2.9-4.6%)	89.7%
11.7 (677; 0.51)	1.3% (595; 0.6-2.7%)	3.9% (596; 2.5-5.8%)	87.6%
13.1 (107; 1.13)	1.1% (91; 0.1-6.8%)	4.3% (93; 1.4-11.3%)	72.1%
10.2 (2,586; 0.19)	1.4% (2,528; 1.0-1.9%)	3.7% (2,379; 3.0-4.5%)	87.7%
18.8 (16; 7.32)	0.0% (14; 0.0-19.3%)	6.3% (16; 0.3-32.3%)	77.4%
9.7 (2,975; 0.15)	1.1% (2,649; 0.7-1.5%)	3.9% (2,597; 3.2-4.7%)	89.9%
16.7 (192; 1.47)	6.7% (164; 3.6-12.0%)	4.3% (161; 1.9-9.1%)	72.6%
10.1 (2,999; 0.18)	1.3% (2,697; 1.0-1.9%)	3.8% (2,640; 3.1-4.6%)	88.7%
11.9 (142; 0.84)	2.3% (128; 0.6-7.2%)	3.2% (124; 1.0-8.6%)	82.7%
9.7 (1,925; 0.21)	1.1% (1,759; 0.7-1.7%)	3.7% (1,698; 2.8-4.7%)	90.8%
10.9 (1,212; 0.30)	2.0% (1,064; 1.3-3.1%)	3.9% (1,068; 2.9-5.3%)	84.7%
10.1 (3,041; 0.18)	1.4% (2,727; 1.0-1.9%)	3.7% (2,671; 3.0-4.5%)	89.0%
13.1 (105; 1.19)	2.0% (102; 0.3-7.6%)	7.2% (97; 3.2-14.8%)	78.4%
10.1 (3,064; 0.17)	1.3% (2,749; 1.0-1.9%)	3.7% (2,711; 3.1-4.5%)	89.8%
16.2 (62; 1.93)	3.8% (53; 0.7-14.1%)	8.3% (48; 2.7-20.9%)	44.5%
10.2 (2,363; 0.21)	1.4% (2,294; 1.0-2.0%)	3.7% (2,188; 2.9-4.6%)	89.3%
10.3 (293; 0.61)	1.0% (295; 0.3-3.2%)	4.5% (243; 2.4-8.2%)	87.2%
10.4 (174; 0.64)	1.7% (172; 0.5-5.4%)	6.0% (151; 2.9-11.4%)	90.4%
8.9 (54; 0.51)	4.0% (50; 0.7-14.9%)	0.0% (45; 0.0-6.4%)	65.3%
13.9 (20; 1.83)	0.0% (19; 0.0-14.6%)	0.0% (20; 0.0-13.9%)	80.0%
10.5 (612; 0.37)	1.1% (458; 0.4-2.7%)	4.5% (492; 2.9-6.8%)	91.1%
16.5 (1,190; 0.28)	1.2% (1,088; 0.7-2.1%)	3.3% (1,051; 2.4-4.7%)	93.0%
10.4 (1,072; 0.00)	1.6% (1,032; 1.0-2.7%)	3.7% (982; 2.6-5.1%)	84.9%
10.2 (262; 0.00)	2.0% (248; 0.7-4.9%)	5.4% (240; 3.0-9.3%)	79.0%

Combined mitral valve repair & CABG surgery

Distributions and outcome rates for major risk factors not reported in detail; financial years 2004-2008

Risk factor		Count	Mortality rate (count; 95% CI)
Body mass index	Underweight	74	17.6% (74; 10.0-28.5%)
	Normal	686	9.9% (684; 7.9-12.5%)
	Overweight	809	6.2% (803; 4.7-8.2%)
	Obese	290	7.0% (287; 4.4-10.7%)
	Morbidly obese	74	10.8% (74; 5.1-20.7%)
	Unspecified	99	
Ejection fraction	Good	780	3.6% (775; 2.5-5.2%)
	Fair	786	9.1% (781; 7.2-11.4%)
	Poor	410	15.2% (409; 11.9-19.1%)
	Unspecified	56	
LMS disease	No	1,473	6.6% (1,462; 5.4-8.1%)
	Yes	348	14.9% (348; 11.5-19.2%)
	Unspecified	211	
Previous cardiac surgery	No	1,984	8.2% (1,974; 7.0-9.5%)
	Yes	42	16.7% (42; 7.5-32.0%)
	Unspecified	6	
Diabetes	No	1,632	6.7% (1,623; 5.6-8.1%)
	Yes	366	14.8% (364; 11.4-19.0%)
	Unspecified	34	
Hypertension	No	736	5.9% (735; 4.3-7.9%)
	Yes	1,260	9.5% (1,250; 8.0-11.3%)
	Unspecified	36	
Extra-cardiac arteriopathy	No	1,753	7.5% (1,743; 6.3-8.9%)
	Yes	243	13.2% (242; 9.3-18.3%)
	Unspecified	36	
Renal disease	No	1,881	7.4% (1,871; 6.3-8.7%)
	Yes	75	25.7% (74; 16.5-37.4%)
	Unspecified	76	
Angina	CCS0	523	4.0% (520; 2.6-6.2%)
	CCS1	275	8.4% (273; 5.5-12.5%)
	CCS2	516	6.3% (512; 4.4-8.8%)
	CCS3	389	11.1% (388; 8.2-14.7%)
	CC4	212	18.5% (211; 13.6-24.5%)
	Unspecified	117	
Dyspnoea	NYHA 1	259	4.7% (258; 2.5-8.2%)
	NYHA 2	652	5.9% (648; 4.2-8.0%)
	NYHA 3	825	8.7% (820; 6.9-10.8%)
	NYHA 4	239	16.8% (238; 12.4-22.3%)
	Unspecified	57	

Post-operative stay / days (count; SE)	Post-operative stroke rate (count; 95% CI)	Re-op for bleeding rate (count; 95% CI)	Survival rate at 5 years
13.9 (71; 1.10)	3.2% (62; 0.6-12.2%)	10.0% (60; 4.1-21.2%)	69.6%
14.3 (663; 0.58)	4.2% (602; 2.8-6.2%)	6.2% (581; 4.4-8.6%)	75.5%
14.9 (786; 0.67)	2.1% (723; 1.2-3.5%)	6.9% (711; 5.2-9.1%)	76.1%
12.4 (281; 0.69)	1.9% (257; 0.7-4.7%)	2.3% (258; 0.9-5.2%)	76.7%
14.7 (74; 1.67)	1.4% (69; 0.1-8.9%)	2.9% (69; 0.5-11.0%)	75.1%
12.6 (750; 0.59)	2.4% (705; 1.5-3.9%)	5.6% (681; 4.0-7.6%)	83.8%
15.1 (750; 0.61)	3.0% (701; 1.9-4.6%)	5.7% (671; 4.1-7.8%)	73.5%
15.8 (389; 0.74)	3.1% (355; 1.6-5.6%)	6.4% (344; 4.1-9.7%)	66.7%
14.3 (1,430; 0.45)	2.7% (1,388; 2.0-3.8%)	5.5% (1,300; 4.3-6.9%)	76.9%
14.6 (329; 0.73)	2.2% (317; 1.0-4.7%)	6.3% (302; 3.9-9.8%)	73.7%
14.3 (1,898; 0.37)	2.8% (1,745; 2.1-3.7%)	5.8% (1,684; 4.8-7.1%)	75.8%
14.7 (41; 1.94)	2.7% (37; 0.1-15.8%)	11.4% (35; 3.7-27.7%)	63.8%
13.5 (1,556; 0.35)	2.6% (1,447; 1.9-3.6%)	5.9% (1,392; 4.7-7.3%)	79.3%
17.6 (354; 1.25)	3.3% (331; 1.8-6.0%)	5.6% (321; 3.5-8.9%)	60.0%
13.0 (703; 0.53)	2.6% (1,562; 1.9-3.5%)	5.9% (1,497; 4.8-7.3%)	81.3%
15.0 (1,205; 0.50)	4.2% (215; 2.1-8.1%)	5.6% (215; 3.1-9.8%)	72.4%
14.0 (1,678; 0.39)	2.1% (666; 1.2-3.6%)	5.4% (630; 3.8-7.5%)	77.1%
16.6 (230; 1.18)	3.2% (1,111; 2.2-4.4%)	6.2% (1,082; 4.9-7.8%)	64.6%
14.1 (1,829; 0.37)	2.7% (1,680; 2.0-3.6%)	5.8% (1,646; 4.8-7.1%)	76.9%
18.8 (69; 2.66)	3.2% (62; 0.6-12.2%)	6.9% (58; 2.2-17.5%)	50.8%
13.7 (503; 0.67)	3.3% (483; 2.0-5.4%)	5.4% (459; 3.6-8.0%)	78.2%
13.9 (263; 1.03)	3.1% (256; 1.5-6.3%)	5.4% (242; 3.0-9.2%)	76.3%
14.0 (492; 0.64)	3.0% (472; 1.7-5.0%)	6.6% (439; 4.5-9.5%)	75.3%
15.3 (375; 1.11)	2.5% (363; 1.2-4.8%)	6.5% (340; 4.2-9.8%)	75.0%
15.9 (206; 0.92)	1.0% (198; 0.2-4.0%)	4.6% (195; 2.3-8.9%)	69.5%
14.3 (250; 0.97)	2.0% (201; 0.6-5.3%)	6.5% (215; 3.7-10.9%)	86.3%
17.6 (624; 0.65)	2.7% (593; 1.6-4.4%)	6.3% (558; 4.5-8.7%)	79.2%
16.4 (797; 0.00)	3.0% (760; 2.0-4.6%)	5.5% (722; 4.0-7.5%)	74.5%
14.3 (228; 0.00)	2.8% (217; 1.1-6.2%)	5.2% (213; 2.7-9.3%)	61.2%

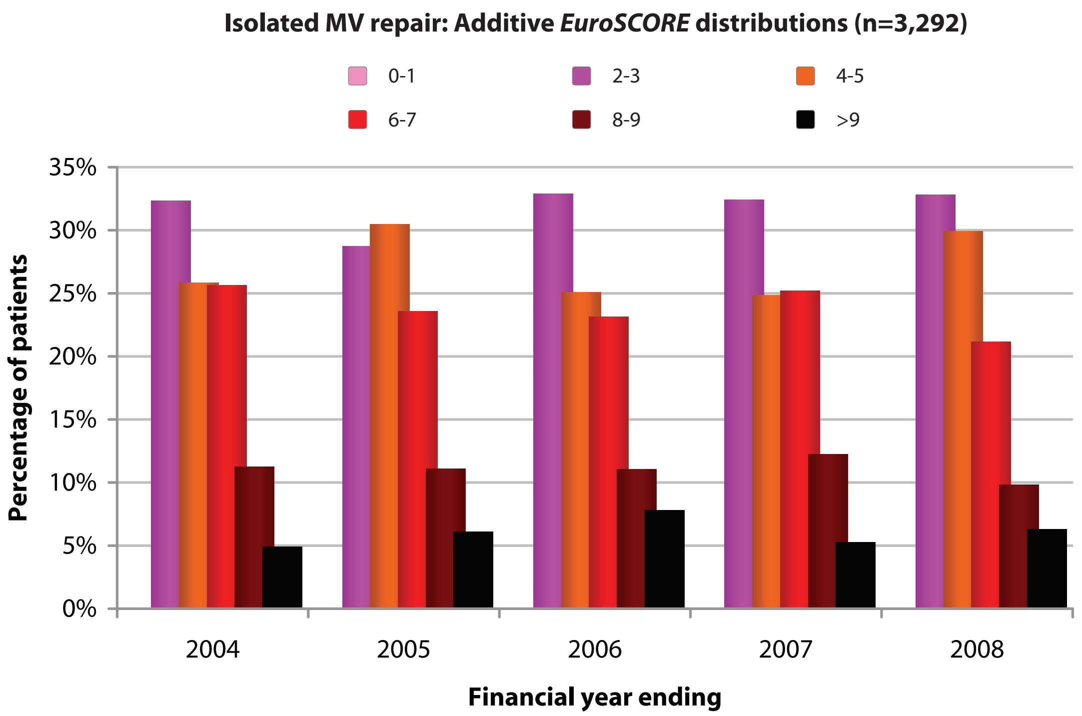
EuroSCORE

The additive *EuroSCORE*

There has been little change in the distribution of the additive ***EuroSCORE*** for patients undergoing either isolated mitral valve repair or combined mitral repair & CABG over time.

Additive ***EuroSCORE*** distributions; isolated MV repair; financial years 2004-2008

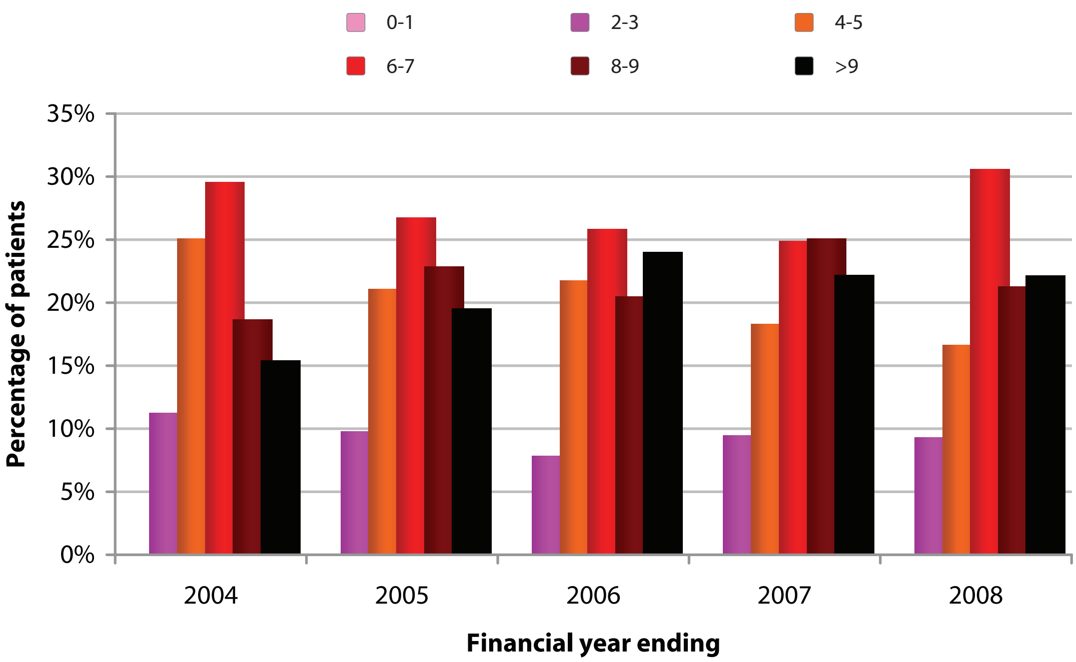
		Additive *EuroSCORE* groupings						
		0-1	2-3	4-5	6-7	8-9	>9	**All**
Financial year	2004	0	164	131	130	57	25	**507**
	2005	0	150	159	123	58	32	**522**
	2006	0	202	154	142	68	48	**614**
	2007	0	257	197	200	97	42	**793**
	2008	0	281	256	181	84	54	**856**
	All	**0**	**1,054**	**897**	**776**	**364**	**201**	**3,292**



Additive ***EuroSCORE*** distributions; combined MV repair & CABG surgery; financial years 2004-2008

		Additive *EuroSCORE* groupings						
		0-1	2-3	4-5	6-7	8-9	>9	**All**
Financial year	2004	0	35	78	92	58	48	**311**
	2005	0	38	82	104	89	76	**389**
	2006	0	31	86	102	81	95	**395**
	2007	0	46	89	121	122	108	**486**
	2008	0	42	75	138	96	100	**451**
	All	**0**	**192**	**410**	**557**	**446**	**427**	**2,032**

Combined MV repair & CABG: Additive *EuroSCORE* distributions (n=2,032)



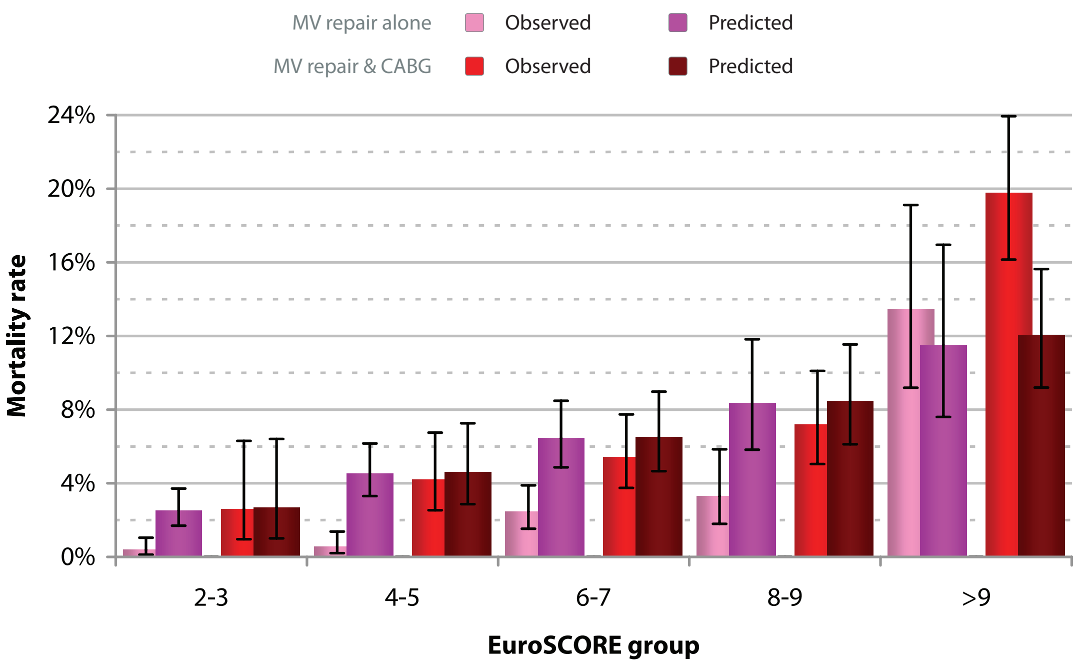
EuroSCORE and mortality

The additive ***EuroSCORE*** significantly over-predicts mortality for isolated mitral valve repair for all but the highest-risk patients. For patients undergoing combined mitral valve repair & CABG, the additive ***EuroSCORE*** does not significantly over-predict mortality.

Observed mortality according to ***EuroSCORE*** groupings; all entries are scored irrespective of missing risk factor data; financial years 2004-2008; the upper numbers represent the crude mortality rate and the lower numbers the procedure count within the sub-group

Additive *EuroSCORE* grouping	Post-operative mortality			
	Isolated MV repair		Combined MV repair & CABG	
	Observed	Predicted	Observed	Predicted
2-3	0.4% 1,051	2.5%	2.6% 192	2.7%
4-5	0.6% 895	4.5%	4.2% 406	4.6%
6-7	2.5% 772	6.4%	5.4% 553	6.5%
8-9	3.3% 364	8.4%	7.2% 445	8.5%
>9	13.4% 201	11.5%	19.8% 425	12.1%
All	**2.0%** **3,283**	**5.2%**	**8.3%** **2,021**	**7.4%**

MV repair: Observed and predicted mortality rates according to the additive *EuroSCORE*; financial years 2004-2008 (n=5,304)

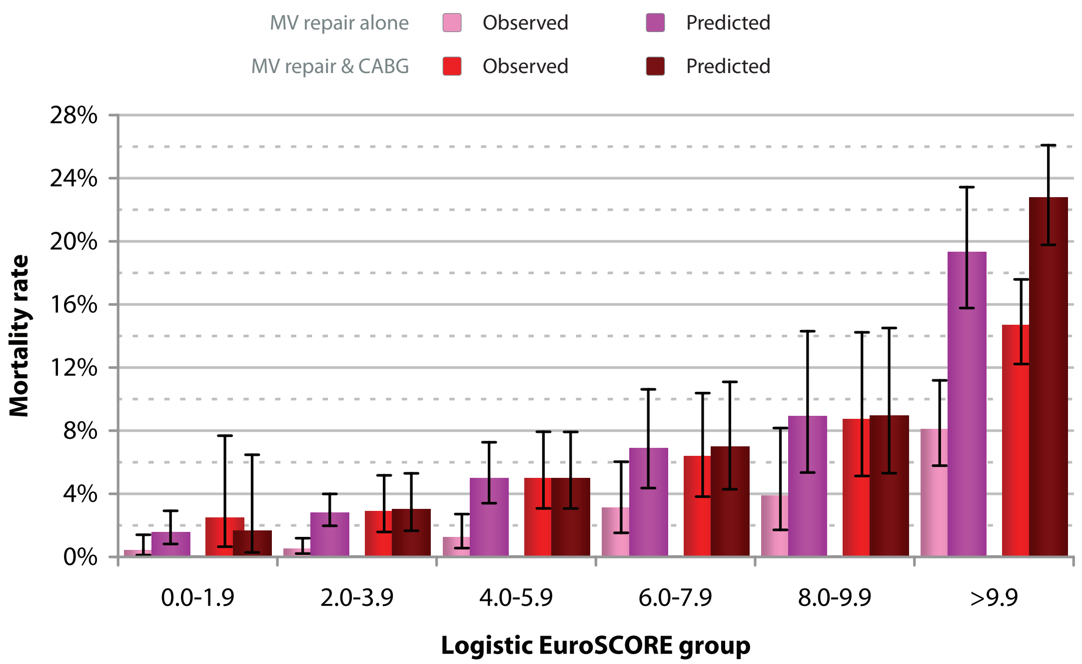


The logistic ***EuroSCORE*** over-predicts mortality for all groups of patients undergoing isolated mitral valve repair, even the highest-risk patients. It is an accurate predictor of mortality in combined mitral valve repair & CABG surgery, except in the group of highest-risk patients, where it again over-predicts mortality.

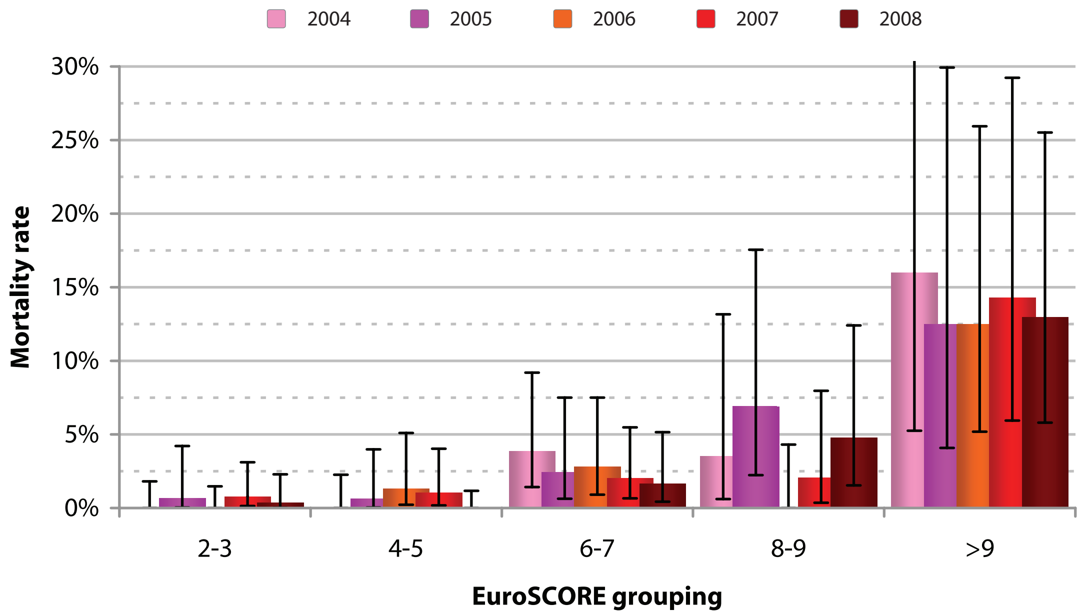
Observed mortality according to logistic ***EuroSCORE*** groupings; all entries are scored irrespective of missing risk factor data; financial years 2004-2008; the upper numbers represent the crude mortality rate and the lower numbers the procedure count within the sub-group

		Post-operative mortality			
		Isolated MV repair		Combined MV repair & CABG	
		Observed	Predicted	Observed	Predicted
Logistic *EuroSCORE* grouping	0.0-1.9	0.4% 676	1.6%	2.5% 120	1.7%
	2.0-3.9	0.5% 1,154	2.8%	2.9% 412	3.0%
	4.0-5.9	1.3% 552	5.0%	5.0% 360	5.0%
	6.0-7.9	3.1% 289	6.9%	6.4% 250	7.0%
	8.0-9.9	3.9% 180	8.9%	8.7% 172	9.0%
	>9.9	8.1% 432	19.3%	14.7% 707	22.8%
	All	**2.0%** **3,283**	**5.8%**	**8.3%** **2,021**	**11.2%**

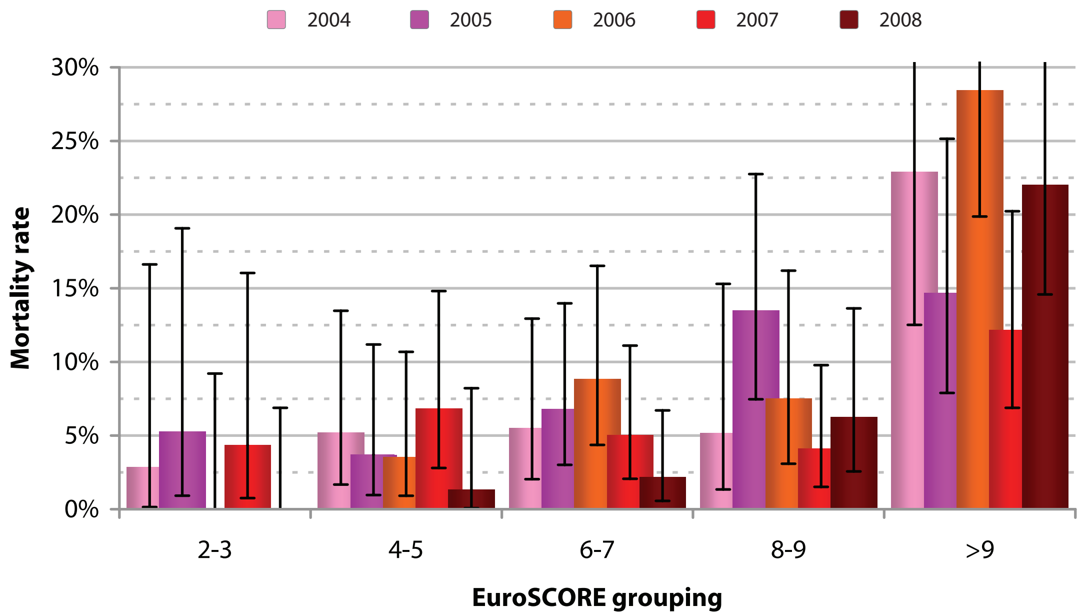
MV repair: Observed and predicted mortality rates according to the logistic *EuroSCORE*; financial years 2004-2008 (n=5,304)



Isolated MV repair: Mortality and additive *EuroSCORE* through time (n=3,283)



Combined MV repair & CABG: Mortality and additive *EuroSCORE* through time (n=2,021)



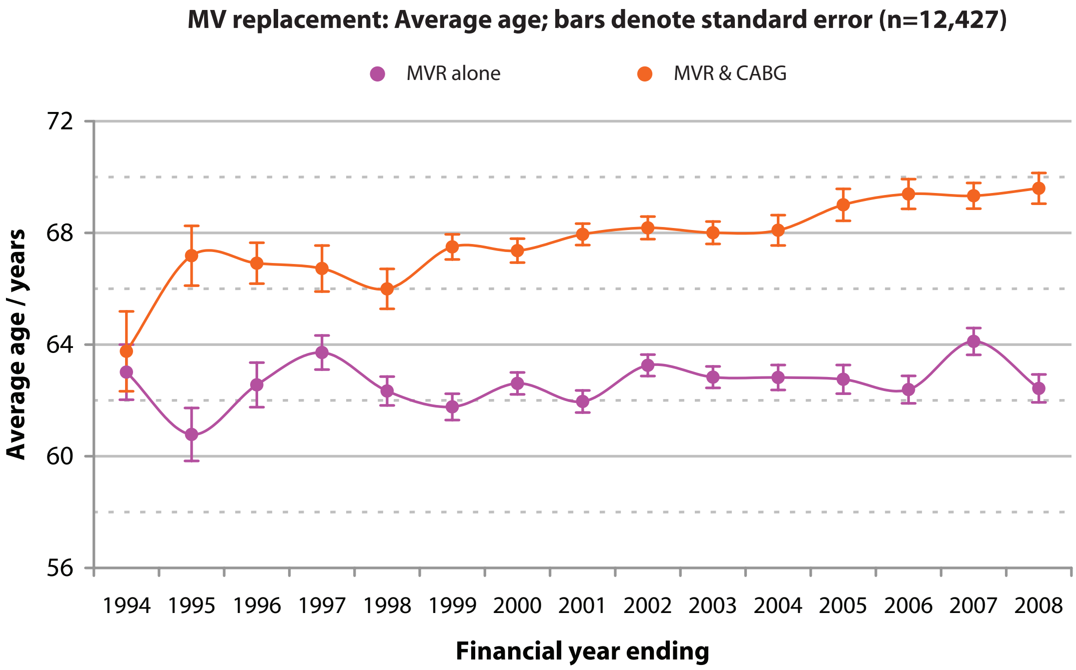
Mitral valve replacement

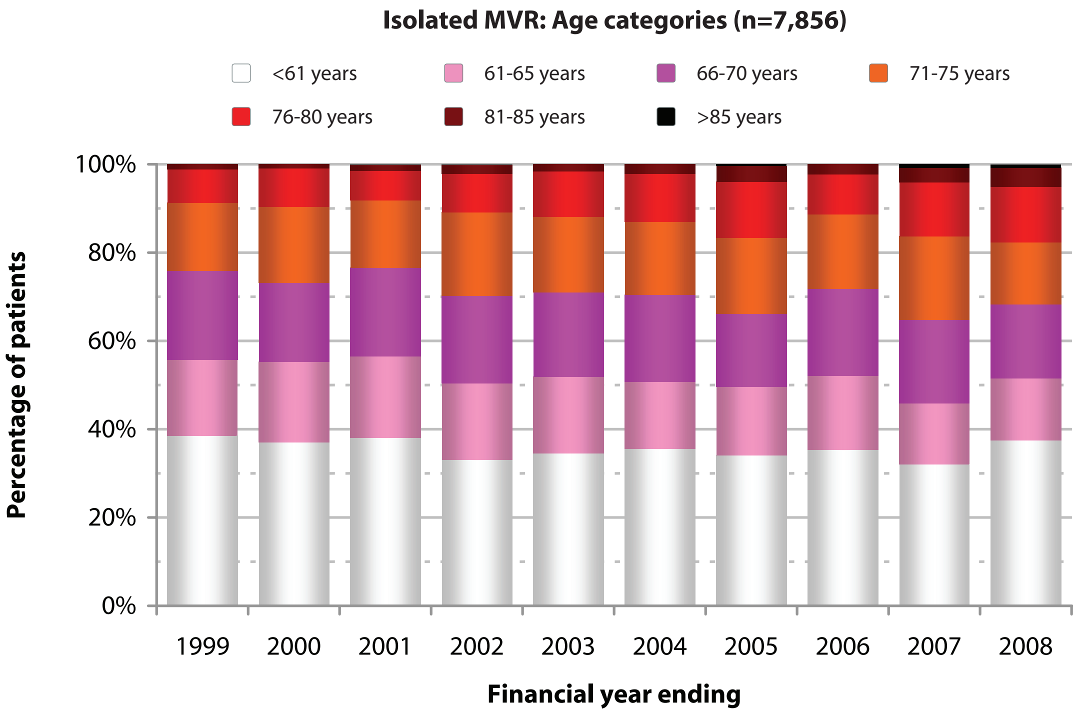
Risk factor analyses

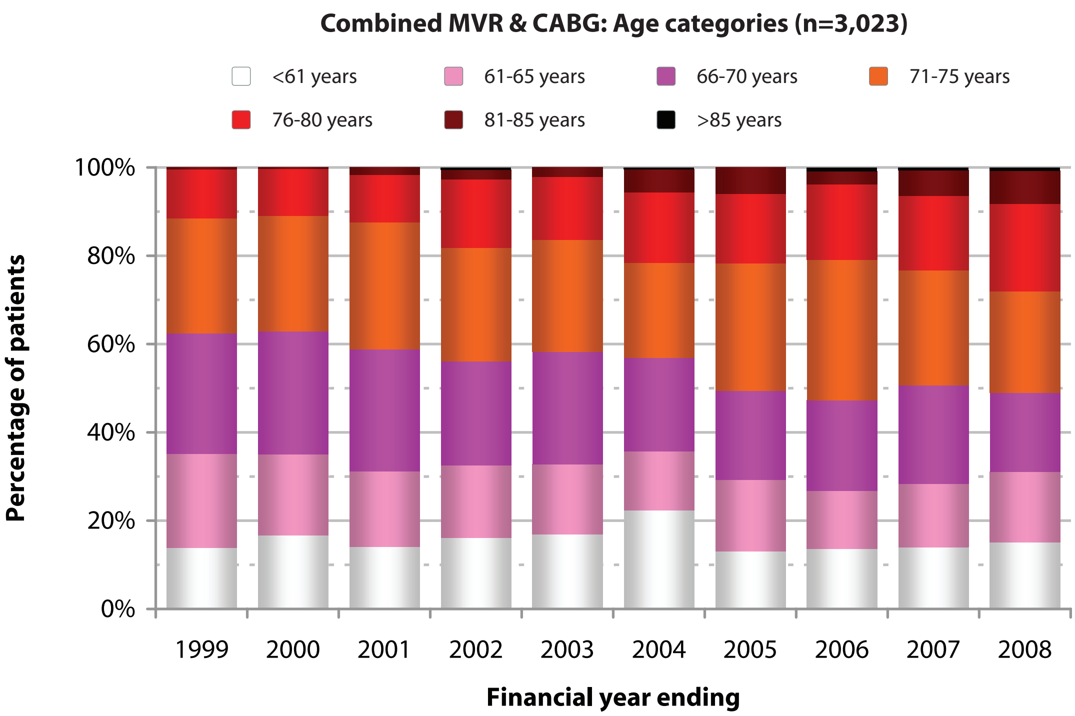
Age

Average age

The age profiles and changes over time for patients undergoing mitral valve replacement are similar to those undergoing repair.




Isolated MVR: Age categories (n=7,856)
<61 years
61-65 years
66-70 years
71-75 years
76-80 years
81-85 years
>85 years
Percentage of patients
100%
80%
60%
40%
20%
0%
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Financial year ending


Combined MVR & CABG: Age categories (n=3,023)
<61 years
61-65 years
66-70 years
71-75 years
76-80 years
81-85 years
>85 years
Percentage of patients
100%
80%
60%
40%
20%
0%
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Financial year ending

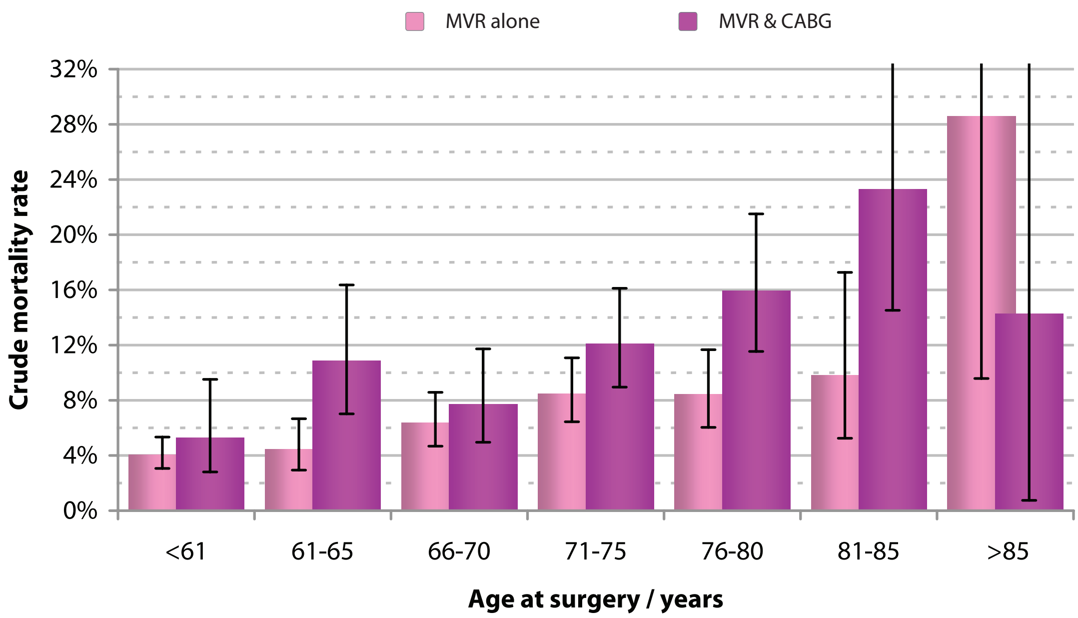
Mortality and age

The mortality associated with mitral valve replacement surgery is high and, as with other procedures, increases markedly with increasing age. The mortality rate for combined mitral replacement & CABG surgery is 11.1% overall. The volume of patients undergoing surgery in their 80s is low compared to aortic valve and coronary artery bypass surgery.

Mortality and age; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

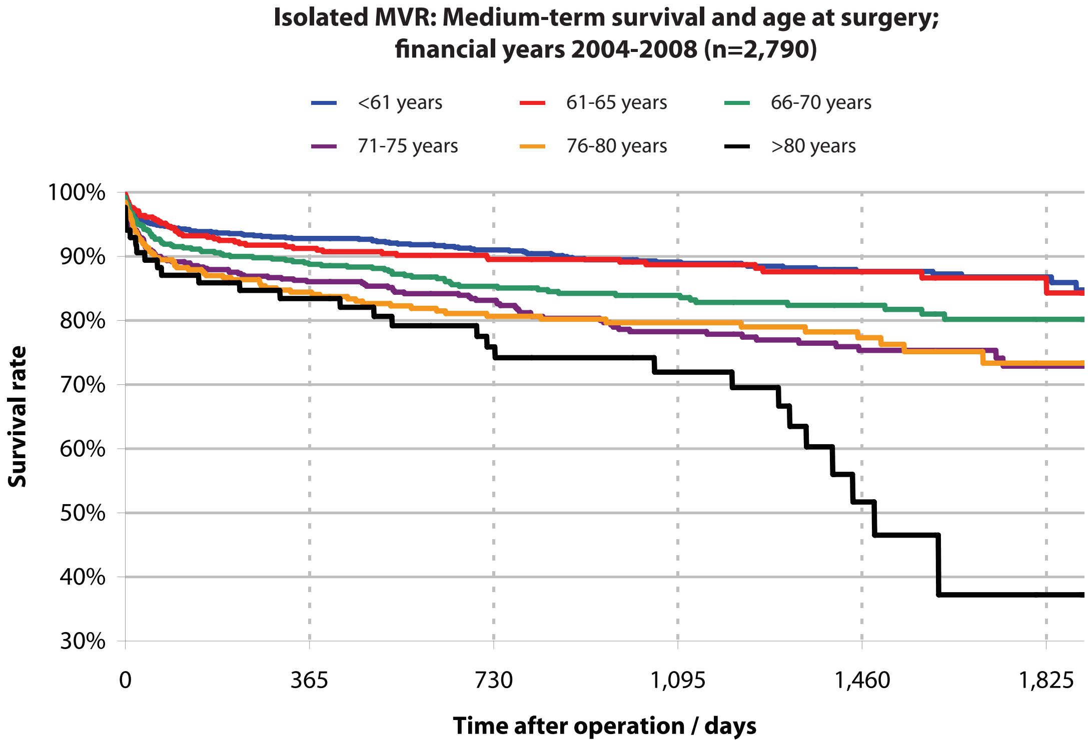
Age at surgery / years	Procedure: Isolated MVR	Procedure: Combined MVR & CABG	Procedure: **All MVR**
<61	4.1% 1,258	5.3% 208	**4.2%** **1,466**
61-65	4.5% 538	10.9% 193	**6.2%** **731**
66-70	6.4% 660	7.7% 272	**6.8%** **932**
71-75	8.5% 601	12.1% 347	**9.8%** **948**
76-80	8.5% 414	15.9% 226	**11.1%** **640**
81-85	9.8% 112	23.3% 73	**15.1%** **185**
>85	28.6% 14	14.3% 7	**23.8%** **21**
Unspecified	5.9% 17	0.0% 11	**3.6%** **28**
All	**6.1%** **3,614**	**11.1%** **1,337**	**7.4%** **4,951**

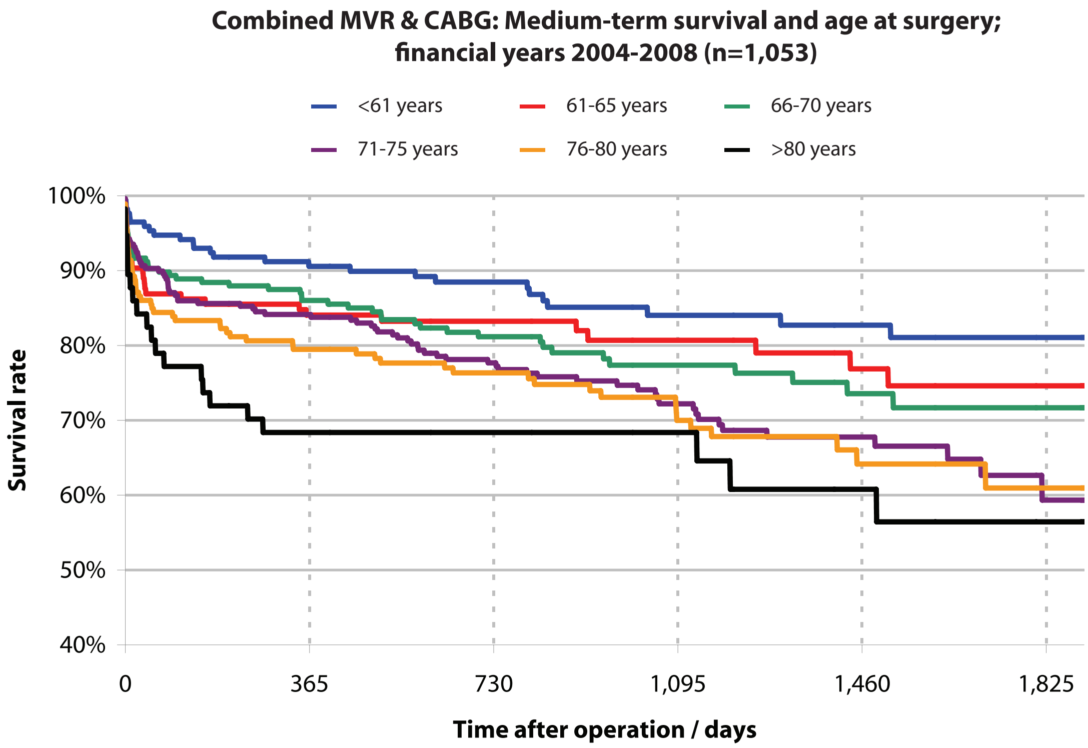
MV replacement: Crude mortality and age; financial years 2004-2008 (n=4,923)



Survival and age

The survival rate following isolated mitral valve replacement is worse than it is after isolated mitral valve repair. This observation has been reported previously. The overall survival rate following combined mitral replacement & CABG is not as good as for many of the other procedures reported in this book. Even in patients under the age of 61 years the Kaplan-Meier survival rate at 5 years after surgery is 80%.





i Enriquez-Sarano M, Schaff HV, Orszulak TA et al. Valve repair improves the outcome of surgery for mitral regurgitation. A multivariate analysis. *Circulation*. 1995; **91:** 1022-1028.

ii Lee EM, Shapiro LM, Wells FC. Superiority of mitral valve repair in surgery for degenerative mitral regurgitation. *Eur Heart J*. 1997; **18:** 655-63.

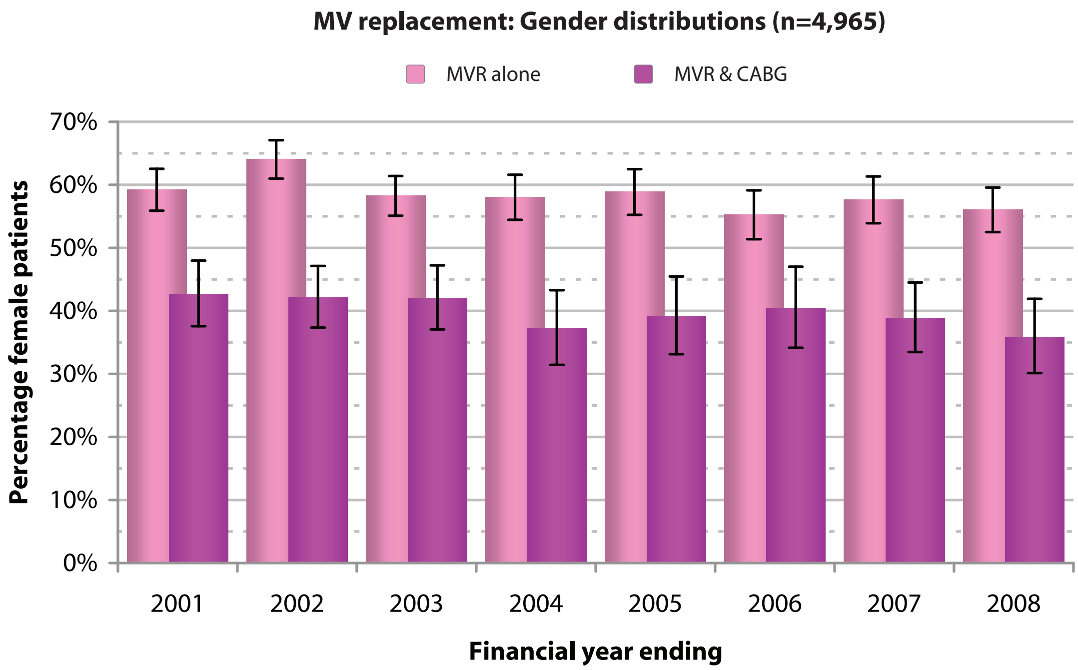
Gender

Gender distributions

Unlike all other procedures reported in this book, patients undergoing isolated mitral valve replacement are more likely to be female, reflecting the increased incidence of rheumatic valve disease in women. However, patients undergoing combined mitral valve replacement & CABG are more likely to be male.

Gender distributions; financial years 2004-2008

		Procedure		
		Isolated MVR	Combined MVR & CABG	**All MVR**
Gender	Male	1,551	827	**2,378**
	Female	2,075	512	**2,587**
	Unspecified	0	0	**0**
	All	**3,626**	**1,339**	**4,965**



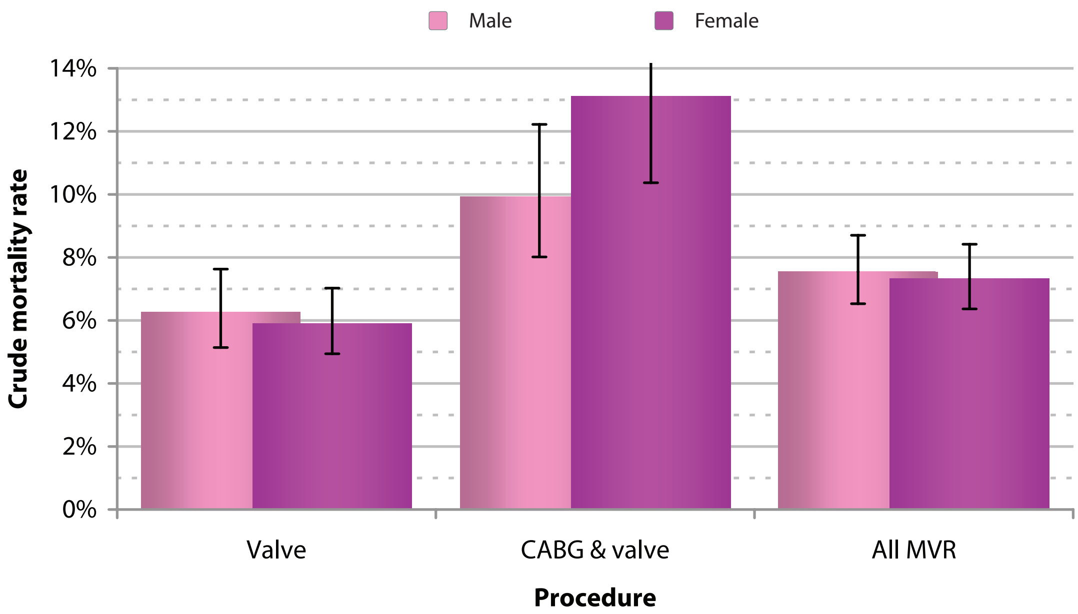
Mortality and gender

As with mitral repair, and unlike AVR and isolated CABG surgery, there is no increase in in-hospital mortality for female patients undergoing mitral surgery.

Mortality and age; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MVR	Combined MVR & CABG	**All MVR**
Gender	Male	6.3% 1,546	9.9% 826	**7.5%** **12,372**
	Female	5.9% 2,068	13.1% 511	**7.3%** **2,579**
	All	**6.1%** **3,614**	**11.1%** **1,337**	**7.4%** **4,951**

MV replacement: Mortality and gender; financial years 2004-2008 (n=4,951)



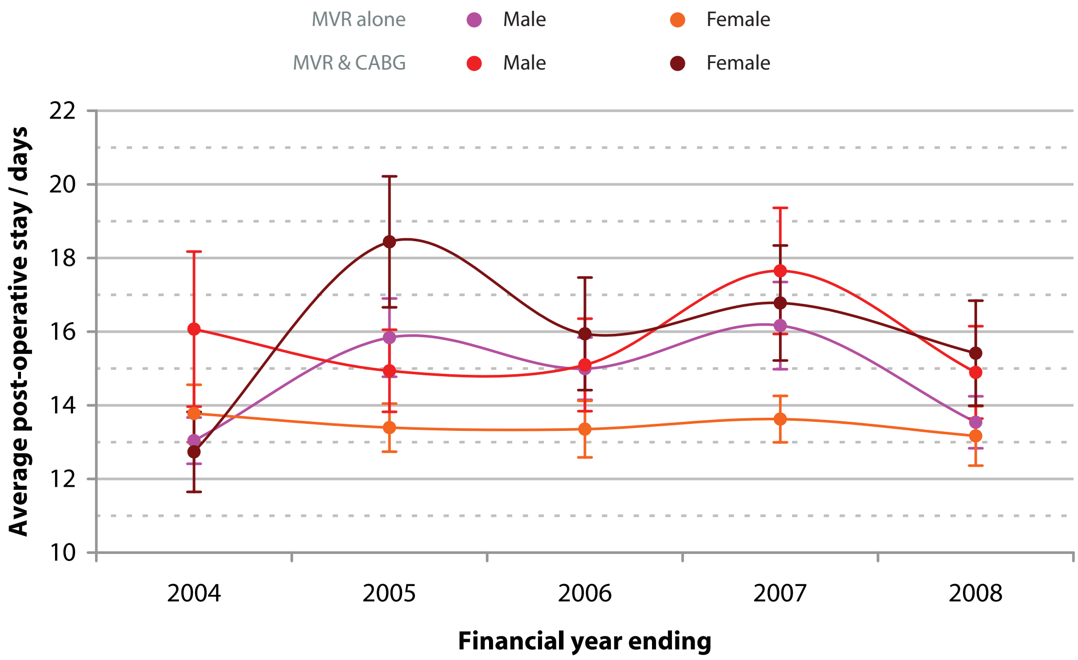
Post-operative stay and gender

In general, post-operative stay is greater following mitral valve replacement than it is for mitral valve repair, but there is no real difference on the basis of gender.

Post-operative stay and gender; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

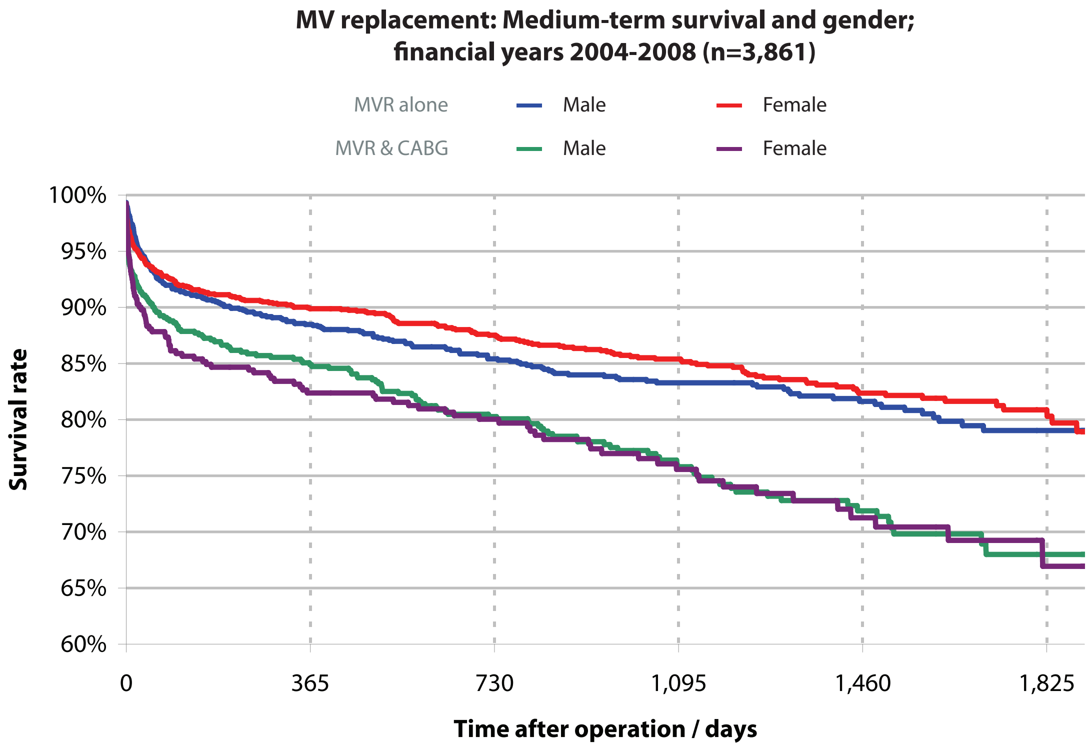
		Procedure			
		Isolated MVR		Combined MVR & CABG	
		Male	Female	Male	Female
Financial year	2004	13.0 293	13.8 423	16.1 159	12.7 98
	2005	15.8 284	13.4 403	14.9 144	18.4 93
	2006	15.0 260	13.4 326	15.1 124	15.9 85
	2007	16.2 280	13.6 377	17.6 177	16.8 117
	2008	13.5 328	13.2 426	14.9 169	15.4 94
	All	**14.7** **1,445**	**13.5** **1,955**	**15.8** **773**	**15.9** **487**

MV replacement: Post-operative stay and gender; bars denote standard error (n=4,660)



Survival and gender

There is no difference in survival on the basis of gender.



Priority

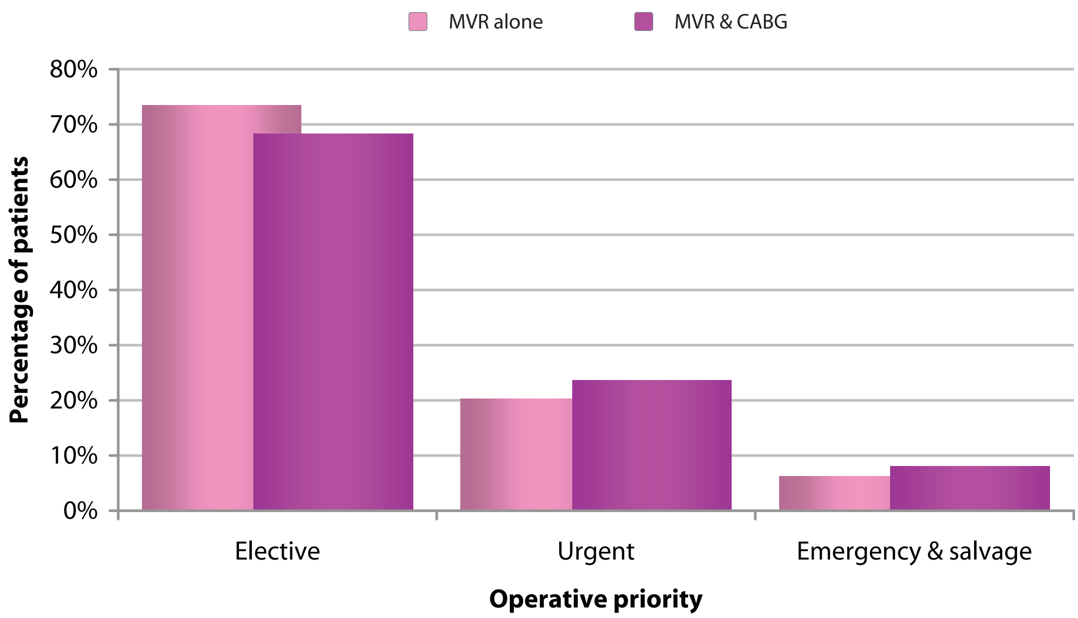
Priority distributions

The proportion of patients undergoing isolated mitral valve replacement as urgent and salvage cases is higher than it is for isolated mitral valve repair. Nearly 10% of the patients undergoing combined mitral replacement & CABG do so as emergency or salvage cases, probably for acute ischaemic mitral regurgitation.

Priority distributions; financial years 2004-2008

		Procedure		
		Isolated MVR	Combined MVR & CABG	**All MVR**
Priority	Elective	2,660	914	**3,574**
	Urgent	734	316	**1,050**
	Emergency	201	90	**291**
	Salvage	26	18	**44**
	Unspecified	5	1	**6**
	All	**3,626**	**1,339**	**4,965**

MV replacement: Priority distributions; financial years 2004-2008 (n=4,959)

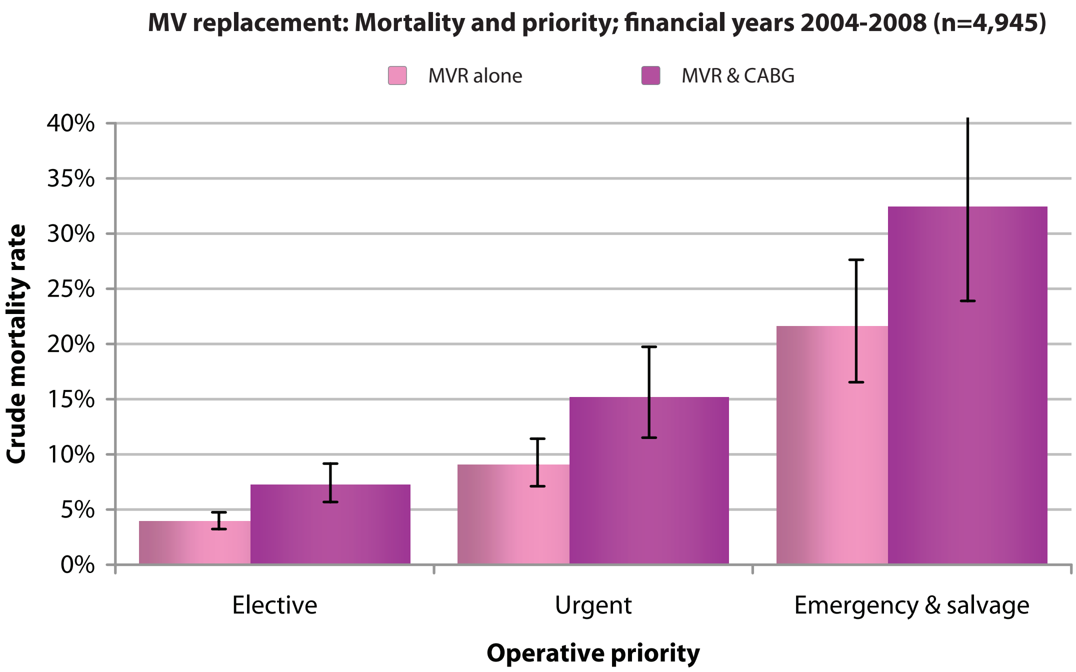


Mortality and priority

Both isolated mitral valve replacement and combined mitral valve replacement & CABG have a mortality rate that is strongly associated with priority. In line with the relatively high incidence of combined mitral valve replacement & CABG undertaken as emergency or savage cases, these patients have a high mortality rate of over 30%

Mortality and priority; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MVR	Combined MVR & CABG	**All MVR**
Priority	Elective	3.9% 2,652	7.2% 912	**4.8%** **3,564**
	Urgent	9.0% 730	15.2% 316	**10.9%** **1,046**
	Emergency	18.4% 201	27.8% 90	**21.3%** **291**
	Salvage	46.2% 26	55.6% 18	**50.0%** **44**
	Unspecified	0.0% 5	0.0% 1	**0.0%** **6**
	All	**6.1%** **3,614**	**11.1%** **1,337**	**7.4%** **4,951**



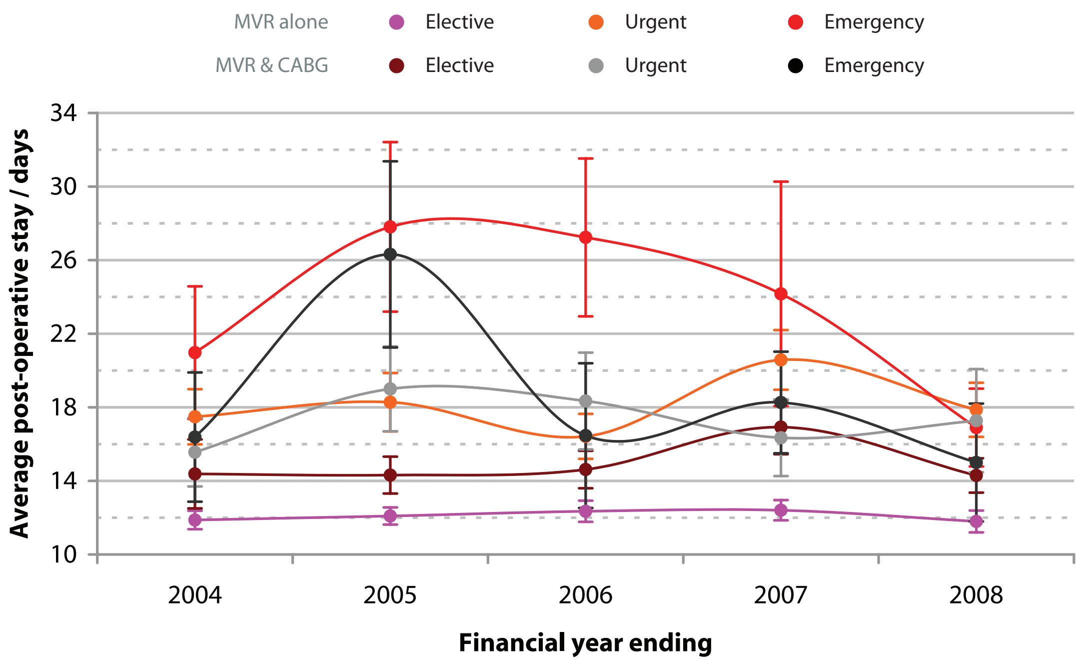
Post-operative stay and priority

There is a difference in post-operative length-of-stay overall, with emergency patients staying longer than those undergoing urgent surgery, who, in turn, stay longer than the elective patients.

Post-operative stay and priority; financial years 2004-2008; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MVR	Combined MVR & CABG	**All MVR**
Priority	Elective	12.1 2,500	15.0 859	**12.8** **3,359**
	Urgent	18.2 685	17.2 299	**17.9** **984**
	Emergency	23.5 186	18.4 86	**21.9** **272**
	Salvage	17.0 25	23.1 15	**19.3** **40**
	Unspecified	16.5 4	18.0 1	**16.8** **5**
	All	**14.0** **3,400**	**15.8** **1,260**	**14.5** **4,660**

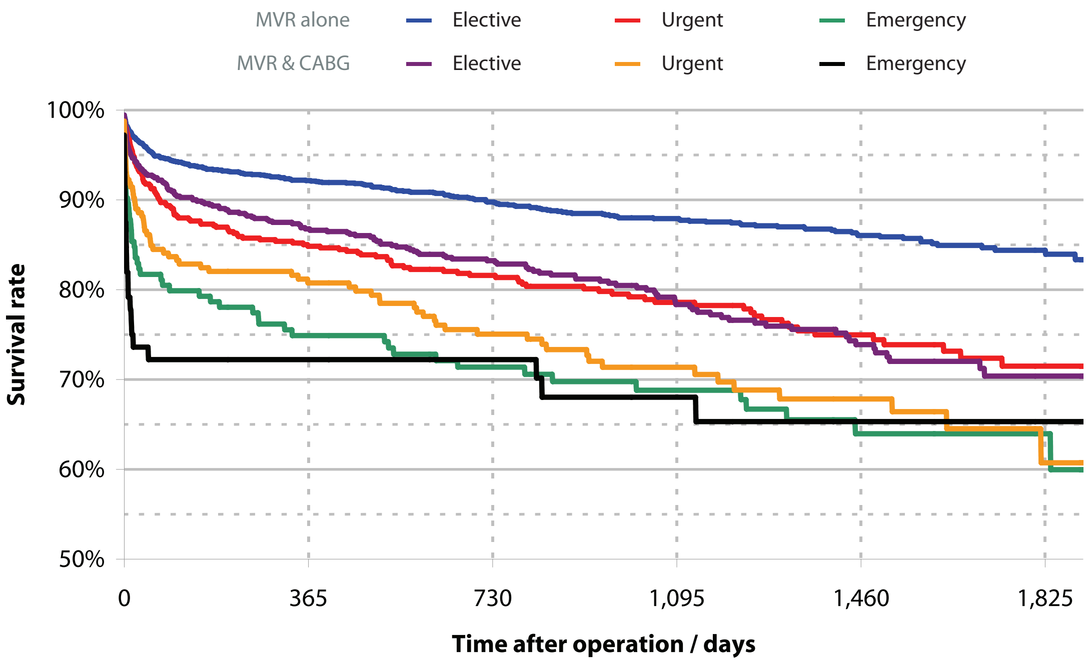
MV replacement: Post-operative stay and priority; bars denote standard error (n=4,615)



Survival and priority

The best medium-term survival rate seen in this group of patients is for elective patients undergoing isolated mitral valve replacement, but survival is worse than that seen for mitral valve repair, AVR or isolated CABG surgery.

MV replacement: Medium-term survival and priority; financial years 2004-2008 (n=3,829)



Haemodynamic pathology

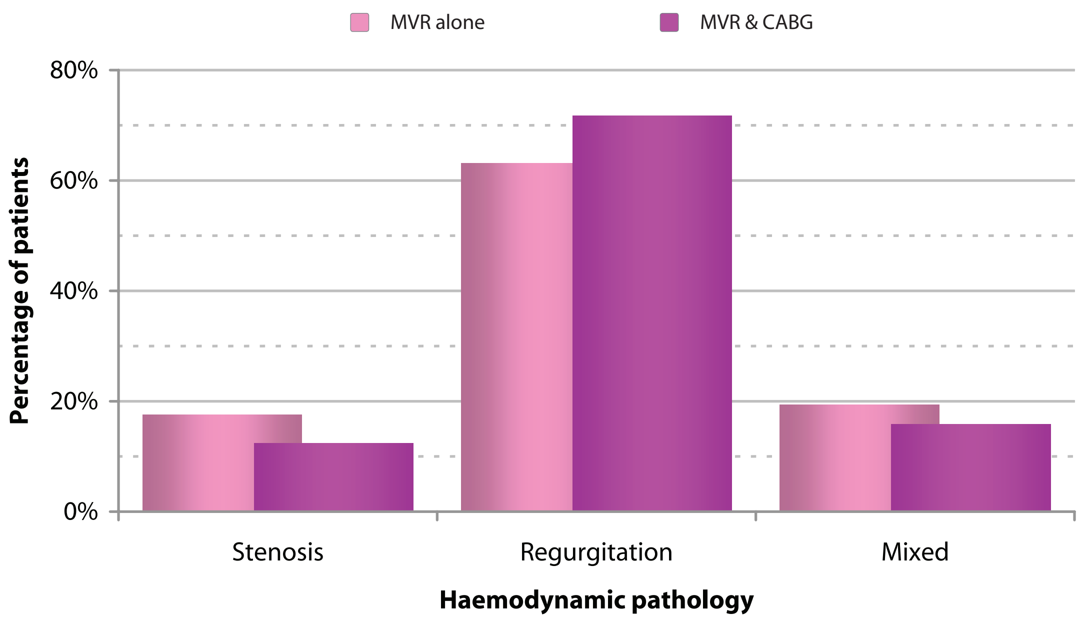
Haemodynamic pathology distributions

For isolated mitral valve replacement about 60% of the operations are undertaken for mitral regurgitation, with 20% for stenosis and 20% mixed. These issues are considered further on page 210 (valve pathology).

Haemodynamic pathology distributions; financial years 2004-2008

		Procedure		
		Isolated MVR	Combined MVR & CABG	**All MVR**
Haemodynamic pathology	Stenosis	620	159	**779**
	Regurgitation	2,226	920	**3,146**
	Mixed	683	203	**886**
	Unspecified	97	57	**154**
	All	**3,626**	**1,339**	**4,965**

MV replacement: Haemodynamic pathology distributions; financial years 2004-2008 (n=4,811)



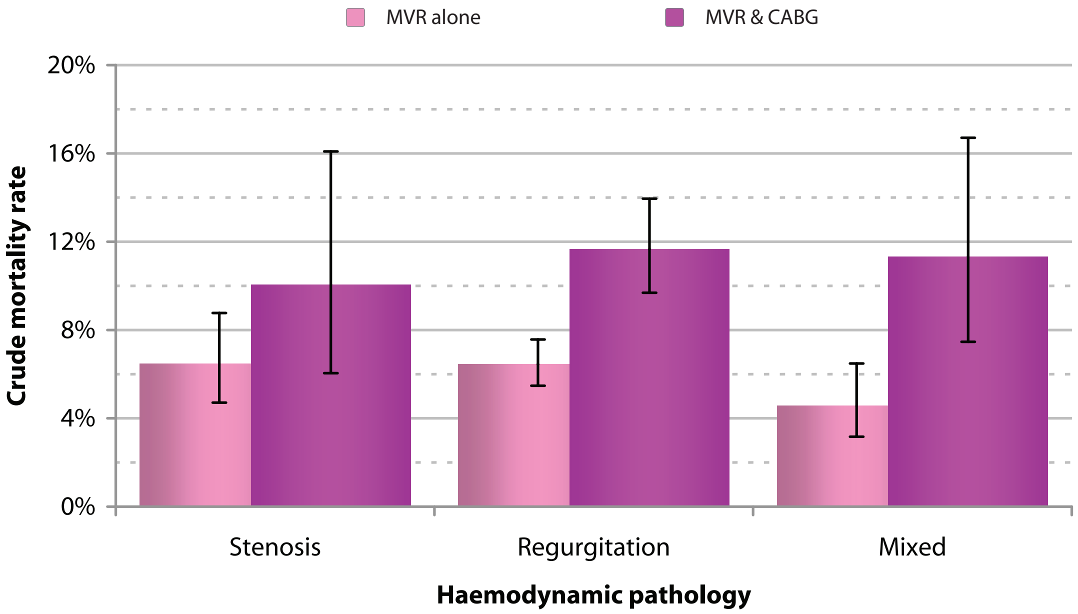
Mortality and haemodynamic pathology

There is no difference in the mortality rate following mitral valve replacement according to the patient's reported haemodynamic pathology.

Mortality and haemodynamic pathology; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MVR	Combined MVR & CABG	**All**
Haemodynamic pathology	Stenosis	6.5% 619	10.1% 159	**7.2%** **778**
	Regurgitation	6.4% 2,218	11.7% 918	**8.0%** **3,136**
	Mixed	4.6% 680	11.3% 203	**6.1%** **883**
	Unspecified	5.2% 97	5.3% 57	**5.2%** **154**
	All	**6.1%** **3,614**	**11.1%** **1,337**	**7.4%** **4,951**

MV replacement: Mortality and haemodynamic pathology; financial years 2004-2008 (n=4,797)



Isolated mitral valve replacement

Distributions and outcome rates for major risk factors not reported in detail; financial years 2004-2008

Risk factor			Count	Mortality rate (count; 95% CI)
	Body mass index	Underweight	306	11.2% (304; 8.0-15.4%)
		Normal	1,319	5.7% (1,313; 4.5-7.1%)
		Overweight	1,175	5.5% (1,173; 4.3-7.0%)
		Obese	449	6.0% (447; 4.1-8.8%)
		Morbidly obese	145	5.5% (145; 2.6-10.9%)
		Unspecified	232	
	Ejection fraction	Good	2,467	5.1% (2,461; 4.3-6.1%)
		Fair	908	7.2% (904; 5.6-9.1%)
		Poor	125	19.4% (124; 13.0-27.6%)
		Unspecified	126	
	LMS disease	No	2,821	6.0% (2,811; 5.2-7.0%)
		Yes	18	11.1% (18; 1.9-36.1%)
		Unspecified	787	
	Previous cardiac surgery	No	2,712	5.1% (2,705; 4.3-6.0%)
		Yes	796	9.4% (791; 7.5-11.7%)
		Unspecified	118	
	Diabetes	No	3,252	5.8% (3,241; 5.0-6.6%)
		Yes	317	9.5% (317; 6.6-13.4%)
		Unspecified	57	
	Hypertension	No	2,228	5.6% (2,219; 4.7-6.7%)
		Yes	1,324	6.8% (1,322; 5.5-8.3%)
		Unspecified	74	
	Extra-cardiac arteriopathy	No	3,413	5.9% (3,402; 5.2-6.8%)
		Yes	156	10.9% (156; 6.7-17.1%)
		Unspecified	57	
	Renal disease	No	3,288	5.2% (3,278; 4.5-6.0%)
		Yes	163	25.3% (162; 19.0-32.8%)
		Unspecified	175	
	Angina	CCS0	2,546	5.5% (2,539; 4.6-6.4%)
		CCS1	428	7.5% (424; 5.3-10.6%)
		CCS2	272	5.9% (272; 3.5-9.6%)
		CCS3	125	10.4% (125; 5.9-17.5%)
		CC4	54	20.4% (54; 11.1-33.9%)
		Unspecified	201	
	Dyspnoea	NYHA 1	318	5.7% (317; 3.5-9.0%)
		NYHA 2	970	3.6% (968; 2.6-5.0%)
		NYHA 3	1,675	5.2% (1,667; 4.2-6.4%)
		NYHA 4	565	13.3% (565; 10.6-16.4%)
		Unspecified	98	

Post-operative stay / days (count; SE)	Post-operative stroke rate (count; 95% CI)	Re-op for bleeding rate (count; 95% CI)	Survival rate at 5 years
15.5 (294; 0.96)	3.6% (247; 15.4-1.8%)	8.6% (255; 1.8-7.0%)	69.0%
13.9 (1,258; 0.39)	2.6% (1,118; 7.1-1.8%)	6.7% (1,096; 1.8-3.8%)	81.4%
13.4 (1,132; 0.49)	2.8% (1,029; 7.0-1.9%)	4.7% (1,021; 1.9-4.1%)	82.0%
13.6 (435; 0.64)	2.6% (387; 8.8-1.3%)	3.3% (389; 1.3-4.9%)	81.7%
14.3 (143; 0.85)	2.4% (126; 10.9-0.6%)	2.4% (126; 0.6-7.3%)	81.7%
13.3 (2,314; 0.30)	2.7% (2,144; 6.1-2.0%)	5.8% (2,079; 2.0-3.5%)	81.7%
15.2 (841; 0.55)	2.5% (761; 9.1-1.6%)	5.6% (728; 1.6-3.9%)	78.5%
17.0 (121; 1.77)	6.2% (113; 27.6-2.7%)	6.5% (108; 2.7-12.8%)	57.5%
13.6 (2,662; 0.28)	2.9% (2,582; 7.0-2.3%)	5.2% (2,429; 2.3-3.7%)	80.6%
17.2 (17; 6.34)	6.3% (16; 36.1-0.3%)	11.8% (17; 0.3-32.3%)	82.5%
13.0 (2,536; 0.27)	2.0% (2,340; 6.0-1.5%)	5.3% (2,226; 1.5-2.6%)	82.6%
17.3 (755; 0.68)	5.6% (661; 11.7-4.0%)	7.4% (676; 4.0-7.7%)	71.0%
13.6 (3,044; 0.25)	2.7% (2,816; 6.6-2.1%)	5.8% (2,710; 2.1-3.4%)	81.2%
17.6 (303; 1.32)	3.4% (262; 13.4-1.7%)	5.3% (265; 1.7-6.6%)	69.1%
13.7 (2,082; 0.31)	2.0% (1,912; 6.7-1.5%)	5.7% (1,846; 1.5-2.8%)	80.8%
14.1 (1,248; 0.45)	3.7% (1,153; 8.3-2.7%)	5.5% (1,119; 2.7-5.0%)	79.0%
13.7 (3,198; 0.25)	2.7% (2,940; 6.8-2.2%)	5.7% (2,840; 2.2-3.4%)	80.7%
18.1 (148; 2.05)	3.6% (139; 17.1-1.3%)	6.0% (133; 1.3-8.6%)	67.6%
13.3 (3,167; 0.24)	2.5% (2,832; 6.0-2.0%)	5.4% (2,817; 2.0-3.2%)	81.9%
23.2 (151; 1.91)	8.3% (133; 32.8-4.4%)	13.5% (133; 4.4-14.7%)	43.2%
14.0 (2,433; 0.31)	2.8% (2,282; 6.4-2.2%)	5.4% (2,187; 2.2-3.6%)	81.4%
12.8 (375; 0.75)	2.1% (381; 10.6-1.0%)	8.0% (324; 1.0-4.3%)	76.9%
14.5 (250; 0.97)	3.2% (247; 9.6-1.5%)	6.2% (225; 1.5-6.5%)	75.2%
14.4 (110; 1.42)	2.9% (105; 17.5-0.7%)	1.0% (97; 0.7-8.7%)	80.6%
14.3 (51; 1.47)	2.0% (49; 33.9-0.1%)	10.9% (46; 0.1-12.2%)	66.1%
14.1 (294; 0.84)	2.5% (243; 9.0-1.0%)	9.0% (244; 1.0-5.6%)	81.1%
12.0 (910; 0.37)	2.9% (829; 5.0-1.9%)	4.2% (810; 1.9-4.3%)	89.1%
13.1 (1,587; 0.33)	2.5% (1,497; 6.4-1.8%)	5.1% (1,422; 1.8-3.4%)	79.4%
19.4 (532; 0.98)	3.5% (492; 16.4-2.1%)	8.8% (477; 2.1-5.6%)	67.0%

Combined mitral valve replacement & CABG surgery

Distributions and outcome rates for major risk factors not reported in detail; financial years 2004-2008

Risk factor			Count	Mortality rate (count; 95% CI)
	Body mass index	Underweight	73	16.4% (73; 9.1-27.3%)
		Normal	414	14.0% (414; 10.9-17.8%)
		Overweight	532	6.6% (531; 4.7-9.1%)
		Obese	190	13.8% (189; 9.3-19.7%)
		Morbidly obese	50	14.0% (50; 6.3-27.4%)
		Unspecified	80	
	Ejection fraction	Good	669	8.8% (668; 6.8-11.3%)
		Fair	484	12.0% (483; 9.3-15.3%)
		Poor	152	19.7% (152; 13.9-27.1%)
		Unspecified	34	
	LMS disease	No	1,037	11.3% (1,035; 9.5-13.4%)
		Yes	137	16.1% (137; 10.5-23.5%)
		Unspecified	165	
	Previous cardiac surgery	No	1,219	11.1% (1,217; 9.4-13.0%)
		Yes	95	14.7% (95; 8.6-23.8%)
		Unspecified	25	
	Diabetes	No	1,112	11.2% (1,110; 9.4-13.2%)
		Yes	208	12.0% (208; 8.1-17.4%)
		Unspecified	19	
	Hypertension	No	562	9.8% (561; 7.5-12.6%)
		Yes	758	12.2% (757; 10.0-14.7%)
		Unspecified	19	
	Extra-cardiac arteriopathy	No	1,170	10.7% (1,168; 9.0-12.7%)
		Yes	151	15.9% (151; 10.6-22.9%)
		Unspecified	18	
	Renal disease	No	1,203	10.0% (1,201; 8.4-11.9%)
		Yes	67	26.9% (67; 17.1-39.3%)
		Unspecified	69	
	Angina	CCS0	422	9.5% (421; 7.0-12.8%)
		CCS1	197	8.6% (197; 5.3-13.7%)
		CCS2	306	9.2% (306; 6.3-13.1%)
		CCS3	225	12.1% (224; 8.2-17.2%)
		CC4	129	24.0% (129; 17.1-32.5%)
		Unspecified	60	
	Dyspnoea	NYHA 1	113	6.2% (113; 2.7-12.8%)
		NYHA 2	379	6.9% (379; 4.6-10.0%)
		NYHA 3	592	11.0% (591; 8.6-13.9%)
		NYHA 4	226	21.3% (225; 16.3-27.4%)
		Unspecified	29	

Post-operative stay / days (count; SE)	Post-operative stroke rate (count; 95% CI)	Re-op for bleeding rate (count; 95% CI)	Survival rate at 5 years
16.3 (72; 1.92)	5.3% (57; 27.3-1.4%)	15.8% (57; 1.4-15.5%)	61.2%
14.4 (395; 0.65)	5.6% (358; 17.8-3.5%)	9.1% (364; 3.5-8.6%)	63.3%
16.3 (513; 0.90)	3.4% (467; 9.1-2.0%)	6.1% (458; 2.0-5.6%)	72.2%
17.3 (184; 1.63)	3.6% (169; 19.7-1.5%)	7.4% (162; 1.5-7.9%)	67.8%
19.5 (50; 2.60)	4.7% (43; 27.4-0.8%)	8.5% (47; 0.8-17.1%)	75.0%
14.7 (627; 0.74)	4.2% (598; 11.3-2.8%)	7.0% (574; 2.8-6.2%)	71.5%
17.2 (457; 0.84)	5.6% (413; 15.3-3.6%)	8.9% (404; 3.6-8.4%)	67.1%
16.8 (143; 1.41)	2.4% (123; 27.1-0.6%)	9.3% (118; 0.6-7.5%)	54.9%
15.9 (989; 0.60)	4.2% (967; 13.4-3.1%)	8.0% (907; 3.1-5.8%)	68.1%
16.1 (130; 1.35)	4.7% (127; 23.5-1.9%)	9.9% (121; 1.9-10.4%)	56.9%
15.9 (1,146; 0.55)	4.5% (1,050; 13.0-3.3%)	8.2% (1,016; 3.3-6.0%)	67.5%
15.3 (89; 1.30)	3.6% (84; 23.8-0.9%)	8.9% (79; 0.9-10.8%)	63.1%
15.2 (1,049; 0.54)	4.4% (963; 13.2-3.2%)	8.7% (928; 3.2-5.9%)	68.8%
19.2 (199; 1.42)	4.8% (187; 17.4-2.4%)	6.0% (182; 2.4-9.2%)	52.3%
15.3 (530; 0.65)	3.7% (485; 12.6-2.3%)	9.3% (475; 2.3-5.9%)	69.2%
16.0 (714; 0.74)	4.7% (660; 14.7-3.3%)	7.3% (631; 3.3-6.7%)	66.2%
15.3 (1,099; 0.53)	4.3% (1,014; 12.7-3.2%)	8.6% (981; 3.2-5.8%)	68.4%
19.4 (145; 1.73)	5.3% (131; 22.9-2.4%)	5.6% (124; 2.4-11.1%)	62.6%
15.4 (1,162; 0.51)	4.4% (1,048; 11.9-3.3%)	8.2% (1,041; 3.3-5.9%)	68.7%
20.7 (64; 2.78)	6.9% (58; 39.3-2.2%)	10.5% (57; 2.2-17.5%)	51.6%
14.9 (400; 1.04)	3.6% (388; 12.8-2.1%)	8.6% (373; 2.1-6.1%)	69.6%
14.7 (178; 1.05)	4.8% (168; 13.7-2.2%)	8.7% (161; 2.2-9.5%)	70.6%
16.0 (287; 0.95)	3.3% (273; 13.1-1.6%)	9.1% (254; 1.6-6.4%)	67.8%
17.3 (218; 1.24)	6.5% (199; 17.2-3.7%)	6.5% (186; 3.7-11.2%)	62.7%
16.9 (125; 1.63)	5.7% (122; 32.5-2.5%)	7.0% (114; 2.5-11.9%)	63.2%
13.1 (105; 0.93)	3.4% (88; 12.8-0.9%)	4.7% (86; 0.9-10.3%)	71.7%
13.8 (350; 0.61)	4.8% (332; 10.0-2.9%)	9.5% (316; 2.9-7.9%)	72.8%
15.9 (568; 0.71)	4.8% (524; 13.9-3.2%)	9.0% (509; 3.2-7.1%)	67.6%
19.7 (219; 1.93)	3.4% (204; 27.4-1.5%)	5.6% (198; 1.5-7.2%)	57.6%

EuroSCORE

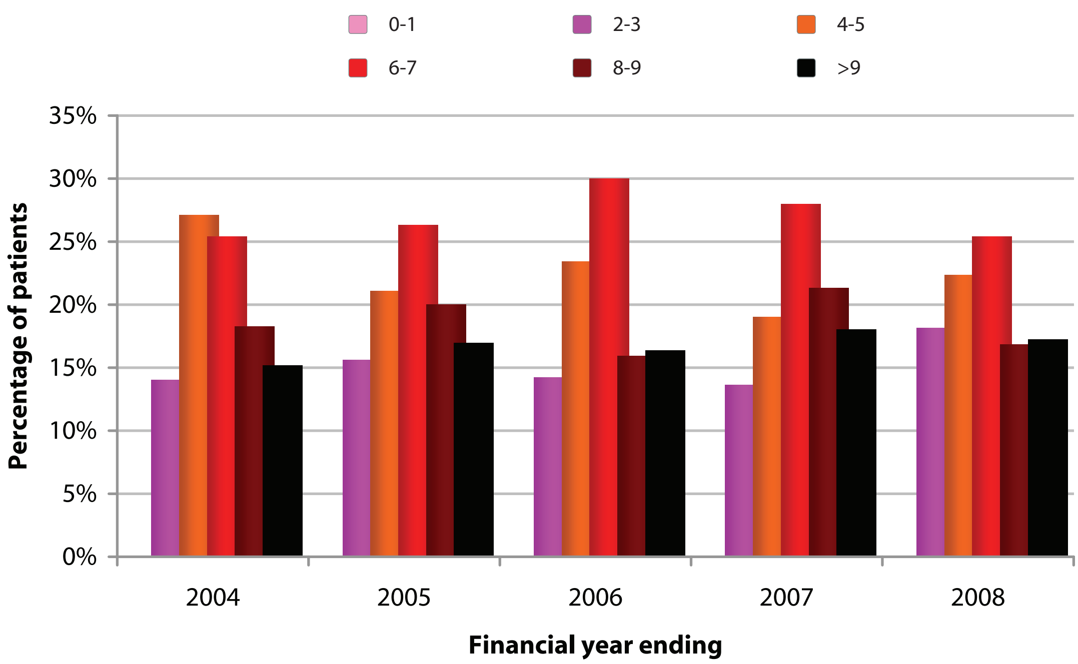
The additive *EuroSCORE*

The additive ***EuroSCORE*** distributions have changed little over time.

Additive ***EuroSCORE*** distributions; isolated MVR; financial years 2004-2008

		Additive *EuroSCORE* groupings						
		0-1	2-3	4-5	6-7	8-9	>9	**All**
Financial year	2004	0	106	205	192	138	115	**756**
	2005	0	114	154	192	146	124	**730**
	2006	0	93	153	196	104	107	**653**
	2007	0	96	134	197	150	127	**704**
	2008	0	142	175	199	132	135	**783**
	All	**0**	**551**	**821**	**976**	**670**	**608**	**3,626**

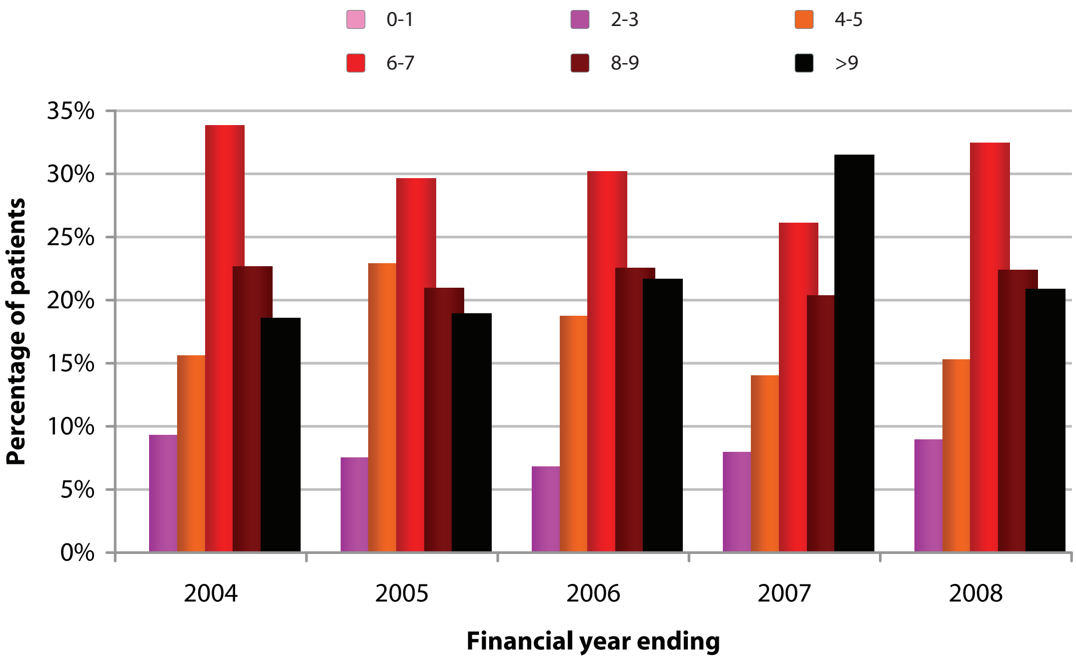
Isolated MVR: Additive *EuroSCORE* distributions (n=3,626)



Additive ***EuroSCORE*** distributions; combined MVR & CABG surgery; financial years 2004-2008

Financial year		Additive *EuroSCORE* groupings						
		0-1	2-3	4-5	6-7	8-9	>9	**All**
	2004	0	25	42	91	61	50	**269**
	2005	0	19	58	75	53	48	**253**
	2006	0	16	44	71	53	51	**235**
	2007	0	25	44	82	64	99	**314**
	2008	0	24	41	87	60	56	**268**
	All	**0**	**109**	**229**	**406**	**262**	**304**	**1,339**

Combined MVR & CABG: Additive *EuroSCORE* distributions (n=1,339)



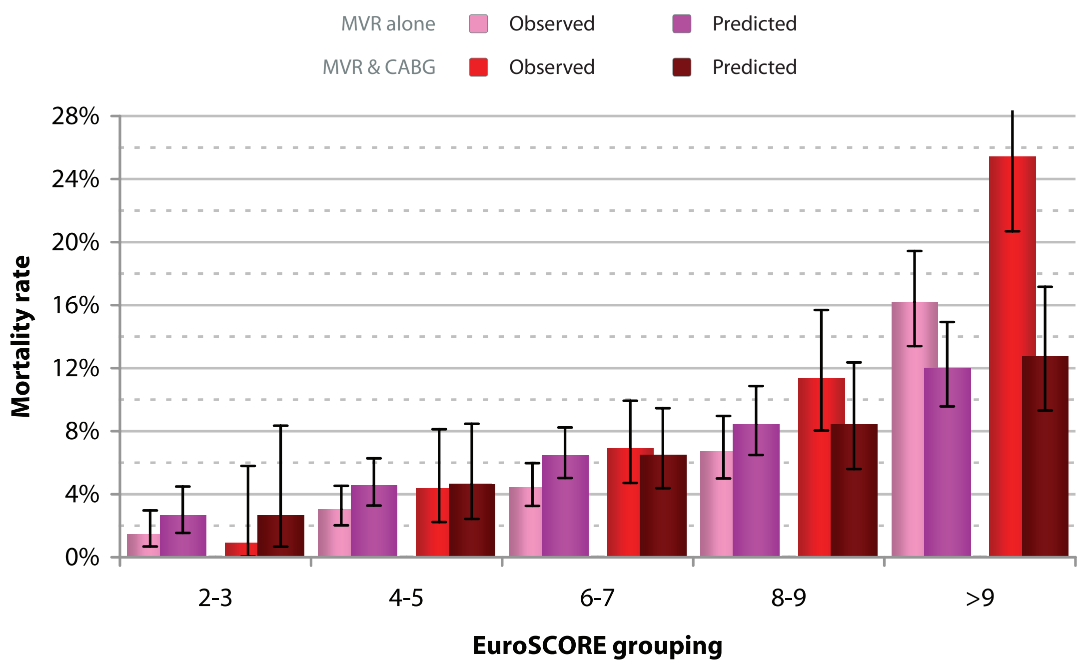
EuroSCORE and mortality

The additive ***EuroSCORE*** does not significantly over-predict observed mortality, neither for isolated mitral valve replacement, nor for combined mitral valve replacement & CABG.

Observed mortality according to additive ***EuroSCORE*** groupings; all entries are scored irrespective of missing risk factor data; financial years 2004-2008; the upper numbers represent the crude mortality rate and the lower numbers the procedure count within the sub-group

Additive *EuroSCORE* grouping	Post-operative mortality			
	Isolated MVR		Combined MVR & CABG	
	Observed	Predicted	Observed	Predicted
2-3	1.5% 549	2.7%	0.9% 108	2.7%
4-5	3.0% 820	4.6%	4.4% 229	4.6%
6-7	4.4% 971	6.5%	6.9% 406	6.5%
8-9	6.7% 669	8.4%	11.3% 291	8.5%
>9	16.2% 605	12.0%	25.4% 303	12.7%
All	**6.1%** **3,614**	**6.7%**	**11.1%** **1,337**	**7.7%**

MV replacement: Observed and predicted mortality rates according to the additive *EuroSCORE*; financial years 2004-2008 (n=4,951)

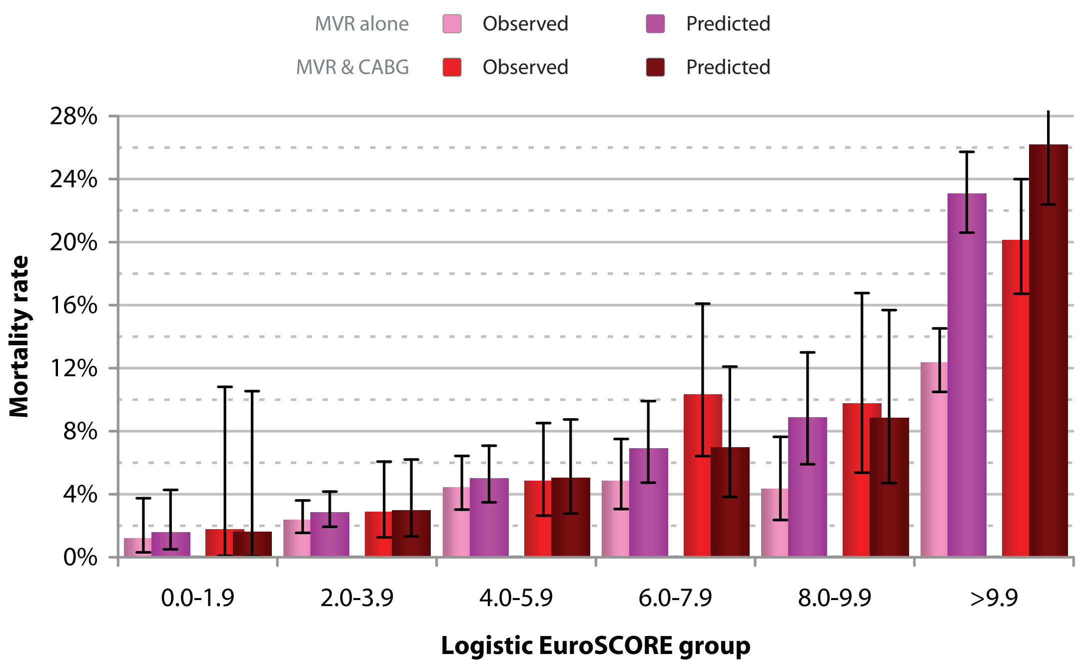


The logistic ***EuroSCORE*** does not significantly over-predict observed mortality, neither for isolated mitral valve replacement, nor for combined mitral valve replacement & CABG.

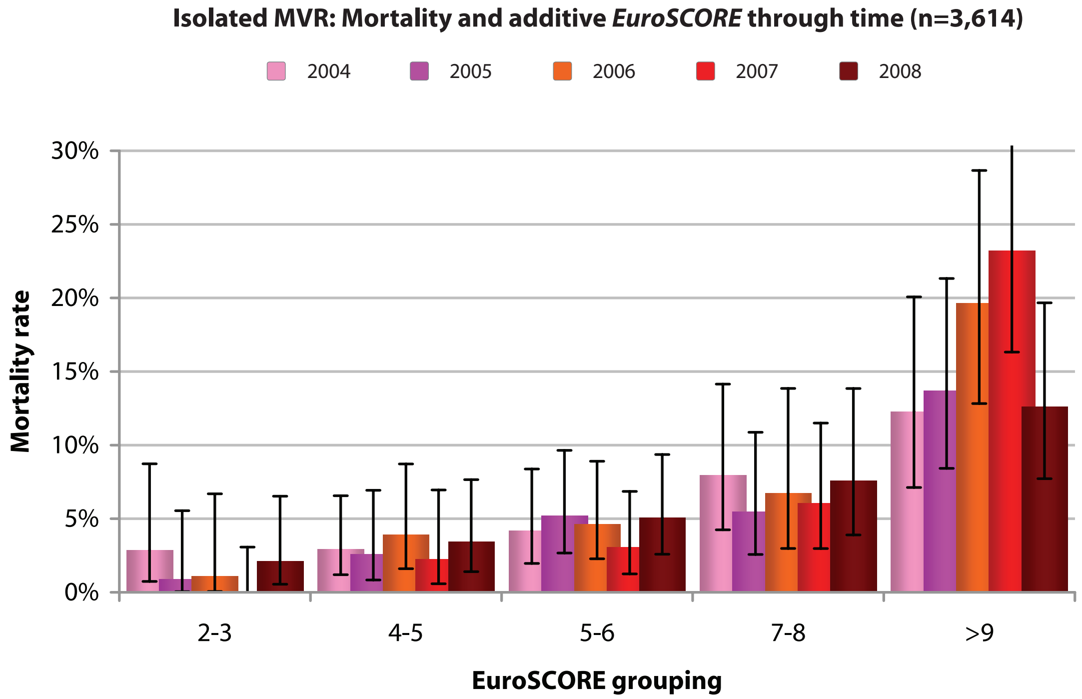
Observed mortality according to logistic ***EuroSCORE*** groupings; all entries are scored irrespective of missing risk factor data; financial years 2004-2008; the upper numbers represent the crude mortality rate and the lower numbers the procedure count within the sub-group

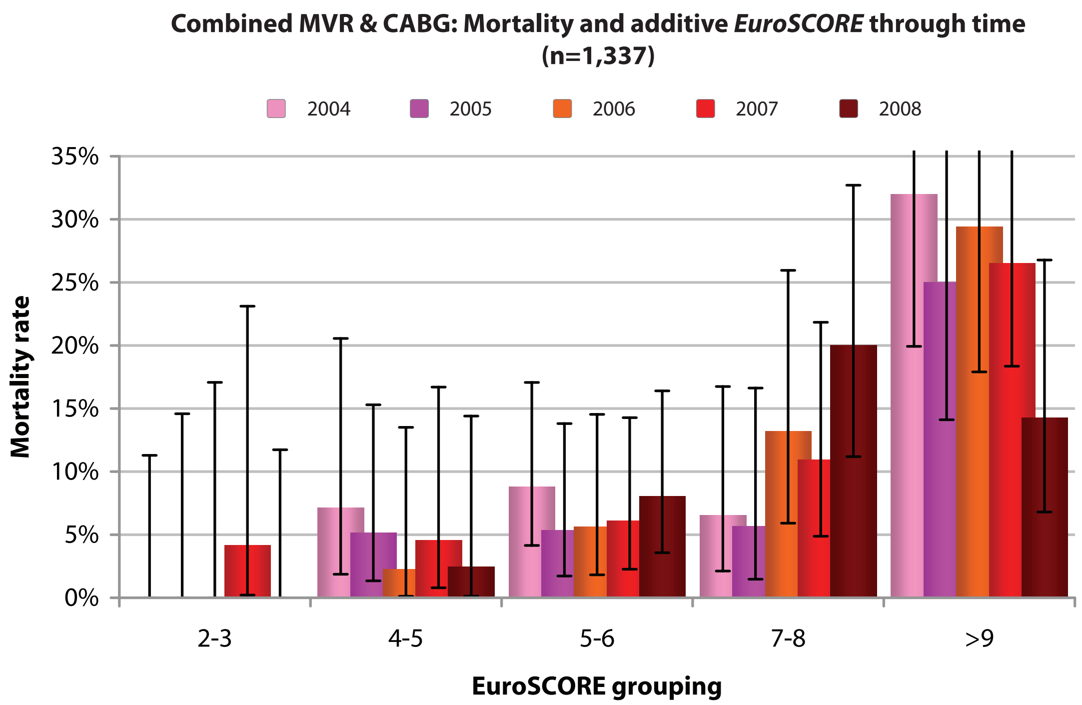
Logistic *EuroSCORE* grouping	Post-operative mortality			
	Isolated MVR		Combined MVR & CABG	
	Observed	Predicted	Observed	Predicted
0.0-1.9	1.2% 251	1.6%	1.8% 56	1.6%
2.0-3.9	2.4% 967	2.9%	2.9% 244	3.0%
4.0-5.9	4.4% 631	5.0%	4.8% 248	5.0%
6.0-7.9	4.8% 413	6.9%	10.3% 174	7.0%
8.0-9.9	4.3% 277	8.9%	9.8% 123	8.8%
>9.9	12.4% 1,075	23.1%	20.1% 492	26.2%
All	**6.1% 3,614**	**10.1%**	**11.1% 1,337**	**12.9%**

MV replacement: Observed and predicted mortality rates according to the logistic *EuroSCORE*; financial years 2004-2008 (n=4,951)



Unlike the findings for isolated CABG surgery and AVR surgery, there has not been a significant decrease in mortality over time for mitral valve replacement surgery in the various ***EuroSCORE*** groupings.





Implanted prosthesis

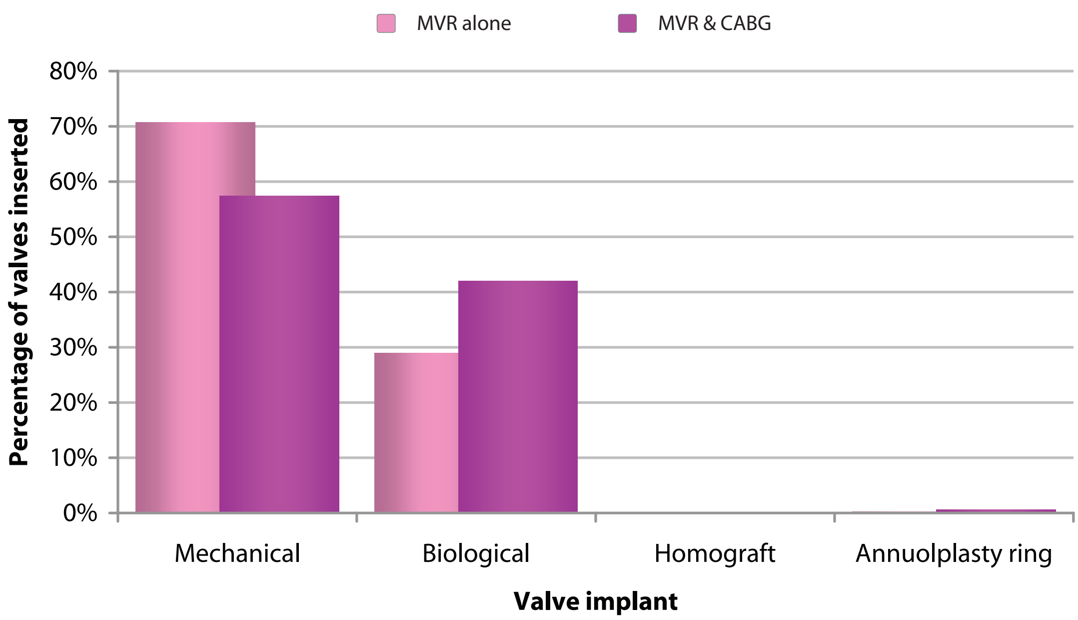
Distributions

Seventy percent of implants used for isolated mitral valve replacements are mechanical and 57% of those for combined mitral valve replacement & CABG. There are a small number of patients who have either been incorrectly defined as replacements but who have had a repair with an annuloplasty, or who have been correctly attributed to the replacement group, but the wrong prosthesis type has been included. There are a tiny number of mitral valve homografts reported and these could either be defined as replacements or repairs.

Implanted prosthesis distributions; financial years 2004-2008

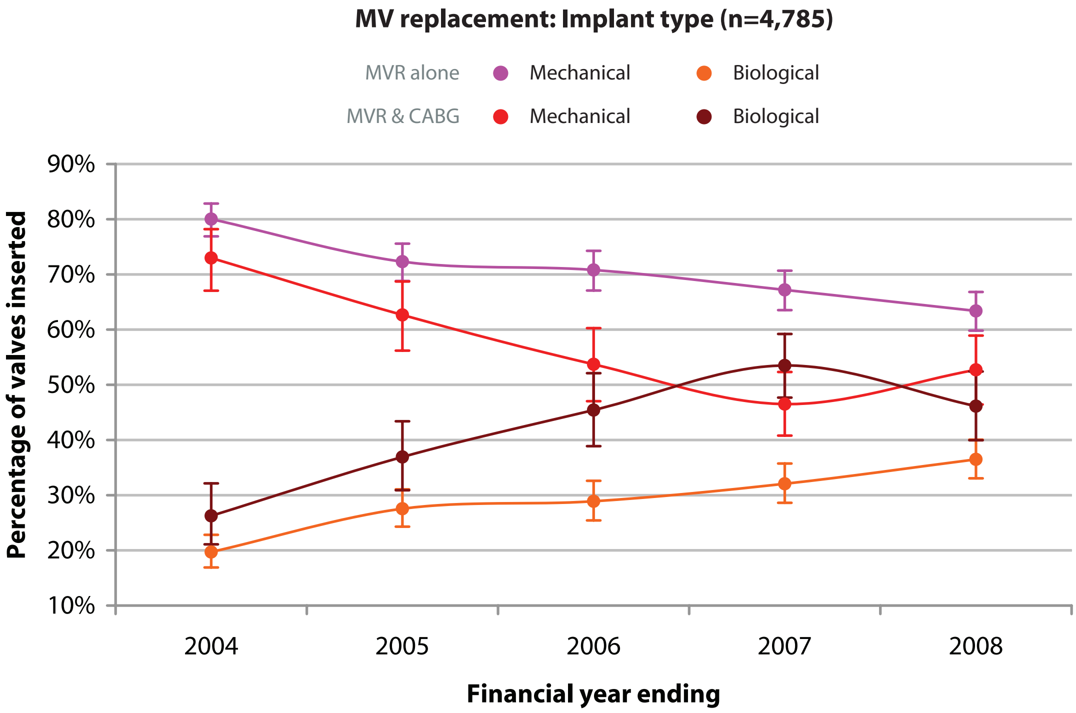
		Procedure		
		Isolated MVR	Combined MVR & CABG	**All MVR**
Implant type	Mechanical	2,473	739	**3,212**
	Biological	1,013	541	**1,554**
	Homograft	3	0	**3**
	Annuloplasty ring	8	8	**16**
	Unspecified	129	51	**180**
	All	**3,626**	**1,339**	**4,965**

MV replacement: Implant prosthesis; financial years 2004-2008 (n=4,785)



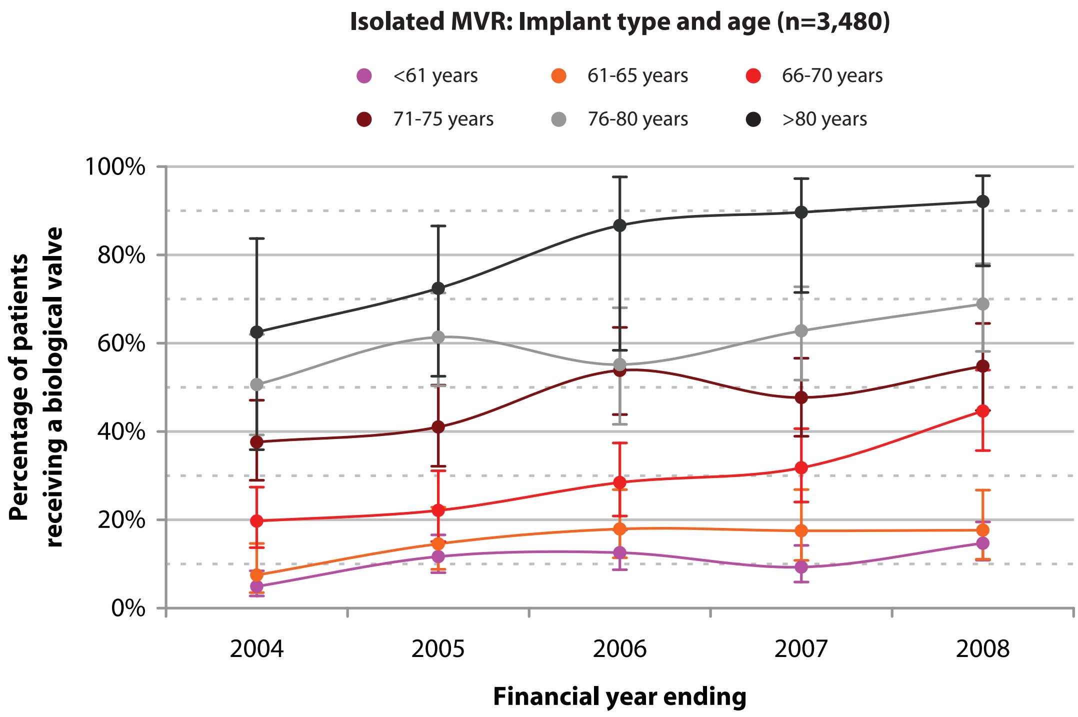
Changes in type of prosthesis with time

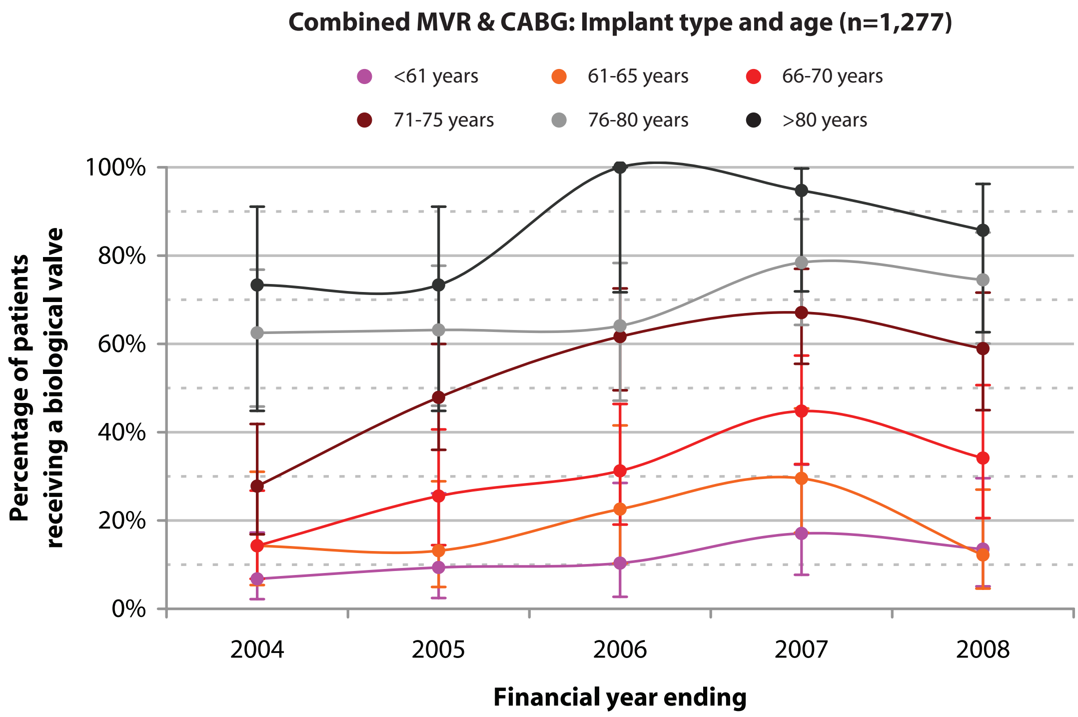
As with aortic prostheses, there has been an increase in the use of biological valves over time.



Prosthesis type and age

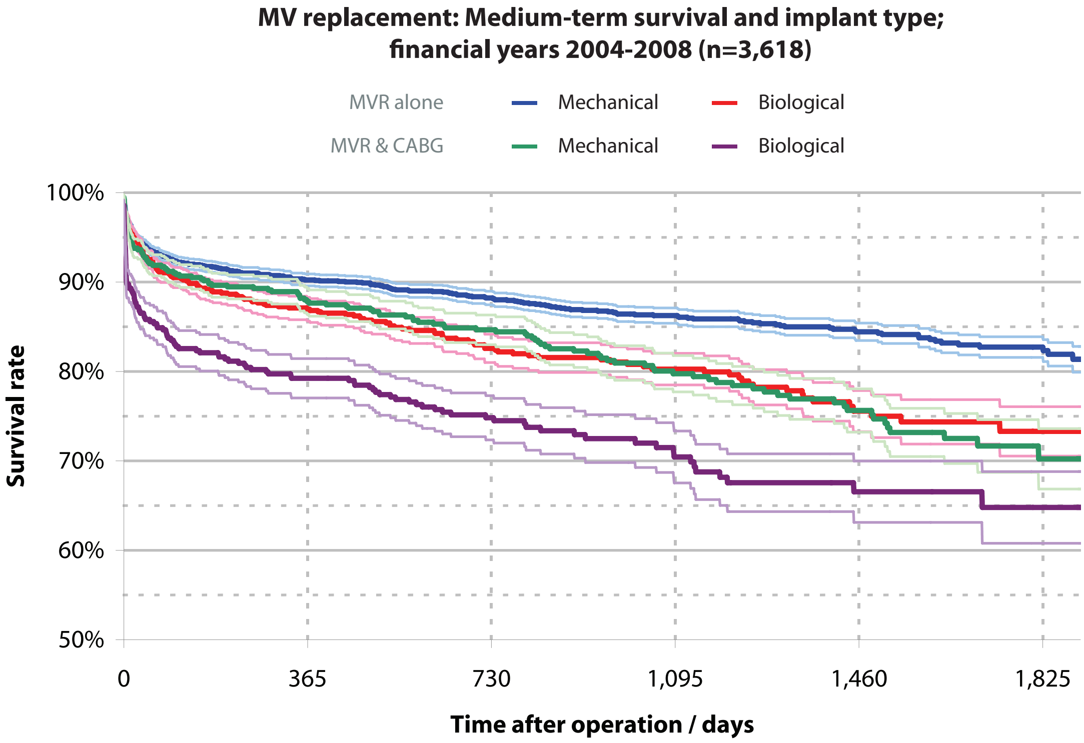
The proportion of patients receiving biological valves has increased in all age groups.





Prosthesis type and medium-term survival

Patients with the best medium-term survival are those receiving mechanical valves during an isolated mitral valve replacement procedure. This almost certainly reflects the younger average age in this group of patients.



Other immediate post-operative outcomes

Post-operative stay

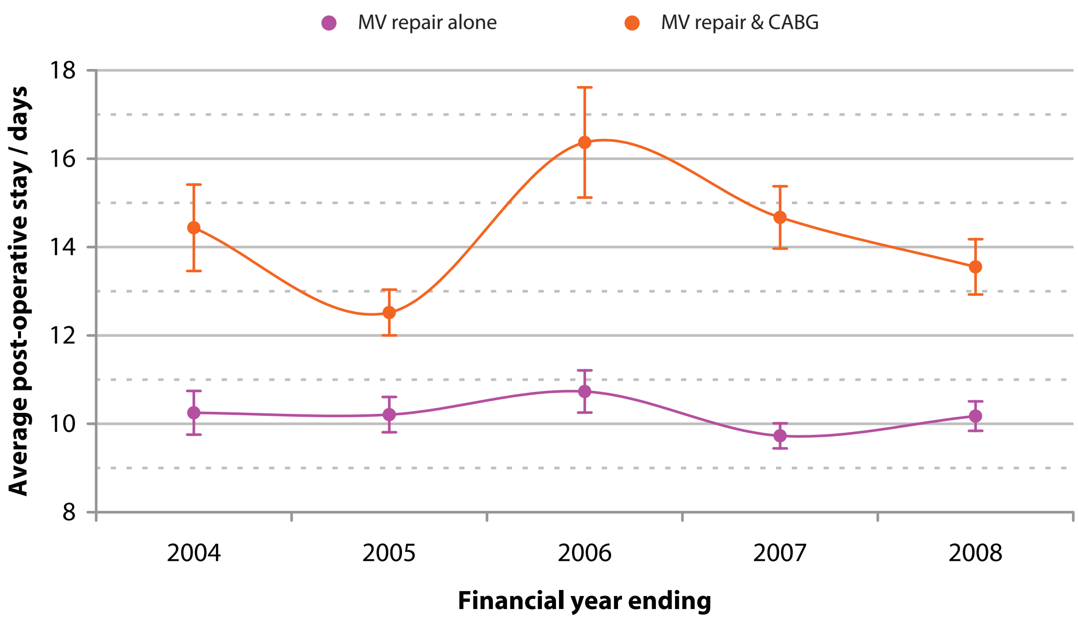
Mitral valve repair

The average post-operative stays following isolated mitral valve repair and combined mitral valve repair & CABG are very similar to those seen after aortic valve replacement.

Post-operative stay; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

Financial year		Procedure		
		Isolated MV repair	Combined MV repair & CABG	**All MV repairs**
	2004	10.2 482	14.4 298	**11.8** **780**
	2005	10.2 511	12.5 380	**11.2** **891**
	2006	10.7 578	16.4 354	**12.9** **932**
	2007	9.7 776	14.7 468	**11.6** **1,244**
	2008	10.2 849	13.6 444	**11.3** **1,293**
	All	**10.2** **3,196**	**14.3** **1,944**	**11.7** **5,140**

MV repair: Post-operative stay;
bars denote standard error (n=5,140)



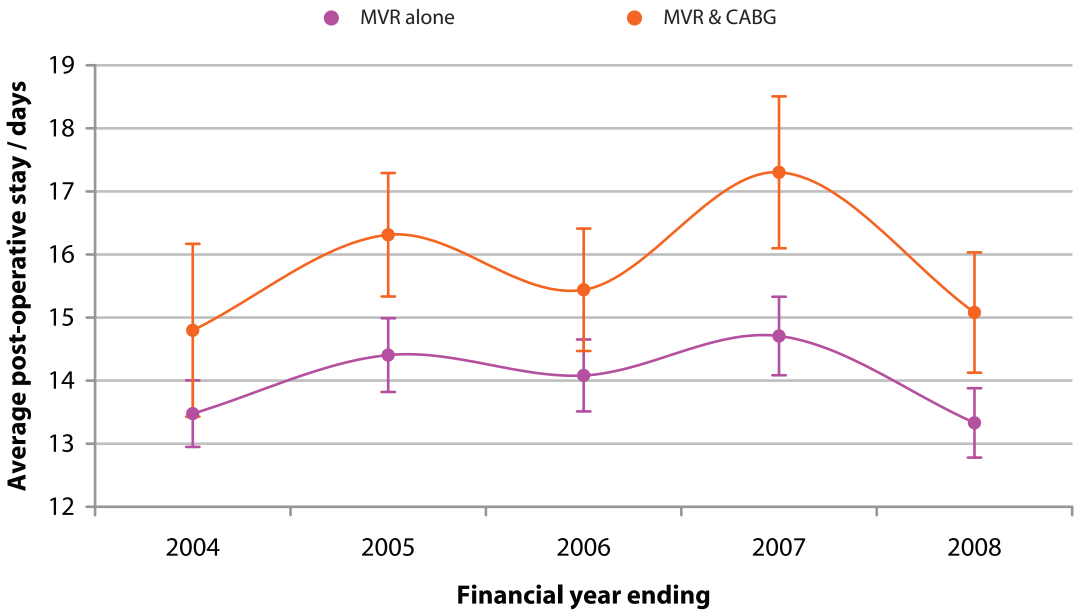
Mitral valve replacement

Length-of-stay is consistently and significantly greater for patients undergoing combined mitral valve replacement & CABG rather than isolated mitral valve replacement surgery.

Post-operative stay; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MVR	Combined MVR & CABG	**All MVR**
Financial year	2004	13.5 716	14.8 257	**13.8** **973**
	2005	14.4 687	16.3 237	**14.9** **924**
	2006	14.1 586	15.4 209	**14.4** **795**
	2007	14.7 657	17.3 294	**15.5** **951**
	2008	13.3 754	15.1 263	**13.8** **1,017**
	All	**14.0** **3,400**	**15.8** **1,260**	**14.5** **4,660**

MV replacement: Post-operative stay; bars denote standard error (n=4,660)



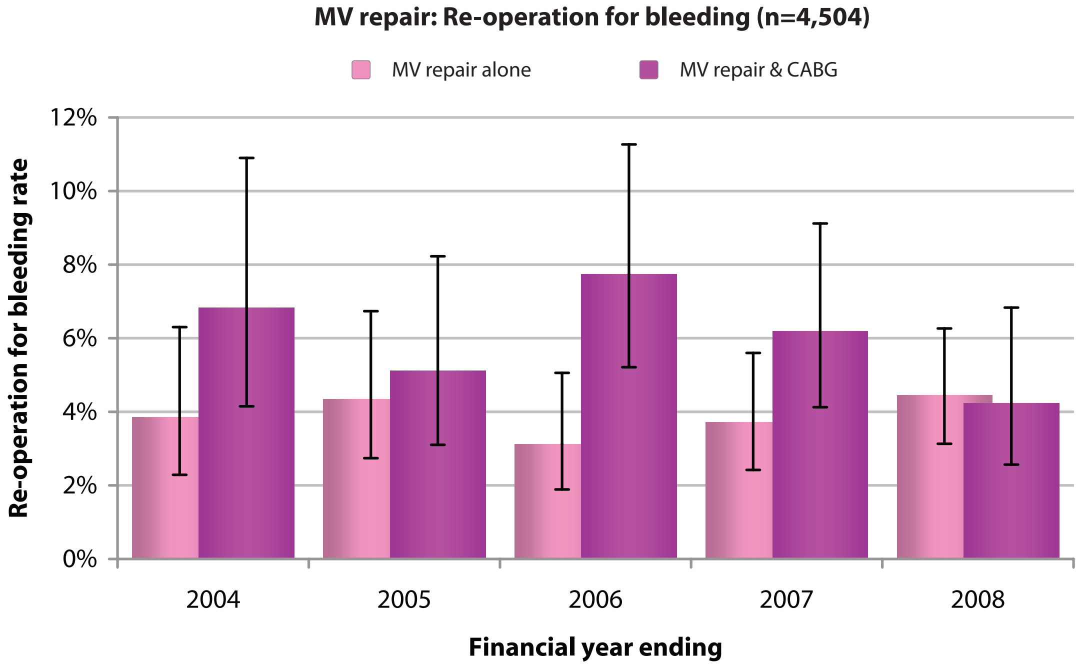
Re-operation for bleeding

Mitral valve repair

The re-operation rates for bleeding are lower than those reported after aortic valve surgery (the rates for 2004 to 2008 are 5.5% and 7.0% for isolated AVR and combined AVR & CABG respectively).

Re-operation for bleeding; the upper numbers represent the crude percentage re-operation rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MV repair	Isolated MV repair & CABG	**All MV repairs**
Financial year	2004	3.8% 416	6.8% 249	**5.0%** **665**
	2005	4.3% 461	5.1% 332	**4.7%** **793**
	2006	3.1% 544	7.7% 336	**4.9%** **880**
	2007	3.7% 620	6.2% 404	**4.7%** **1,024**
	2008	4.5% 741	4.2% 401	**4.4%** **1,142**
	All	**3.9%** **2,782**	**5.9%** **1,722**	**4.7%** **4,504**

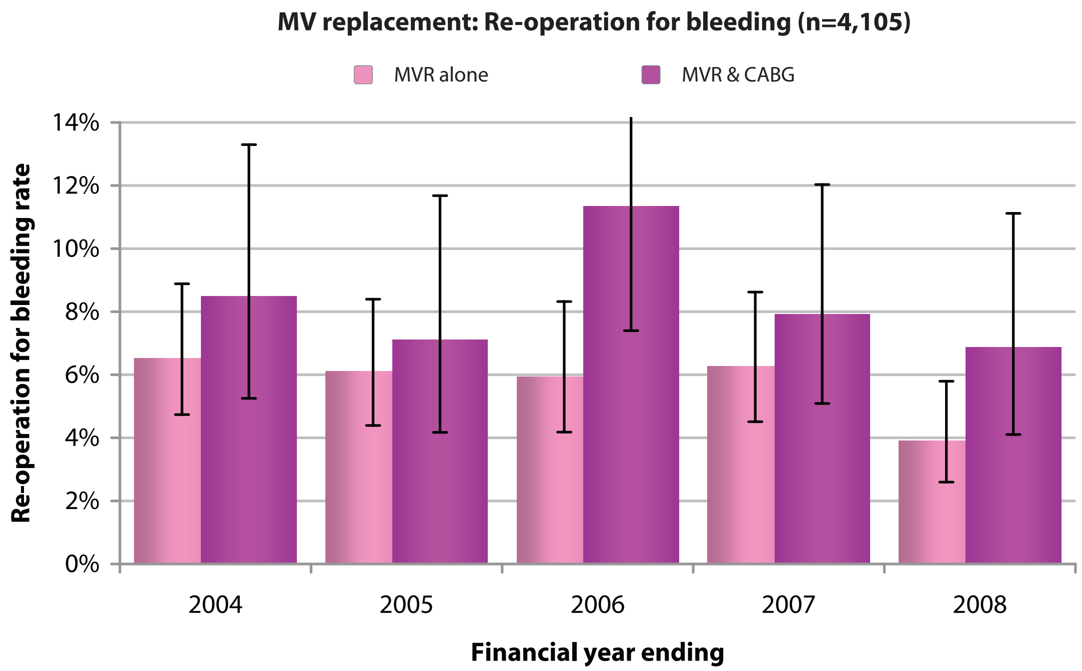


Mitral valve replacement

Re-exploration rates for bleeding are higher after mitral valve replacement surgery than after mitral valve repair.

Re-operation for bleeding; the upper numbers represent the crude percentage re-operation rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MVR	Combined MVR & CABG	**All MVR**
Financial year	2004	6.5% 598	8.5% 212	**7.0%** **810**
	2005	6.1% 606	7.1% 211	**6.4%** **817**
	2006	5.9% 556	11.3% 194	**7.3%** **750**
	2007	6.3% 590	7.9% 265	**6.8%** **855**
	2008	3.9% 640	6.9% 233	**4.7%** **873**
	All	**5.7%** **2,990**	**8.3%** **1,115**	**6.4%** **4,105**



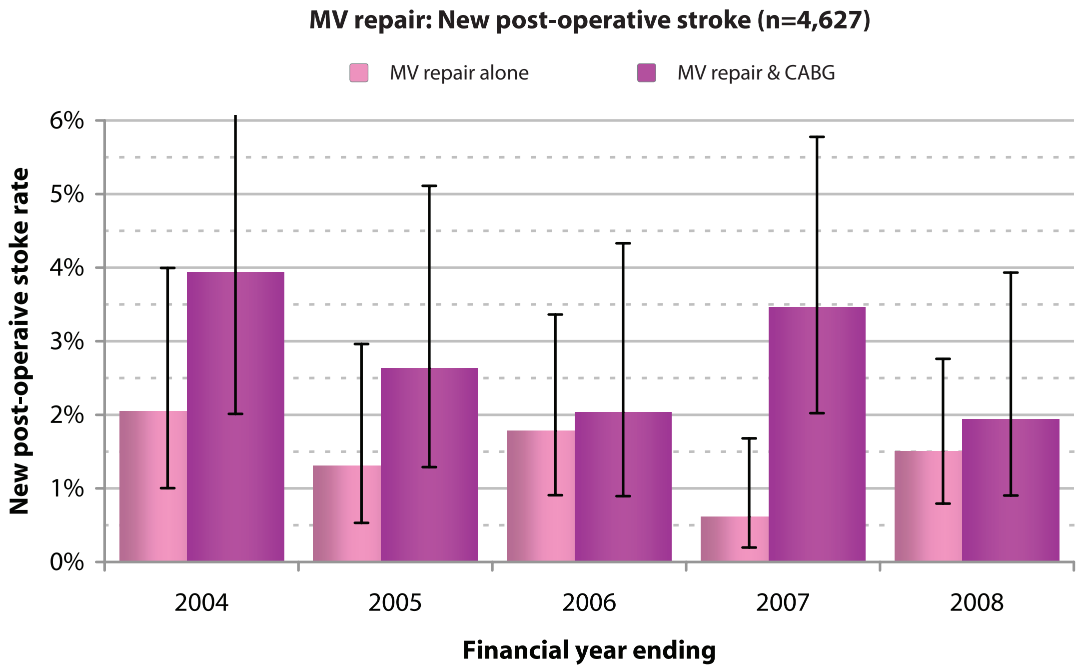
New post-operative stroke

Mitral valve repair

The post-operative stroke rates following mitral repair are higher than those recorded following isolated CABG surgery, but similar to those seen after AVR. As with AVR, the stroke rates for combined valve & CABG surgery are higher than for isolated valve surgery.

New post-operative stroke; the upper numbers represent the crude percentage stroke rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MV repair	Combined MV repair & CABG	**All MV repair**
Financial year	2004	2.1% 439	3.9% 254	**2.7%** **693**
	2005	1.3% 460	2.6% 342	**1.9%** **802**
	2006	1.8% 561	2.0% 344	**1.9%** **905**
	2007	0.6% 650	3.5% 433	**1.8%** **1,083**
	2008	1.5% 731	1.9% 413	**1.7%** **1,144**
	All	**1.4%** **2,841**	**2.7%** **1,786**	**1.9%** **4,627**

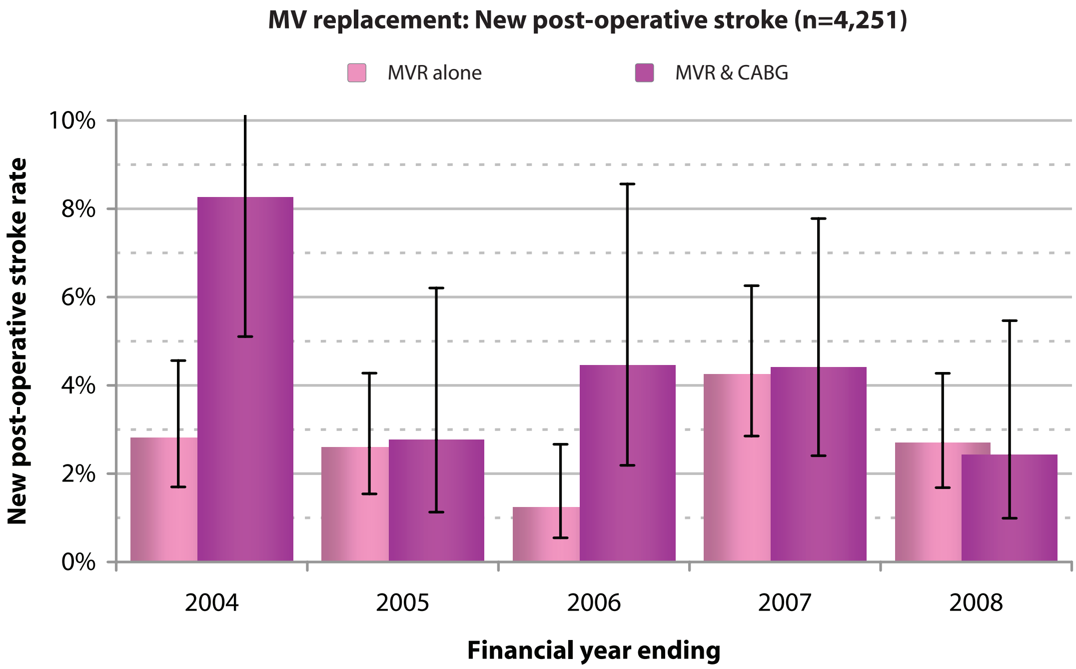


Mitral valve replacement

The new post-operative stroke rates following mitral valve replacement are higher than they are for repair (where rates of 1.4% and 2.7% were reported for isolated mitral valve repair and combined mitral valve repair & CABG respectively).

New post-operative stroke; the upper numbers represent the crude percentage stroke rate and the lower numbers the procedure count within the sub-group

Financial year	Procedure: Isolated MVR	Procedure: Combined MVR & CABG	Procedure: All MVR
2004	2.8% 604	8.3% 218	**4.3%** **822**
2005	2.6% 616	2.8% 217	**2.6%** **833**
2006	1.2% 562	4.5% 202	**2.1%** **764**
2007	4.3% 611	4.4% 272	**4.3%** **883**
2008	2.7% 702	2.4% 247	**2.6%** **949**
All	**2.7%** **3,095**	**4.4%** **1,156**	**3.2%** **4,251**



New post-operative HF / dialysis

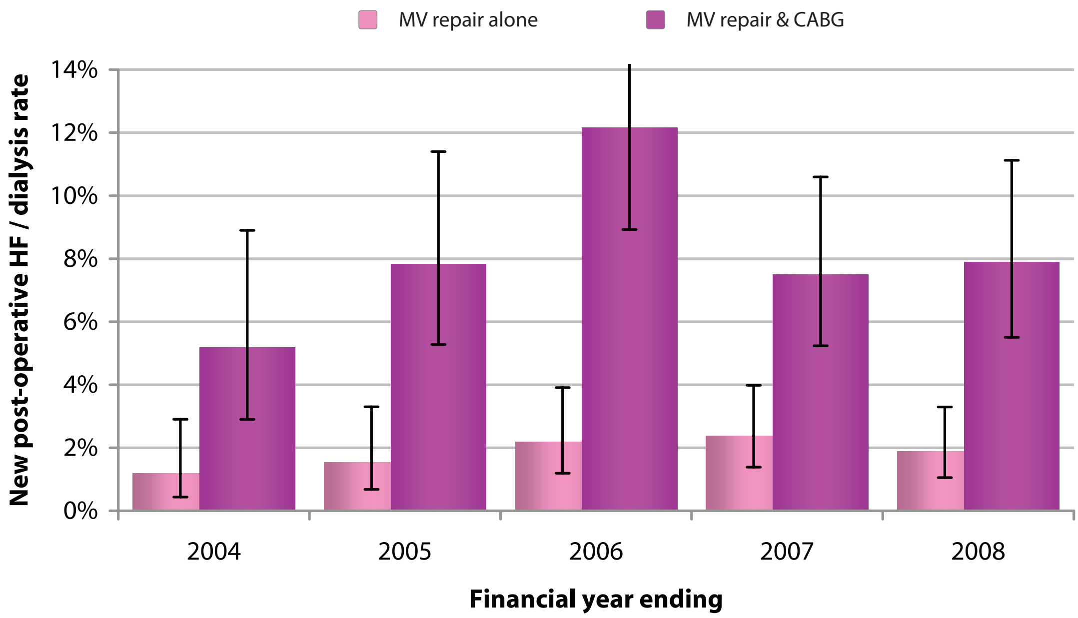
Mitral valve repair

The new renal intervention rates following isolated mitral valve repair are low, and lower than for isolated AVR surgery. However, the rates following combined mitral valve repair & CABG surgery are high at 8.2%; this probably reflects the patients' underlying pathology in this group, a sizeable proportion of whom will have mitral regurgitation due to underlying ischaemic myocardial damage, which will increase the risk of post-operative renal impairment.

New post-operative HF / dialysis; the upper numbers represent the crude percentage HF / dialysis rate and the lower numbers the procedure count within the sub-group

		Procedure		
		Isolated MV repair	Isolated MV repair & CABG	**All MV repairs**
Financial year	2004	1.2% 422	5.2% 251	**2.7% 673**
	2005	1.5% 453	7.8% 332	**4.2% 785**
	2006	2.2% 547	12.2% 329	**5.9% 876**
	2007	2.4% 631	7.5% 413	**4.4% 1,044**
	2008	1.9% 688	7.9% 393	**4.1% 1,081**
	All	**1.9% 2,741**	**8.2% 1,718**	**4.3% 4,459**

MV repair: New post-operative HF / dialysis (n=4,459)

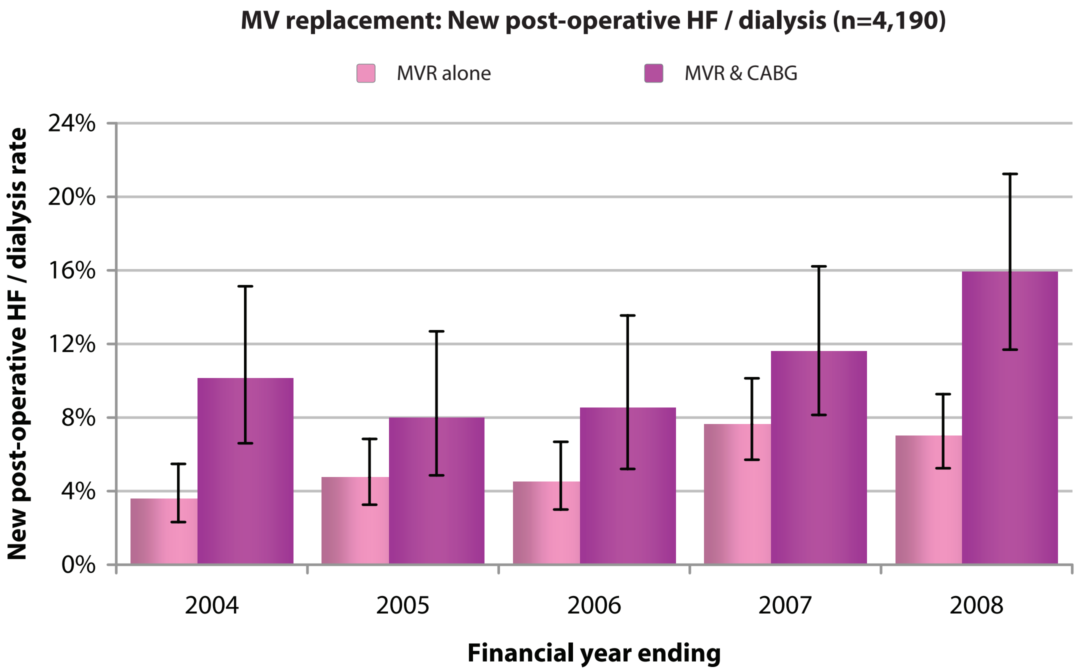


Mitral valve replacement

The new renal intervention rates are much higher following mitral valve replacement rather than mitral valve repair, with a very high rate of 11% being seen after combined mitral valve replacement & CABG.

New post-operative HF / dialysis; the upper numbers represent the crude percentage HF / dialysis rate and the lower numbers the procedure count within the sub-group

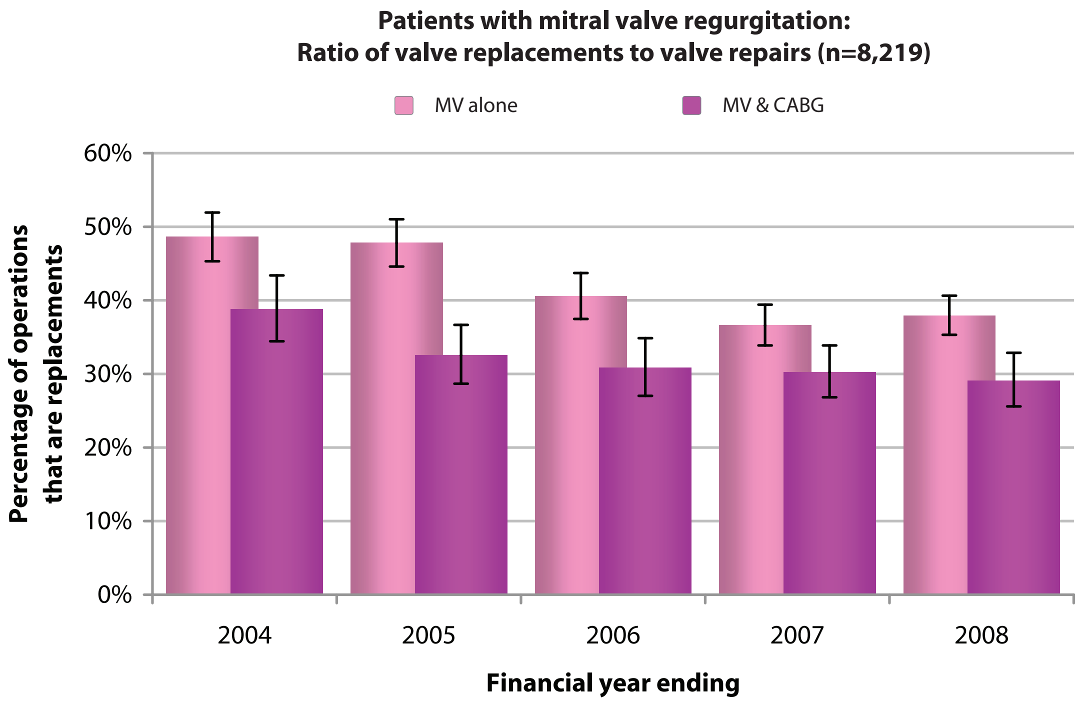
	Procedure		
Financial year	Isolated MVR	Combined MVR & CABG	**All MVR**
2004	3.6% 612	10.1% 217	**5.3%** **829**
2005	4.8% 610	8.0% 213	**5.6%** **823**
2006	4.5% 554	8.5% 199	**5.6%** **753**
2007	7.6% 602	11.6% 267	**8.9%** **869**
2008	7.0% 671	15.9% 245	**9.4%** **916**
All	**5.5%** **3,049**	**11.0%** **1,141**	**7.0%** **4,190**



Mitral regurgitation

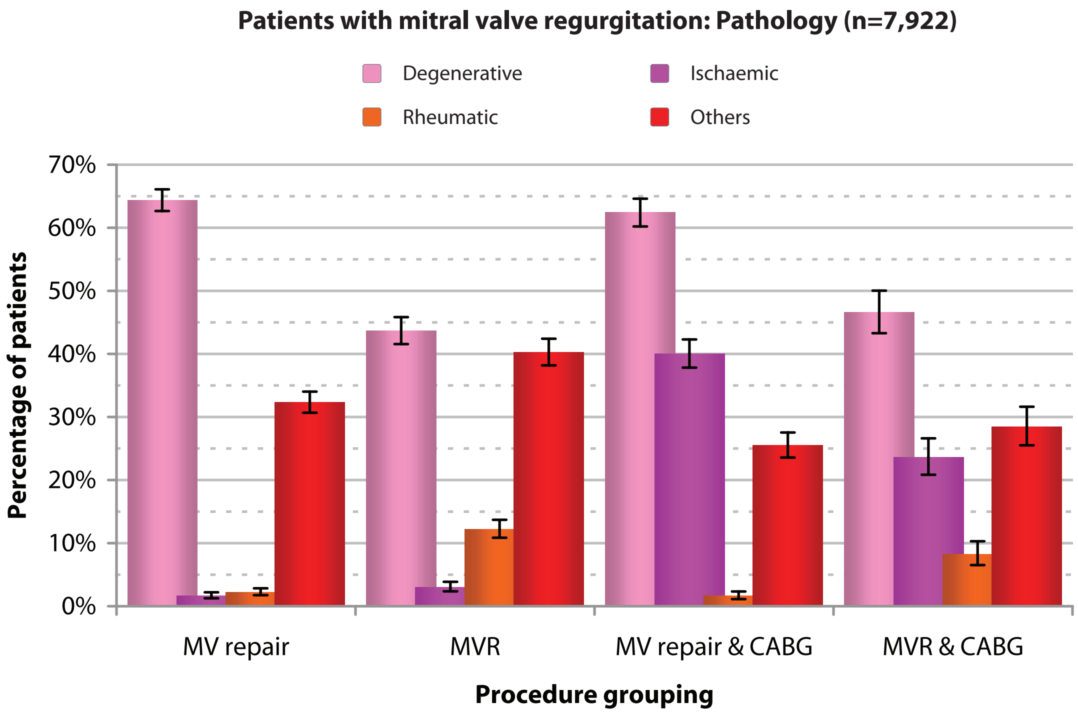
Mitral regurgitation is usually due to degenerative valve disease, ischaemia or rheumatic disease. The proportion of patients with mitral regurgitation with the different pathologies over time has remained constant.

The proportion of patients with mitral regurgitation who undergo mitral valve replacement (rather than repair) has decreased over time. This should be seen against the context of better short- and medium-term outcomes following mitral repair (χ^2 trend through time: $p<0.001$ for both isolated MV and combined MV & CABG).



Pathology for patients with mitral regurgitation; financial year 2004-2008

		Procedure			
		Isolated MV		Combined MV & CABG	
		Repair	Replacement	Repair	Replacement
Pathology	Degenerative	1,962	923	1,185	403
	Ischaemic	51	64	760	204
	Rheumatic	68	258	31	71
	Other	985	851	484	246
	Unspecified	67	113	61	56
	All	**3,114**	**2,226**	**1,959**	**920**



Other post-operative outcomes for patients with mitral regurgitation; financial year 2004-2008

		Procedure			
		Isolated MV		Combined MV & CABG	
		Repair	Replacement	Repair	Replacement
Analysis	Overall count	3,114	2,226	1,959	920
	Crude mortality rate	1.9% 3,105	6.4% 2,218	8.4% 1,948	11.7% 918
	Average post-operative stay / days	10.1 3,022	14.6 2,071	14.4 1,874	16.3 857
	Kaplan-Meier survival rate at 5 years post-surgery	88.9% 2,495	78.1% 1,754	75.2% 1,603	67.4% 738

Asymptomatic patients with good LV function undergoing MV repair

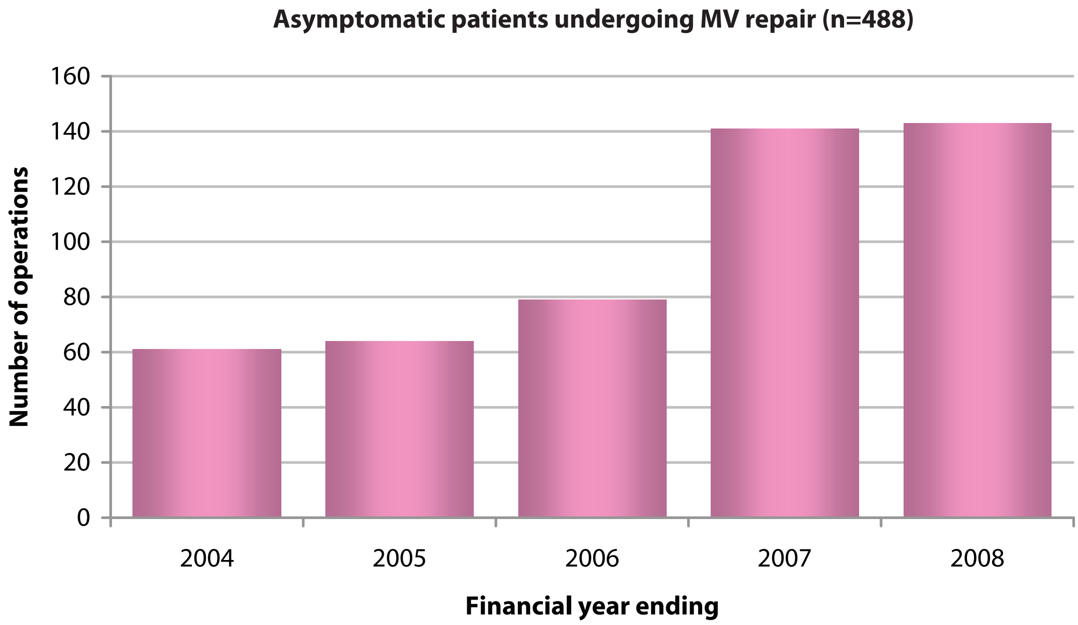
Distributions

Historically, MV repair surgery has been recommended either when patients develop symptoms or the heart starts to stretch up or beat less strongly. Recent data from the Mayo Clinic has suggested that patients with severe mitral regurgitation should undergo surgery purely on the basis of the severity of regurgitation, irrespective of symptoms or left ventricular size or function (Enriquez-Sarano *et al*. 2005). Recent guidelines from the American Heart Association / American College of Cardiology recommend that mitral valve repair should be considered in *experienced centres* if there is a high likelihood of repair (Bonow *et al*. 2006); this strategy has, however, been disputed (Rosenhek *et al*. 2006). To look at surgical practice for these patients in Great Britain & Ireland in more detail we have undertaken an analysis of patients coming to mitral repair surgery with no symptoms (NYHA class I) and good left ventricular function. We do not have metrics of left ventricular size in our database and it may be that some of these patients had an indication for surgery purely on the basis of left ventricular dialatation.

The database categorises patient's left ventricular function according to ejection fraction, with >50% being regarded as *good*; because of the haemodynamic effects of severe mitral regurgitation it is possible to have an ejection fraction of greater than 50%, but still have impaired left ventricular function, which may be a clear indication for surgery. In line with the changing recommendations over time the number of patients in this group undergoing surgery has increased, and the risk profile of these patients was low.

Risk factor distributions for asymptomatic patients with good LV function undergoing mitral valve repair; financial years 2004-2008

		Risk factor presence			
		No	Yes	Unspecified	Rate
Risk factor	Age >70 years (average = 57.4 years)	400	88	0	18.0%
	Female	379	109	0	22.3%
	BMI >25	250	226	12	47.5%
	LMS disease	339	0	149	0.0%
	Diabetes	475	13	0	2.7%
	Hypertension	330	157	1	32.2%
	Extra-cardiac arteriopathy	482	4	2	0.8%
	Renal disease	478	3	7	0.6%
	Angina CCS3-4	392	2	94	0.5%



Outcomes

The overall mortality rate for these patients was low at 0.2%, and in line with what would be expected for what is essentially a *prophylactic* operation; the reported stroke rate of 1.1% is obviously of concern for this group of patients. The medium-term survival rate at 5 years post-surgery for patients of this age (93%) is in line with that of an age-matched healthy population.

Outcomes for asymptomatic patients with good LV function undergoing mitral valve repair; financial years 2004-2008

		Data		
		Count	Rate	95% CI
Outcome	Crude mortality rate	488	0.2%	0.0-1.3%
	Re-operation for bleeding	394	4.1%	24-6.6%
	New post -operative stroke	375	1.1%	0.3-2.9%
	New post-operative HF / dialysis	363	0.3%	0.0-1.8%
		Count	Average	SE
	Post-operative stay / days	472	8.5	0.25
		Count	Rate	SE
	Kaplan-Meier survival rate at 5 years	368	92.7%	89.6-95.7%

i Enriquez-Sarano M, Avierinos JF, Messika-Zeitoun D *et al.* Quantitative determinants of the outcome of asymptomatic mitral regurgitation. *N Eng J Med.* 2005; **352:** 875-883.

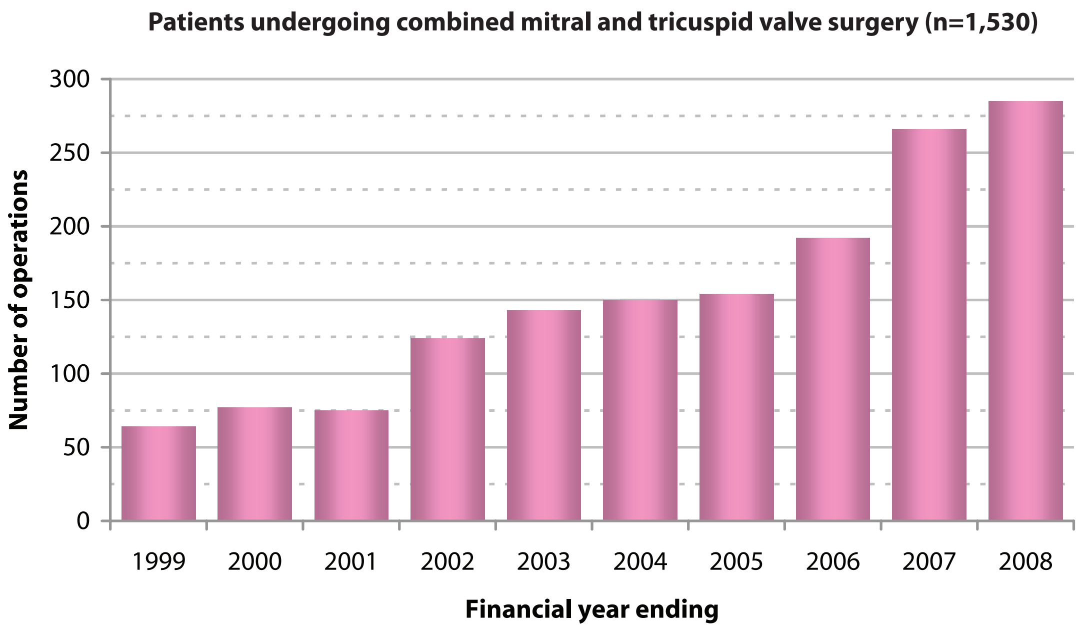
ii Rosenhek R, Rader F, Klaar U, Gabriel H, Krejc M, Kalbeck D, Schemper M, Maurer G, Baumgartner H. Outcome of watchful waiting in asymptomatic severe mitral regurgitation. *Circulation.* 2006; **113(18):** 2238-44.

iii Bonow RO, Carabello BA, Chatterjee K, de Leon AC Jr, Faxon DP, Freed MD, Gaasch WH, Lytle BW, Nishimura RA, O'Gara PT, Otto CM, Shah PM, Shanewise JS. ACC / AHA. 2006; Guidelines for the management of patients with valvular heart disease. American College of Cardiology Website. www.acc.org/clinical/guidelines/valvular/index.pdf.

Combined mitral and tricuspid valve surgery

Risk factor distributions

There has been an increase in the number of patients undergoing combined mitral & tricuspid surgery over time, which reflects new evidence that there may be benefits to intervening on the tricuspid valve at the time of mitral surgery in some circumstances. Despite the increase over time, the proportion of all patients with mitral disease who undergo concomitant tricuspid surgery remains low.



i Dreyfus GD, Corbi PJ and Chan J and Bahrami T. Secondary Tricuspid Regurgitation or Dilatation: Which Should Be the Criteria for Surgical Repair? *Annals of thoracic surgery.* 2005; **79(1):** 127-132.

ii Bonow RO, Carabello BA, Chatterjee K, de Leon AC Jr, Faxon DP,Freed MD, Gaasch WH, Lytle BW, Nishimura RA, O'Gara PT, Otto CM, Shah PM, Shanewise JS. ACC/AHA. 2006 Guidelines for the management of patients with valvular heart disease. American College of Cardiology Website. www.acc.org/clinical/guidelines/valvular/index.pdf.

Risk factor distributions

Patients undergoing combined mitral & tricuspid surgery are high risk, with 25% undergoing concomitant CABG, 29% having non-elective surgery and 42% having impairment of left ventricular ejection fraction. They also have a high incidence of renal disease (6.9%) and severe dyspnoea (67.9%).

Risk factor distributions for patients undergoing combined mitral and tricuspid valve surgery; financial years 2004-2008

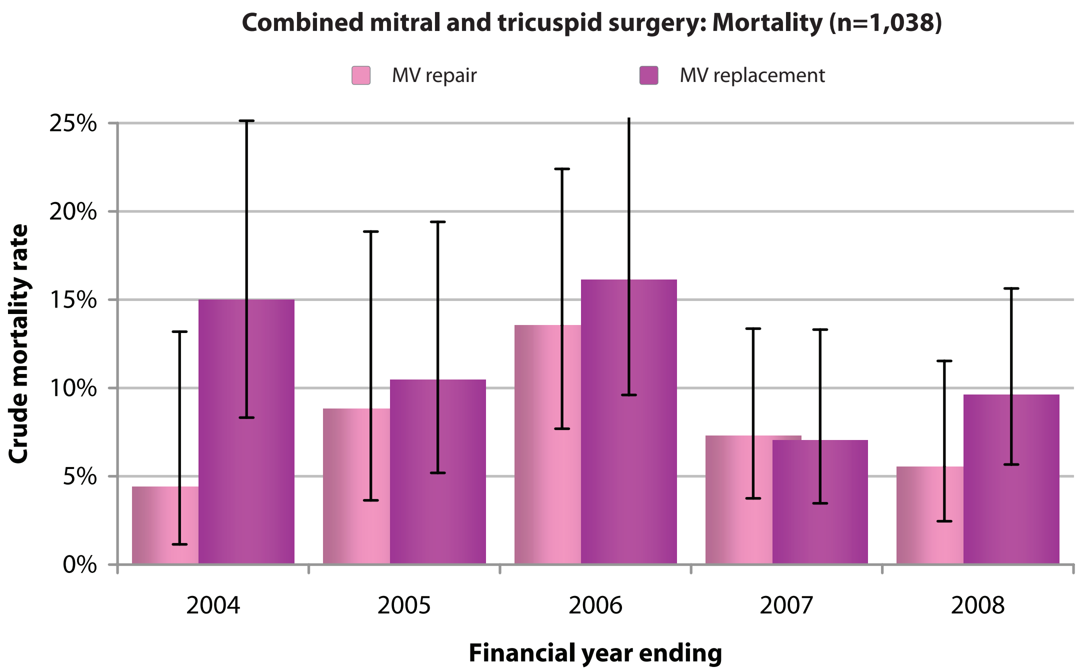
		Risk factor presence			
		No	Yes	Unspecified	Rate
Risk factor	Age >70 years	547	495	5	47.5%
	Female	477	570	0	54.4%
	BMI >25	527	479	41	47.6%
	Mitral regurgitation	271	762	14	73.8%
	Triscupid regurgitation	23	967	57	97.7%
	Concomitant CABG	784	263	0	25.1%
	Non-elective	747	300	0	28.7%
	Fair or poor ejection fraction	587	423	37	41.9%
	Previous cardiac surgery	813	206	28	20.2%
	Diabetes	885	134	28	13.2%
	Hypertension	572	450	25	44.0%
	Extra-cardiac arteriopathy	962	61	24	6.0%
	Renal disease	943	63	41	6.3%
	Dyspnoea NYHA 3-4	327	691	29	67.9%
	Angina CCS2-3	781	205	61	20.8%

Mortality

The mortality rate for patients undergoing combined mitral & tricuspid surgery is higher than for those undergoing mitral surgery alone. This reflects the fact that patients who develop right-heart difficulties subsequent to mitral valve disease usually have disease that is further progressed than patients with isolated left-heart problems.

Mortality for patients undergoing combined mitral and tricuspid valve surgery; the upper numbers represent the crude mortality rate and the lower numbers the procedure count within the sub-group

		MV procedure with tricuspid valve surgery		
		MV repair	MV replacement	**All MV**
Financial year	2004	4.4% 68	15.0% 80	**10.1%** **148**
	2005	8.8% 68	10.5% 86	**9.7%** **154**
	2006	13.5% 96	16.1% 93	**14.8%** **189**
	2007	7.3% 137	7.0% 128	**7.2%** **265**
	2008	5.6% 126	9.6% 156	**7.8%** **282**
	All	**7.9%** **495**	**11.0%** **543**	**9.5%** **1,038**



Other outcomes

All of the in–hospital outcomes of combined mitral & tricuspid surgery are worse than for isolated mitral surgery. Of particular note are the high re-operation rate (11.4%) and new HF / dialysis rate (13.6%) for patients undergoing mitral valve replacement and concomitant tricuspid surgery.

Other post-operative outcomes for patients undergoing combined mitral and tricuspid valve surgery; financial years 2004-2008

		MV procedure with tricuspid valve surgery		
		MV repair	MV replacement	**All MV**
Outcome	Re-operation for bleeding	7.4% 461	11.4% 465	**7.4%** **926**
	New post-operative stroke	3.0% 461	3.4% 471	**3.2%** **932**
	New post-operative HF / dialysis	7.4% 448	13.6% 456	**10.5%** **904**
	Average post-operative stay / days	16.1 494	18.2 525	**17.1** **1,023**

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1. Adams DH, Anyanwu A. Pitfalls and limitations in measuring and interpreting the outcomes of mitral valve repair. *J Thorac Cardiovasc Surg.* 2006; **131(3):** 523-9.
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3. Bonow RO, Carabello BA, Kanu C, de LA, Jr., Faxon DP, Freed MD, *et al*. ACC / AHA 2006 guidelines for the management of patients with valvular heart disease: a report of the American College of Cardiology / American Heart Association Task Force on Practice Guidelines (writing committee to revise the 1998 Guidelines for the Management of Patients With Valvular Heart Disease): developed in collaboration with the Society of Cardiovascular Anesthesiologists: endorsed by the Society for Cardiovascular Angiography and Interventions and the Society of Thoracic Surgeons. *Circulation.* 2006; **1;114(5):** e84-231.
4. Bridgewater B, Hooper T, Munsch C, Hunter S, von OU, Livesey S, *et al*. Mitral repair best practice: proposed standards. *Heart.* 2006; **92(7):** 939-44.
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Surgery on the aorta

Surgery on the aorta

Principles of major aortic surgery

The aorta is the major blood vessel leaving the heart and it carries blood to the rest of the body. It has a valve at its junction with the heart (the aortic valve) and its first branches, the coronary arteries, supply blood to the heart; these come off just above the aortic valve. This first section, the ascending aorta, runs from the heart, upwards towards the head for several inches and then bends backwards into the *arch* of the aorta, which in turn gives off branches to the head and neck. It then turns downwards towards the abdomen to become the descending thoracic aorta, and in this stage it gives off branches to the chest wall and spine. At the diaphragm the aorta passes through a small opening to become the abdominal aorta.

Cardiac surgeons in the United Kingdom in general become involved with the ascending, arch and descending thoracic aorta. The abdominal aorta is usually the *domain* of the vascular surgeon, and in various circumstances disorders of the descending thoracic aorta may be treated by vascular surgeons or interventional radiologists.

The commonest pathology that affects the aorta is an aneurysm, which is defined as a permanent localised dilatation of the artery. High blood pressure, smoking, high cholesterol, increasing age and a number of genetic factors can increase the risk of developing an aneurysm. An aortic aneurysm can potentially affect any part and, depending on where it is located, different operations might be needed; aneurysms affecting the aorta from the aortic valve upwards will require a different operation (a composite root replacement) than those that affect the aorta above the origin of the coronary arteries (that will often require an inter-position tube graft, with or without an aortic valve replacement depending on the function of the aortic valve). These three operations (composite aortic root replacement, interposition graft and valve replacement plus interposition graft) make up the majority of major aortic surgery.

Aortic aneurysms may be stable and be an incidental finding on other medical investigations, such as chest X-rays or CT scans. Patients will then be able to undergo surgery as routine cases, and they will usually have a lower mortality. Others will have symptoms from large, rapidly expanding or leaking aneurysms, and may require surgery as urgent or emergency cases, which are associated with a much higher mortality.

The other common pathology affecting the aorta is aortic dissection. This is a devastating disorder when blood tracks out of the usual lumen of the aorta and splits the layers of the aortic wall apart. This is often associated with severe pain and it may be instantly fatal. Aortic dissection in the ascending aorta has a high mortality if left untreated and, once a diagnosis is made, undertaking surgery without delay is the best way of preventing further problems, including mortality. As the layers of the aortic wall split, it may affect the patency of any of the branches of the aorta (including the coronary arteries) or the function of the aortic valve. It may even lead to rupture of the overall integrity of the blood vessel. The commonest site for the dissection to occur is in the ascending aorta, just above the origin of the coronary arteries. Depending on the original site and extent of an aortic dissection, different treatments may be necessary; dissections affecting the ascending aorta and arch usually require surgery and those in the descending aorta do not. Similarly the amount of damage the dissection causes in the ascending aorta will determine the exact operation required. When the aortic valve is damaged beyond repair, a composite root replacement or interposition graft and AVR may be necessary. If the dissection is limited to the ascending aorta above the coronary arteries, an interposition graft may be the best operation.

Introduction

Of all the sections in this book, the most complex to analyse and describe are these data about surgery on the aorta. Previous editions of the blue book have simply included operations on the aorta in different categories, with the relevant in-hospital mortality, from the paper-based returns to the old Cardiac Surgical Register. Analysing the aortic operations from the database is complex for the following reasons:

- The database categorises operations into groups which include *CABG alone; CABG and valve; CABG, valve and other; CABG and other; valve alone; valve and other;* and *other.*
- Major aortic surgery is classified as an *other* operation, but may be included within *CABG, valve and other; CABG & other; valve and other;* or *other* alone.
- The aorta may undergo surgery at a number of different sites, which are classified as the aortic root, ascending aorta, aortic arch, descending aorta and abdominal aorta.
- The aortic procedure is classified as one from the following:
    - interposition tube graft
    - tube graft + separate AVR
    - root replacement with composite graft & coronary re-implantation
    - root replacement with preservation of native valve and coronary re-implantation
    - homograft root replacement
    - autograft root replacement
    - aortic patch graft, sinus of valsalva repair
    - reduction aortoplasty
- The database also allows for the collection of data on aortic pathology, for which the options are:
    - aneurysms
    - syphilis
    - dissection
    - transection
    - coarctation
    - atheromatous
    - Marfan's
    - mycotic
    - other connective tissue disorder
    - infection – native
    - infection – graft
    - unknown

Combining all the above factors leads to the potential for subdividing the aortic operations into a huge number of groups, all with small numbers, which would limit the ability to draw any conclusions from the data.

For the purposes of the following sections we have initially analysed the aortic operations by the aortic procedure, and shown how they fit into the various operative groups. We have then shown the in-hospital mortality for those procedures, sub-divided into the groups. We have looked at the in-hospital mortality outcome of the procedures, subdivided by operative priority. We have looked at the pathology associated with the different aortic procedures and finally we have looked at surgery and outcomes for aortic dissection.

Distributions

There have been 5,245 major aortic procedure records submitted to the database since 2004. The largest operative groups are: interposition tube grafts, which comprise 38% of the total, and aortic root replacement with composite valve graft with coronary re-implantation, which makes up 23% of all aortic surgery. The next largest group, making up 10% of the total, is AVR with additional interposition tube graft. All other groups are small.

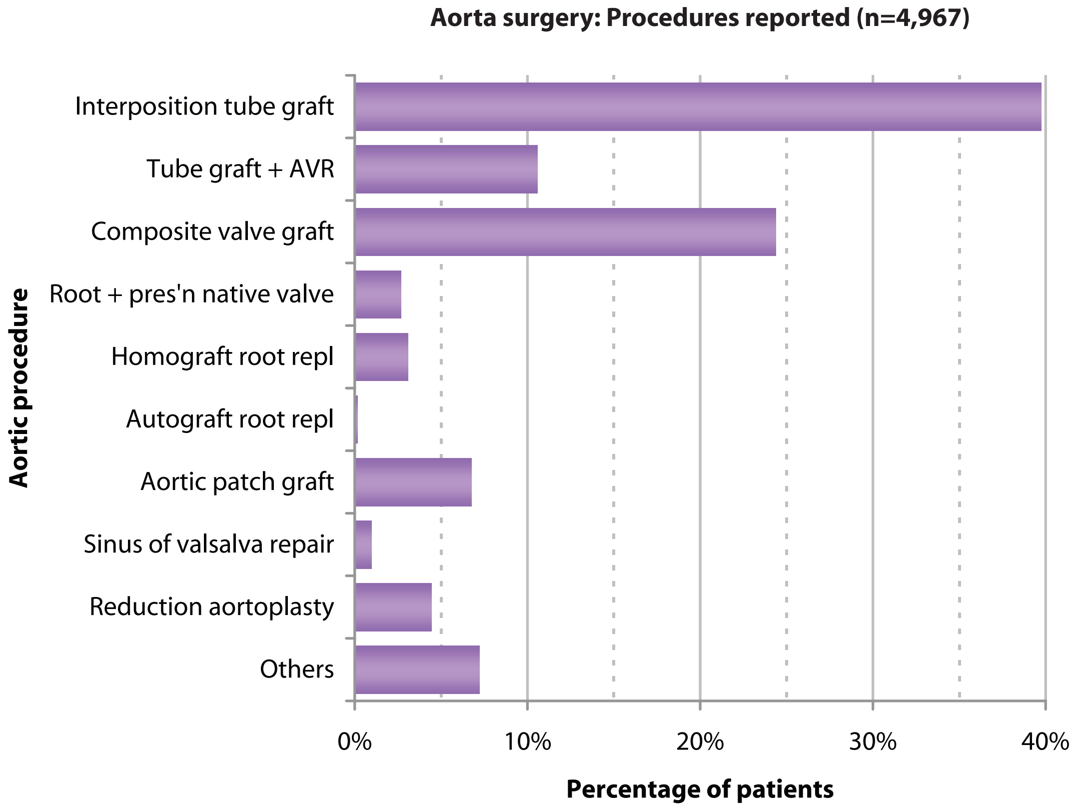
Of the interposition tube graft procedures, the majority are isolated procedures, but a significant number have been categorised as *valve & other,* and it is likely that the procedures were AVR plus interposition grafts and should have been categorised along with the second category. The largest proportion of patients undergoing composite root replacement are categorised as valve & other, with smaller numbers recorded as CABG & other, or simply *other* (which must by definition be incorrect).

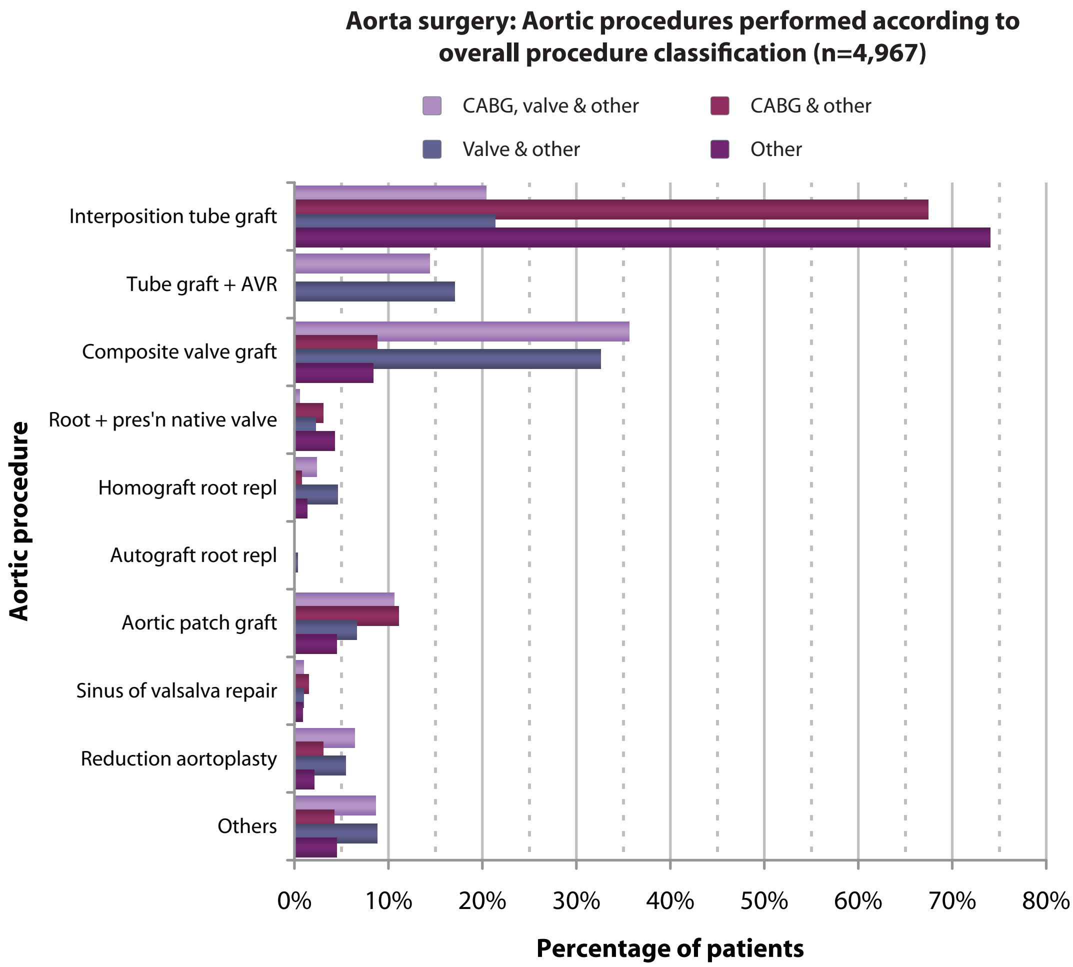
Procedures involving the aorta; financial years 2004-2008

		Main procedure group [i]				
		CABG & Other	CABG, valve & other	Valve & other	Other	**All**
Aortic procedure	Interposition tube graft	146	176	527	1,125	**1,974**
	Tube graft + AVR	103	0	421	1	**525**
	Composite valve graft	256	23	805	127	**1,211**
	Root repl. + pres'n native valve [ii]	4	8	56	65	**133**
	Homograft root replacement	17	2	113	21	**153**
	Autograft root replacement	0	0	8	0	**8**
	Aortic patch graft	76	29	163	68	**336**
	Sinus of valsalva repair	7	4	24	13	**48**
	Reduction aortoplasty	46	8	135	32	**221**
	Others	62	11	217	68	**358**
	Unspecified	36	17	121	104	**278**
	All	**753**	**278**	**2,590**	**1,624**	**5,245**

i The main procedure group is that to which all operations are classified within the database and includes *CABG alone; CABG & valve; CABG, valve & other; CABG & other; Valve alone; Valve & other,* and *Other*.

ii Root replacement with preservation of native valve and coronary re-implantation.


Aorta surgery: Procedures reported (n=4,967)
Aortic procedure
Interposition tube graft
Tube graft + AVR
Composite valve graft
Root + pres'n native valve
Homograft root repl
Autograft root repl
Aortic patch graft
Sinus of valsalva repair
Reduction aortoplasty
Others
0%
10%
20%
30%
40%
Percentage of patients


Aorta surgery: Aortic procedures performed according to overall procedure classification (n=4,967)
CABG, valve & other
CABG & other
Valve & other
Other
Aortic procedure
Interposition tube graft
Tube graft + AVR
Composite valve graft
Root + pres'n native valve
Homograft root repl
Autograft root repl
Aortic patch graft
Sinus of valsalva repair
Reduction aortoplasty
Others
0%
10%
20%
30%
40%
50%
60%
70%
80%
Percentage of patients

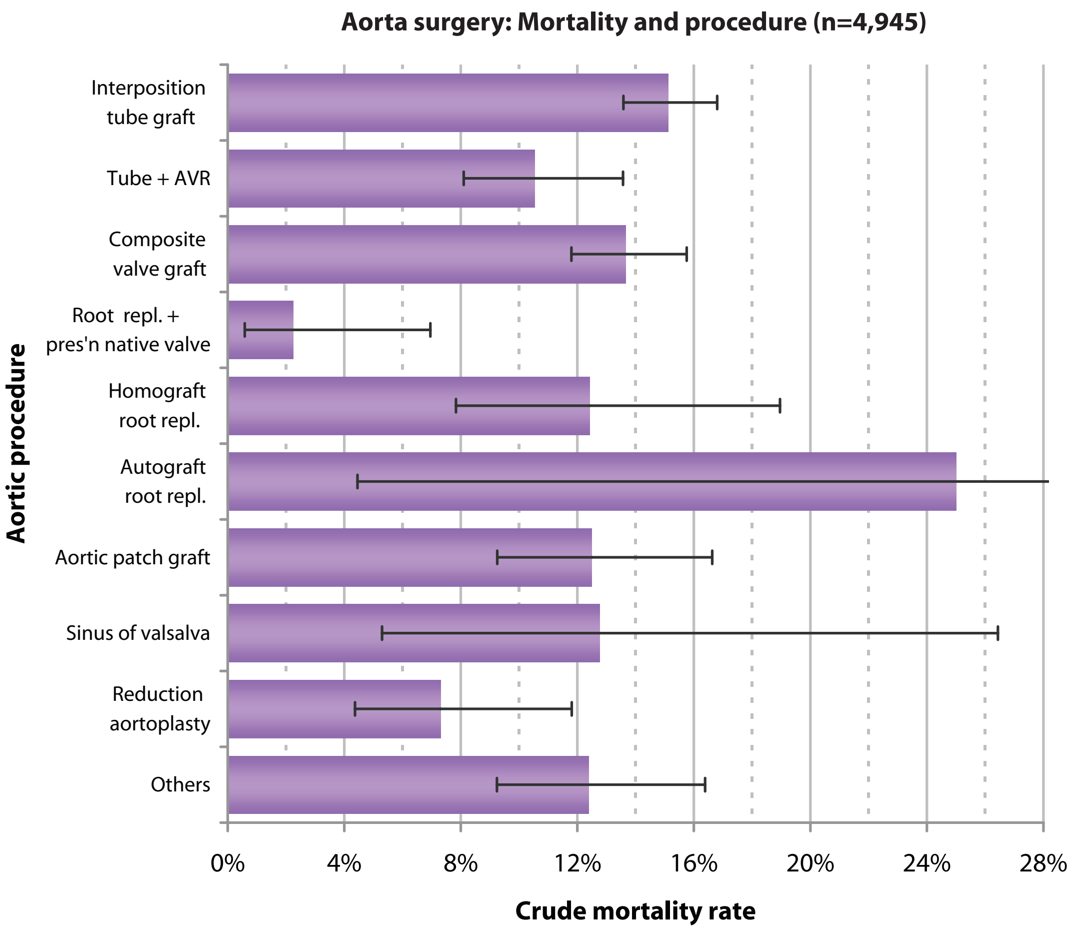
Mortality

Mortality and procedure

The overall mortality rate associated with the insertion of an interposition tube graft is 15.1%. The mortality rate varies significantly with the urgency of the operation (see page 328). Composite root replacement has an overall mortality rate of 13.7% and the risk is again highly dependent on urgency. AVR and tube graft has an overall mortality rate of 10.5%, but the risk for elective patients is 6.8% and for emergencies is 34.8%.

Mortality and procedure; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Main procedure group				
		CABG & Other	CABG, valve & other	Valve & other	Other	**All**
Aortic procedure	Interposition tube graft	16.4% 146	24.3% 173	9.5% 526	16.2% 1,119	**15.1%** **1,964**
	Tube graft + AVR	22.3% 103	NA 0	7.7% 418	0.0% 1	**10.5%** **522**
	Composite valve graft	26.7% 255	17.4% 23	9.6% 803	12.6% 127	**13.7%** **1,208**
	Root repl. + pres'n native valve	0.0% 4	12.5% 8	0.0% 56	3.1% 65	**2.3%** **133**
	Homograft root replacement	23.5% 17	0.0% 2	10.6% 113	14.3% 21	**12.4%** **153**
	Autograft root replacement	NA 0	NA 0	25.0% 8	NA 0	**25.0%** **8**
	Aortic patch graft	13.2% 76	10.3% 29	9.8% 163	19.1% 68	**12.5%** **336**
	Sinus of valsalva repair	33.3% 6	25.0% 4	8.3% 24	7.7% 13	**12.8%** **47**
	Reduction aortoplasty	4.4% 45	12.5% 8	5.2% 134	18.8% 32	**7.3%** **219**
	Others	18.0% 61	27.3% 11	9.8% 215	13.2% 68	**12.4%** **335**
	Unspecified	8.3% 36	5.9% 17	5.0% 121	14.6% 103	**9.0%** **277**
	All	**19.6%** **749**	**20.4%** **275**	**8.7%** **2,581**	**15.2%** **1,617**	**12.9%** **5,222**

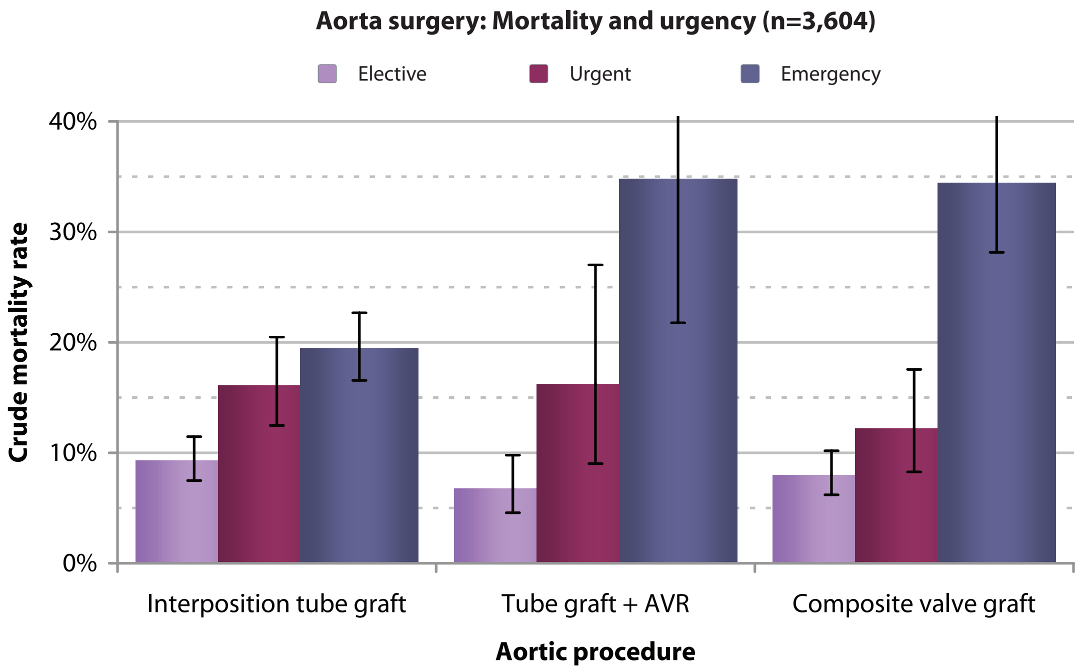

Aorta surgery: Mortality and procedure (n=4,945)
Aortic procedure
Interposition tube graft
Tube + AVR
Composite valve graft
Root repl. + pres'n native valve
Homograft root repl.
Autograft root repl.
Aortic patch graft
Sinus of valsalva
Reduction aortoplasty
Others
0%
4%
8%
12%
16%
20%
24%
28%
Crude mortality rate

Mortality and urgency

Mortality is associated with urgency, with emergency and salvage procedures having the worst outcomes. There is little difference between the mortality rates for patients undergoing the 3 most common procedures as elective surgery (interposition grafts, tube grafts and AVR and composite valve grafts), but there is a difference between patients having these different procedures as emergency operations.

Mortality, urgency and procedure; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Urgency				
		Elective	Urgent	Emergency	Salvage	**All**
Aortic procedure	Interposition tube graft	9.3% 872	16.1% 348	19.4% 674	42.0% 69	**15.1% 1,964**
	Tube graft + AVR	6.8% 400	16.2% 74	34.8% 46	0.0% 2	**10.5% 522**
	Composite valve graft	8.0% 765	12.2% 213	34.4% 212	29.4% 17	**13.7% 1,208**
	Root repl. + pres'n native valve	1.0% 102	10.5% 19	0.0% 11	0.0% 1	**2.3% 133**
	Homograft root replacement	3.4% 58	15.4% 65	23.3% 30	NA 0	**12.4% 153**
	Autograft root replacement	0.0% 4	0.0% 2	100.0% 2	NA 0	**25.0% 8**
	Aortic patch graft	6.4% 219	16.5% 79	38.9% 36	50.0% 2	**12.5% 336**
	Sinus of valsalva repair	4.2% 24	27.3% 11	16.7% 12	NA 0	**12.8% 47**
	Reduction aortoplasty	4.1% 169	17.1% 41	22.2% 9	NA 0	**7.3% 219**
	Others	10.3% 194	13.0% 77	14.9% 74	30.0% 10	**12.4% 335**
	Unspecified	4.6% 175	11.4% 44	17.3% 52	50.0% 6	**9.0% 277**
	All	**7.4% 2,982**	**14.8% 973**	**23.1% 1,158**	**38.3% 107**	**12.9% 5,222**


Aorta surgery: Mortality and urgency (n=3,604)
Elective
Urgent
Emergency
40%
30%
20%
10%
0%
Crude mortality rate
Interposition tube graft
Tube graft + AVR
Composite valve graft
Aortic procedure

Pathology

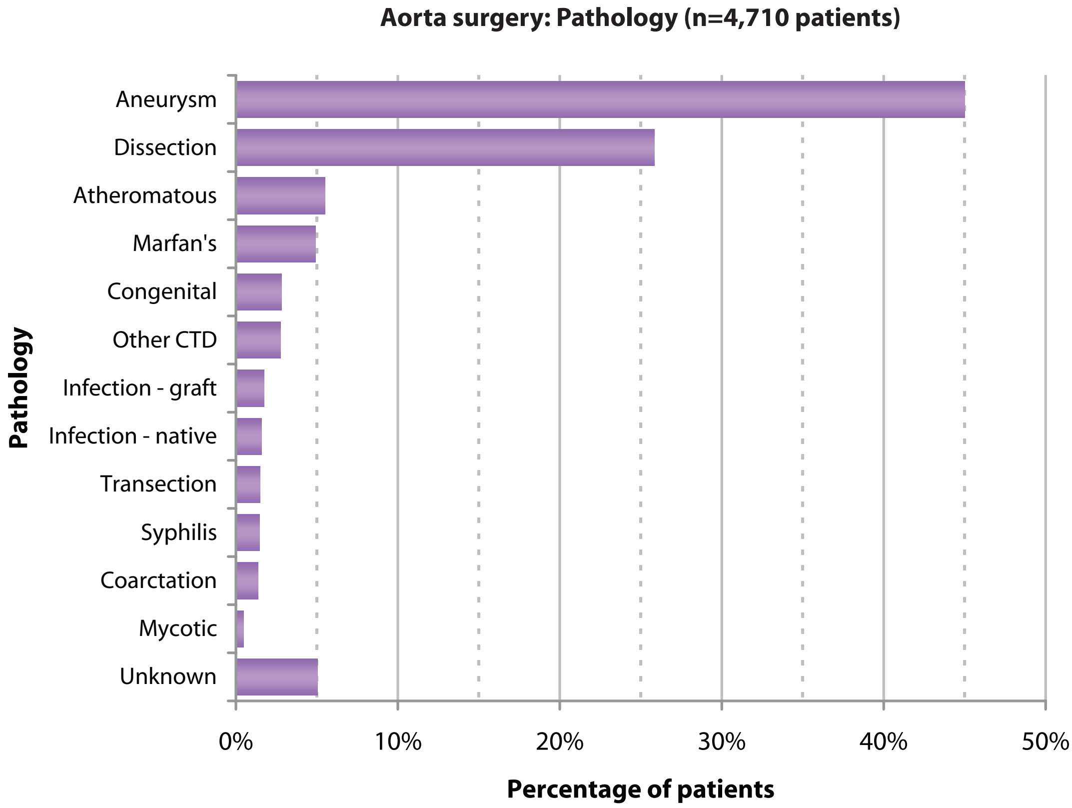
This is complex. The most common pathology reported in the database as leading to major aortic surgery is aortic aneurysm, with the next most common diagnosis being aortic dissection.

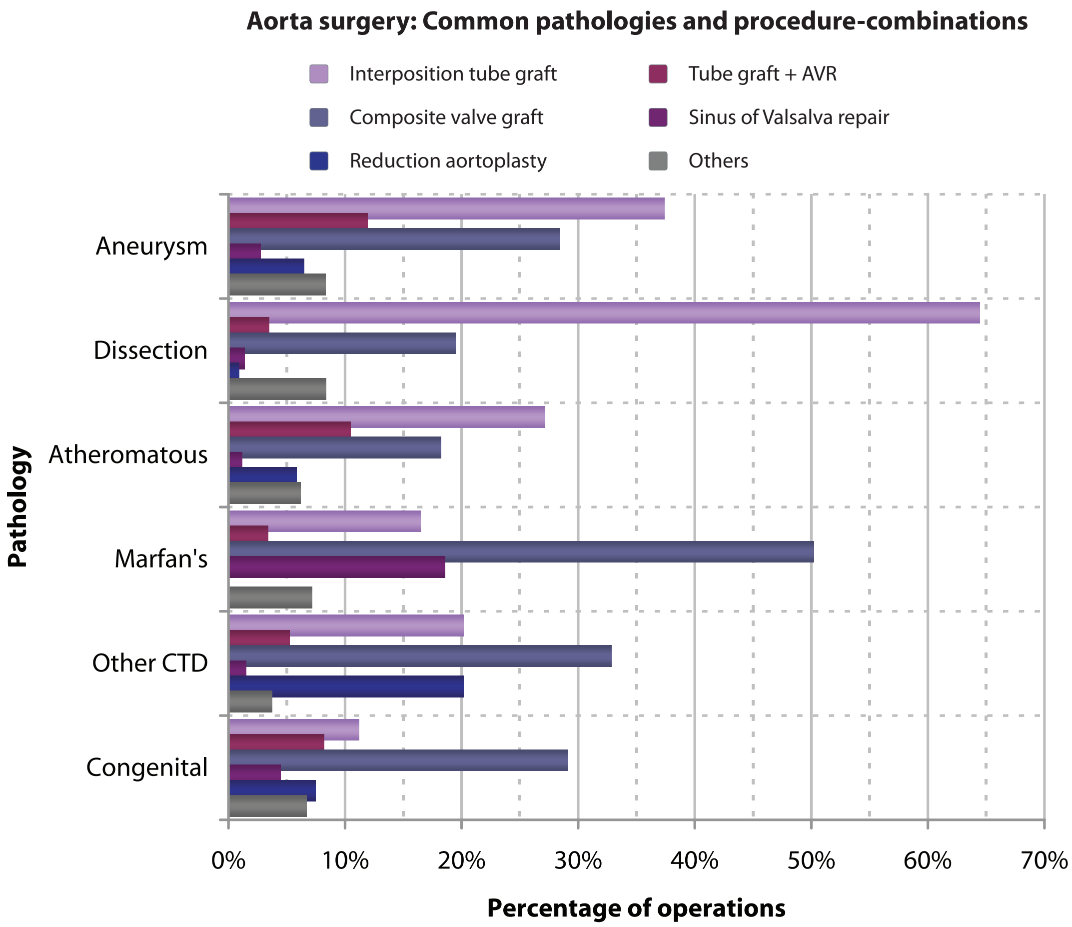
The commoner diagnosis and procedure combinations have been drawn out below. The commonest operation for both aortic aneurysm and aortic dissection is an interposition tube graft. The commonest operation for Marfan's disease is a composite root replacement.

Aortic pathology and procedure; financial years 2004-2008

		Aortic procedure											
		Interposition tube graft	Tube graft + AVR	Composite valve graft	Root repl. + pres'n native valve	Homograft root replacement	Autograft root replacement	Aortic patch graft	Sinus of valsalva repair	Reduction aortoplasty	Others	Unspecified	**All**
Pathology	Aneurysm	785	250	597	58	24	0	61	13	136	175	146	**2,245**
	Syphilis	40	5	21	1	0	0	0	0	1	3	2	**73**
	Dissection	794	43	240	17	2	1	18	3	11	103	56	**1,288**
	Transection	54	0	1	0	0	0	5	0	0	2	13	**75**
	Coarctation	45	1	3	0	0	0	4	0	3	5	8	**69**
	Atheromatous	70	27	47	3	3	0	75	2	15	16	16	**274**
	Marfan's	39	8	119	44	3	1	3	3	0	17	8	**245**
	Mycotic	5	0	3	0	7	0	4	0	1	2	1	**23**
	Other CTD [i]	27	7	44	2	3	0	16	3	27	5	3	**137**
	Congenital	15	11	39	6	12	2	24	6	10	9	7	**141**
	Infection - native	3	1	21	0	31	0	13	6	1	1	2	**79**
	Infection - graft	8	3	21	0	40	1	4	0	0	5	5	**87**
	Unknown	46	20	72	3	6	0	51	4	11	22	16	**251**
	Unspecified	167	161	86	8	23	3	62	8	15	1	1	**535**

i Other connective tissue disorder.

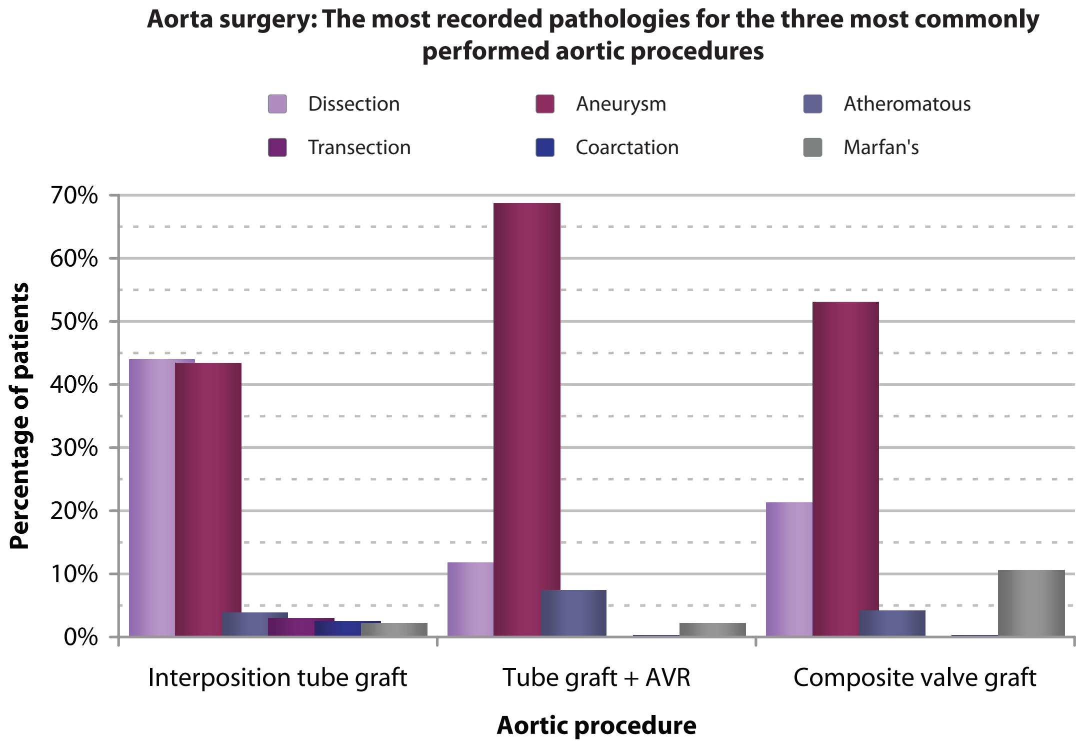

Aorta surgery: Pathology (n=4,710 patients)
Aneurysm
Dissection
Atheromatous
Marfan's
Congenital
Other CTD
Infection - graft
Infection - native
Transection
Syphilis
Coarctation
Mycotic
Unknown
Pathology
0%
10%
20%
30%
40%
50%
Percentage of patients


Aorta surgery: Common pathologies and procedure-combinations
Interposition tube graft
Tube graft + AVR
Composite valve graft
Sinus of Valsalva repair
Reduction aortoplasty
Others
Aneurysm
Dissection
Atheromatous
Marfan's
Other CTD
Congenital
Pathology
0%
10%
20%
30%
40%
50%
60%
70%
Percentage of operations

The most commonly performed aortic procedures

Pathology

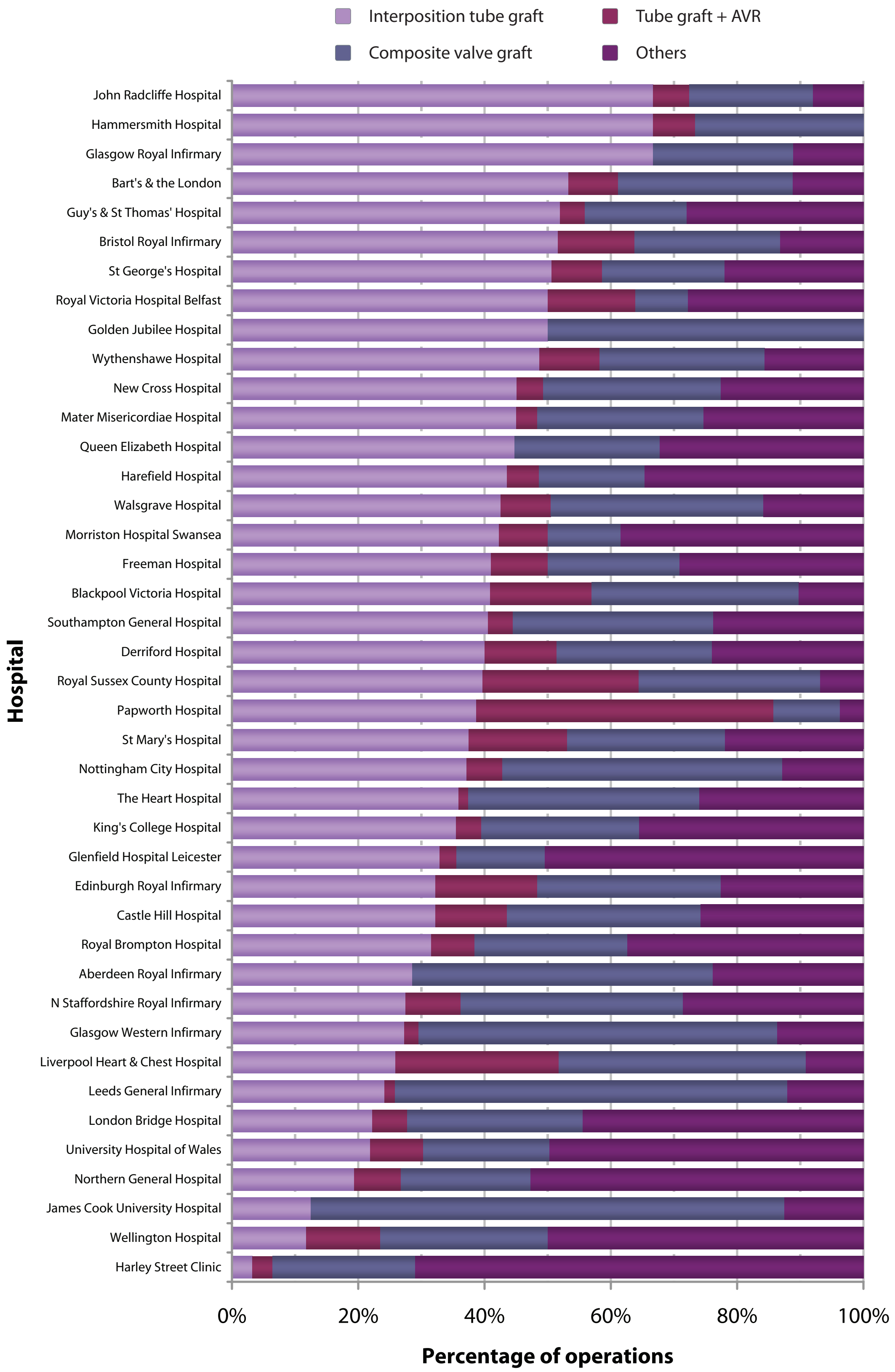
Interposition tube grafts are performed for aortic dissection and aortic aneurysm in almost equal measure. Aortic aneurysm is the commonest pathology in patients undergoing tube graft & AVR and composite valve grafts.



Inter-hospital comparisons

The aortic dataset was agreed in 2003 and has not been analysed in detail since. The definitions included in the dataset are complex and do not necessarily lend themselves to accurate classification of procedures, and because of a lack of regular and rigorous analysis, units have not always been able to learn from shortcomings in their data quality for these procedures; the following table needs to be seen in this context. We are currently in the process of revising the dataset.

Aorta surgery: Procedure and hospital (n=4,967)



		Aortic procedures				
		Interposition tube graft	Tube graft + AVR	Composite valve graft	Others	All
Hospital	Aberdeen Royal Infirmary	6	0	10	5	**21**
	Bart's & the London	81	12	42	17	**152**
	Blackpool Victoria Hospital	56	22	45	14	**137**
	Bristol Royal Infirmary	141	33	63	36	**273**
	Castle Hill Hospital, Hull	40	14	38	32	**124**
	Derriford Hospital, Plymouth	70	20	43	42	**175**
	Edinburgh Royal Infirmary	10	5	9	7	**31**
	Freeman Hospital, Newcastle	55	12	28	39	**134**
	Glasgow Royal Infirmary	6	0	2	1	**9**
	Glasgow Western Infirmary	12	1	25	6	**44**
	Glenfield Hospital, Leicester	73	6	31	112	**222**
	Golden Jubilee Hospital, Glasgow	1	0	1	0	**2**
	Guy's & St Thomas's Hospital, London	158	12	49	85	**304**
	Hammersmith Hospital, London	10	1	4	0	**15**
	Harefield Hospital, Middlesex	78	9	30	62	**179**
	Harley Street Clinic, London	1	1	7	22	**31**
	James Cook University Hospital, Middlesbrough	1	0	6	1	**8**
	John Radcliffe Hospital, Oxford	92	8	27	11	**138**
	King's College Hospital, London	44	5	31	44	**124**
	Leeds General Infirmary	14	1	36	7	**58**
	Liverpool Heart & Chest Hospital	37	37	56	13	**143**
	London Bridge Hospital, London	8	2	10	16	**36**
	Mater Misericordiae Hospital, Dublin	41	3	24	23	**91**
	Morriston Hospital, Swansea	11	2	3	10	**26**
	New Cross Hospital, Wolverhampton	32	3	20	16	**71**
	N Staffordshire Royal Infirmary, Stoke-on-Trent	25	8	32	26	**91**
	Northern General Hospital, Sheffield	47	18	50	128	**243**
	Nottingham City Hospital	26	4	31	9	**70**
	Papworth Hospital, Cambridge	147	179	40	14	**380**
	Queen Elizabeth Hospital, Birmingham	136	0	70	98	**304**
	Royal Brompton Hospital, London	60	13	46	71	**190**
	Royal Sussex County Hospital, Brighton	29	18	21	5	**73**
	Royal Victoria Hospital, Belfast	18	5	3	10	**36**
	Southampton General Hospital	92	9	72	54	**227**
	St George's Hospital, London	120	19	46	52	**237**
	St Mary's Hospital, London	12	5	8	7	**32**
	The Heart Hospital, London	47	2	48	34	**131**
	University Hospital of Wales, Cardiff	34	13	31	77	**155**
	Walsgrave Hospital, Coventry	43	8	34	16	**101**
	Wellington Hospital, London	4	4	9	17	**34**
	Wythenshawe Hospital, Manchester	56	11	30	18	**115**
	All	**1,974**	**525**	**1,211**	**1,257**	**4,967**

i The data from Aberdeen Royal Infirmary, Edinburgh Royal Infirmary & Glasgow Jubilee Hospital for the financial year ending 2007 were not included in this report. The data were collected locally & transferred to CCAD. However, due to a CCAD systems error with data transfer, they were not transferred to the analytical unit at Dendrite Clinical Systems.

Non-elective surgery for aortic dissection

Procedure

In the period 2004-2008, there are 1,084 patient-entries in the database with a recorded diagnosis of aortic dissection who have undergone non-elective surgery. The overall mortality rate for this group was 22.8%. The majority of these patients had surgery with insertion of an interposition tube graft, and these patients had a mortality rate of 20.7%. A smaller number (who will have had more serious anatomical disruption from their dissection) had a composite root replacement; these patients had a higher mortality rate of 32.5%. All other operations were performed in small numbers.

Some of these operations seem, on the surface, to be surprising operations for acute aortic dissection, but it is impossible to make clear judgements about this from the data contained in the database.

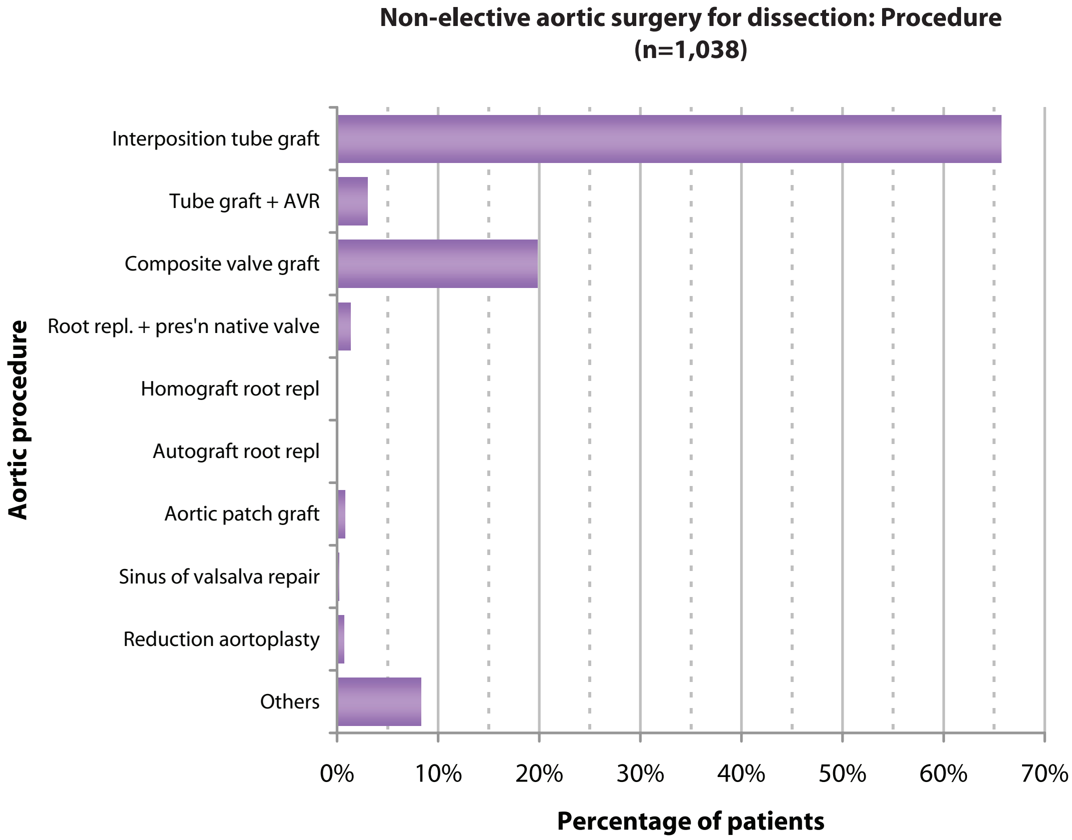
Procedure data for patients undergoing non-elective surgery for dissection; financial years 2004-2008

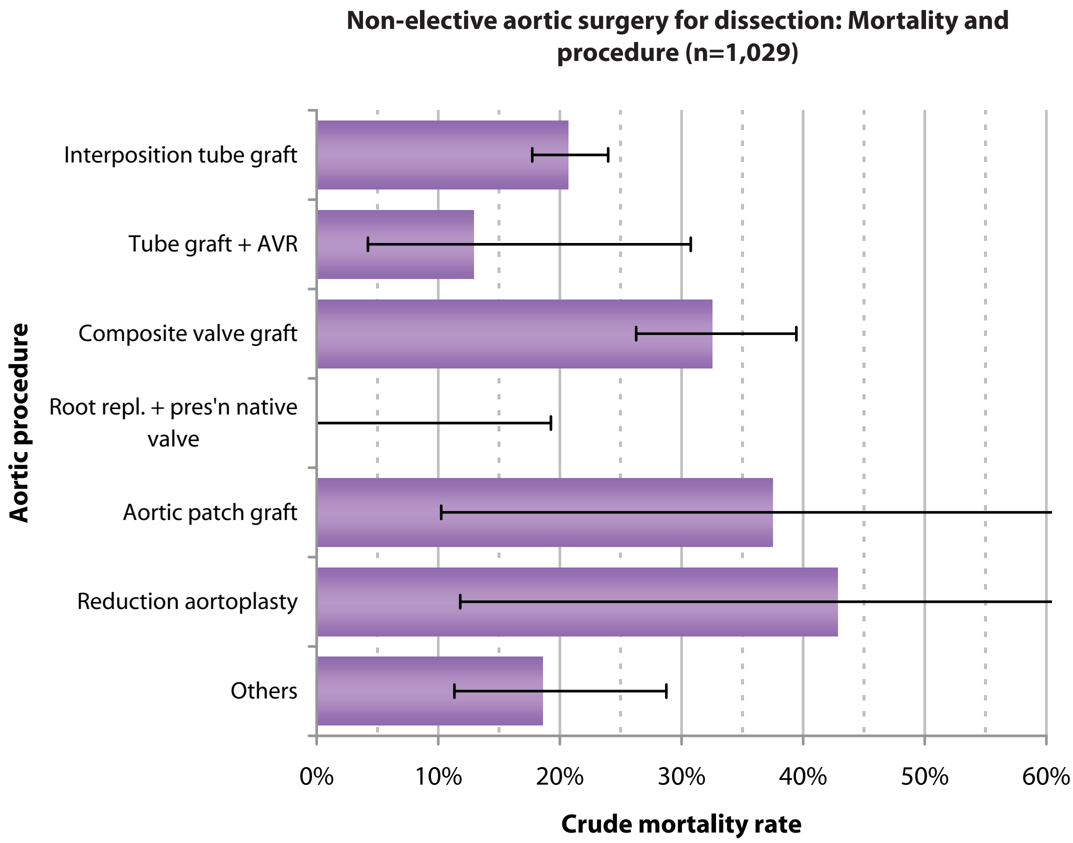
		Data		
		Count	Mortality rate	95% CI
Aortic procedure	Interposition tube graft	682	20.7%	17.7-24.0%
	Tube graft + AVR	31	12.9%	4.2-30.8%
	Composite valve graft	206	32.5%	26.3-39.4%
	Root repl. + pres'n native valve	14	0.0%	0.0-19.3%
	Homograft root replacement	1	0.0%	0.0-95.0%
	Autograft root replacement	1	100.0%	5.0-100.0%
	Aortic patch graft	8	37.5%	10.2-74.1%
	Sinus of valsalva repair	2	50.0%	2.7-97.3%
	Reduction aortoplasty	7	42.9%	11.8-79.8%
	Others	86	18.6%	11.3-28.8%
	Unspecified	46	23.9%	13.1-39.1%
	All	**1,084**	**22.8%**	**20.4-25.4%**

The surgical mortality for acute dissection is similar to that found published in the literature.

i Hagan P, Nienaber CA, Isselbacher EM *et al*. The International Registry of Acute Aortic Dissection (IRAD) New Insights Into an Old Disease. *JAMA*. 2000; **283:** 8 97-903

ii Trimarchi S, Nienaber CA, Rampoldi V, Myrmel T, Suzuki T, Mehta RH, Bossone E, Cooper JV, Smith DE, Menicanti L, Frigiola A, Oh JK, Deeb MG, Isselbacher EM, Eagle KA; International Registry of Acute Aortic Dissection Investigators. Contemporary results of surgery in acute type A aortic dissection: The International Registry of Acute Aortic Dissection experience. *J Thorac Cardiovasc Surg*. 2005; **129(1):** 112-22.


Non-elective aortic surgery for dissection: Procedure (n=1,038)
Aortic procedure
Interposition tube graft
Tube graft + AVR
Composite valve graft
Root repl. + pres'n native valve
Homograft root repl
Autograft root repl
Aortic patch graft
Sinus of valsalva repair
Reduction aortoplasty
Others
0%
10%
20%
30%
40%
50%
60%
70%
Percentage of patients

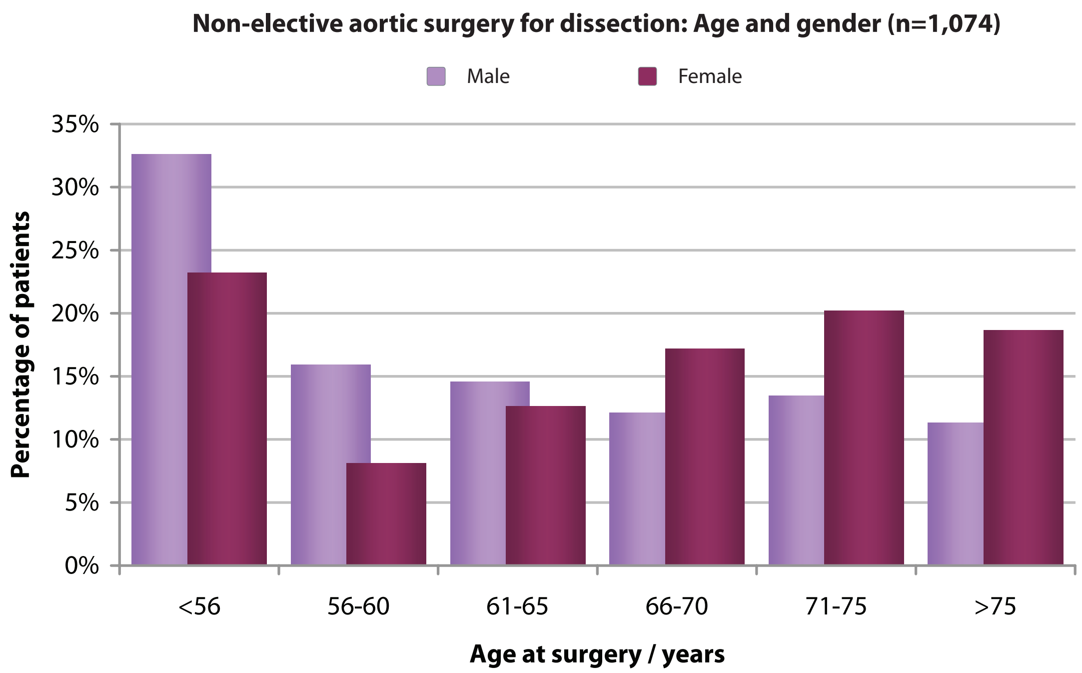

Non-elective aortic surgery for dissection: Mortality and procedure (n=1,029)
Aortic procedure
Interposition tube graft
Tube graft + AVR
Composite valve graft
Root repl. + pres'n native valve
Aortic patch graft
Reduction aortoplasty
Others
0%
10%
20%
30%
40%
50%
60%
Crude mortality rate

Age

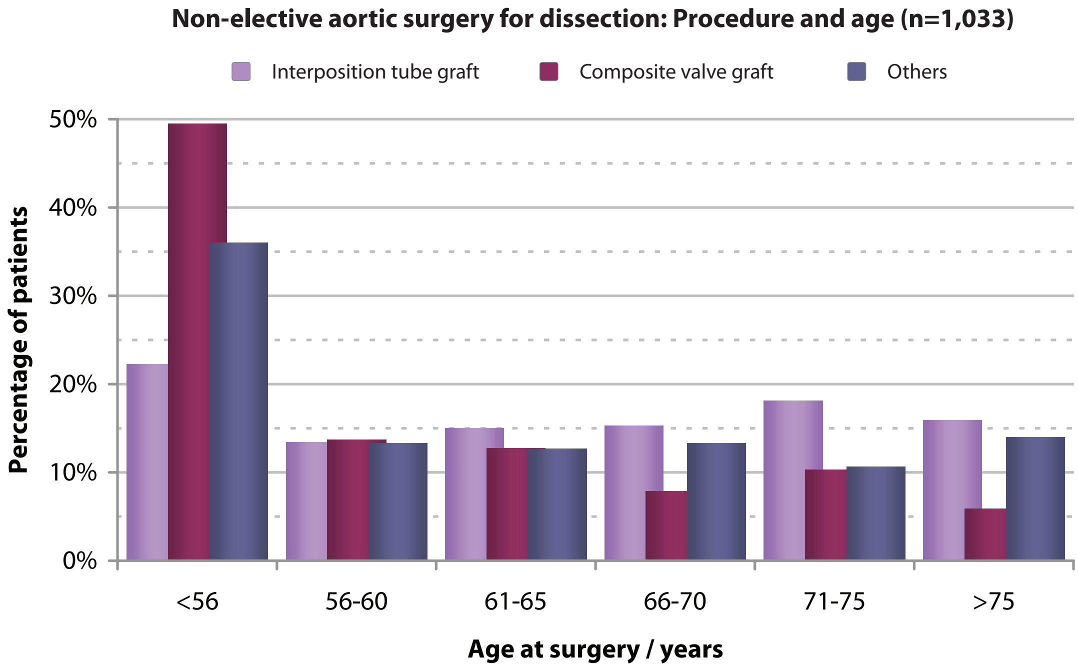
Surgery for aortic dissection is more common in men than in women, up to the age of 65 years. Amongst the older patients it is more common in women. There is no difference in in-hospital mortality on the basis of gender.

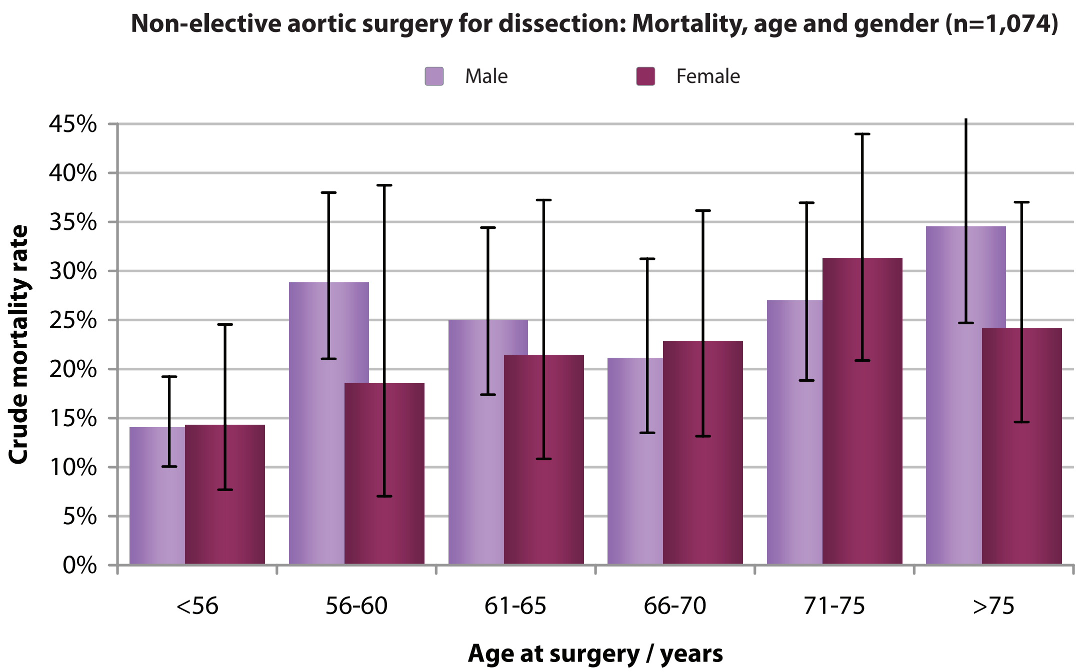
Non-elective surgery for dissection; mortality, gender and age; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

Age at surgery / years	Gender: Male	Gender: Female	Gender: Unspecified	Gender: All
<56	14.0% 242	14.3% 77	0	**14.1%** **319**
56-60	28.8% 118	18.5% 27	0	**26.9%** **145**
61-65	25.0% 108	21.4% 42	0	**24.0%** **150**
66-70	21.1% 90	22.8% 57	0	**21.8%** **147**
71-75	27.0% 100	31.3% 67	0	**28.7%** **167**
>75	34.5% 84	24.2% 62	0	**30.1%** **146**
Unspecified	40.0% 5	NA 0	0	**40.0%** **5**
All	**23.0%** **747**	**22.3%** **332**	**0**	**22.8%** **1,079**



Younger patients are more likely to undergo surgery with insertion of composite valve grafts. Older patients are more likely to have an interposition tube graft.





Multiple & miscellaneous procedures

Multiple valves, miscellaneous operations and multiple procedures

Introduction

The previous sections have included analyses on isolated coronary artery bypass surgery, aortic valve surgery with and without CABG, mitral surgery with and without CABG and major procedures on the aorta. Mitral surgery with concomitant tricuspid surgery has also been described on page 316. A number of patients undergo multiple valve procedures (other than combined mitral and tricuspid surgery) and these are described, for completeness, in more detail in the following sections. There are also a number of other *miscellaneous* procedures, which are performed in small volumes that are also included here.

Some patients also undergo multiple operations in the same hospital admission. For the previous sections, cases have been allocated to the appropriate procedural grouping depending on the first operation in a hospital admission. So, for example, if a patient were admitted for an aortic valve replacement, and then on the second post-operative day they went on to develop an aortic dissection requiring an ascending aortic replacement, that patient has been analysed on an *intention-to-treat-basis* as an isolated AVR. However, the small group of patients who have had multiple procedures within one admission are important as they have a high mortality rate, and so we have analysed these in more detail here.

Multiple valves

All the valves in the heart can be repaired or replaced, and can be done so in any combination. In line with previous data from the United Kingdom Cardiac Surgical Register, we have analysed these patients according to combined mitral & aortic valve surgery, combined aortic & tricuspid valve surgery and other double valves. We have examined the data for these patients according to the presence or absence of concomitant CABG. As mitral and tricuspid valve surgery is usually undertaken for a combination of primary mitral pathology with associated tricuspid regurgitation, and is carried out with relative frequency, we have analysed these patients in the mitral section on page 316.

By far the predominant multiple-valve procedure is combined AVR & MVR. All other multiple valve procedures are carried out in small numbers.

Double valve procedures

			Financial year					
			2004	2005	2006	2007	2008	**All**
Procedures	Valve alone	Aortic & mitral	301	302	347	428	357	**1,735**
		Mitral & tricuspid	106	121	126	214	217	**784**
		Aortic & tricuspid	7	15	18	29	21	**90**
		Other double valves	11	1	12	10	18	**58**
		All	**425**	**445**	**503**	**681**	**613**	**2,667**
	CABG & valve	Aortic & mitral	93	111	112	148	132	**596**
		Mitral & tricuspid	44	33	66	52	68	**263**
		Aortic & tricuspid	3	1	3	7	12	**26**
		Other double valves	0	0	1	1	3	**5**
		All	**140**	**145**	**182**	**208**	**215**	**890**

Aortic and mitral surgery

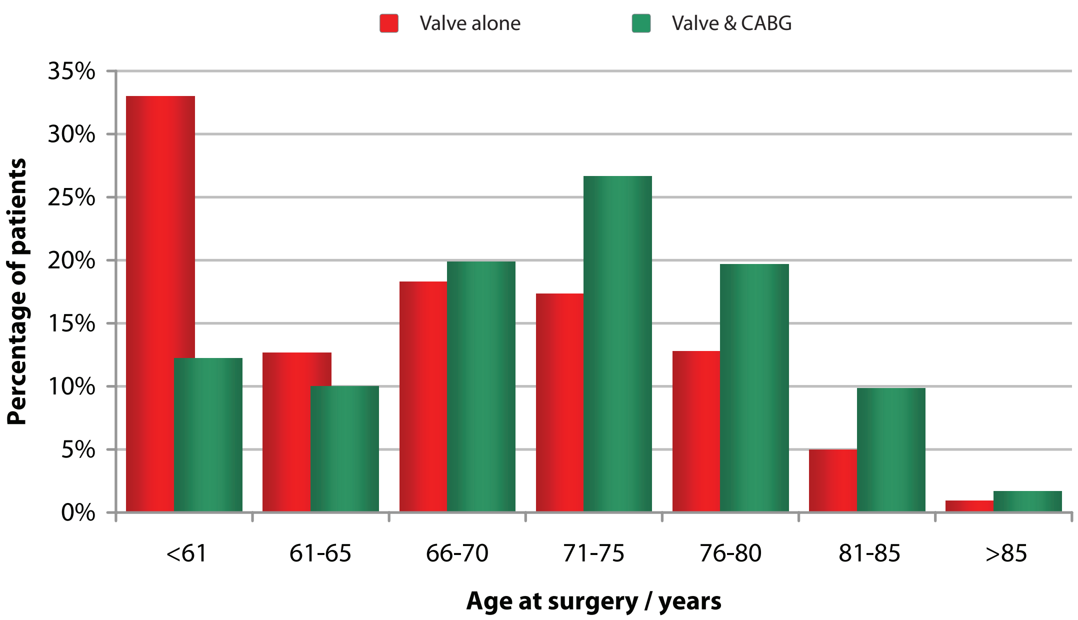
Age at surgery

One-third of all patients undergoing isolated double valve surgery are under the age of 61. Double valve surgery is performed in octogenarians, but only in small numbers. The age distribution of patients undergoing combined AVR & MVR with concomitant CABG surgery shows these patients are somewhat older, in line with the increasing incidence of coronary artery disease with increasing age.

Age and procedure for combined aortic & mitral valve surgery; financial years 2004-2008

		Procedure		
		Valve alone	Valve & CABG	All
Age at surgery / years	<61	570	72	**642**
	61-65	219	59	**278**
	66-70	316	117	**433**
	71-75	300	157	**457**
	76-80	221	116	**337**
	81-85	86	58	**144**
	>85	16	10	**26**
	Unspecified	7	7	**14**
	All	**1,735**	**596**	**2,331**

Combined aortic & mitral valve surgery: Age distribution; financial years 2004-2008 (n=2,317)



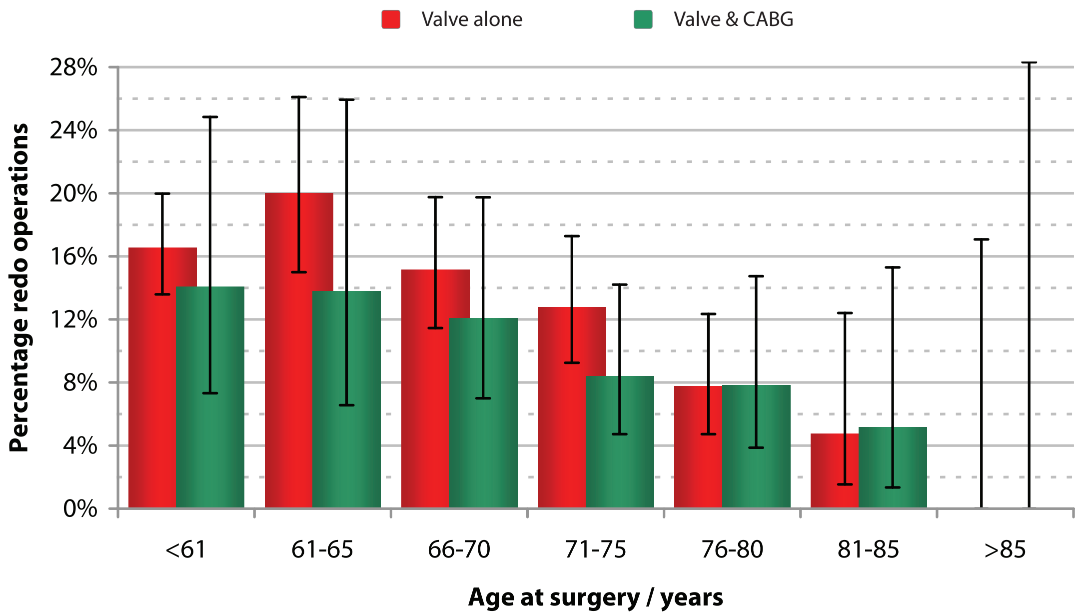
Redo surgery

The proportion of patients undergoing repeat (redo) double valve surgery is high (only 1.8% of CABG operations and 2.3% of isolated AVR have had previous cardiac surgery). This is one of the factors that contributes to the high in-hospital mortality in this group described below.

Operation sequence and age for combined aortic and mitral valve surgery; financial years 2004-2008

		Procedure					
		Valve alone			Valve & CABG		
		First operation	Redo operation	Not known	First operation	Redo operation	Not known
Age at surgery / years	<61	459	91	20	61	10	1
	61-65	172	43	4	50	8	1
	66-70	263	47	6	102	14	1
	71-75	253	37	10	142	13	2
	76-80	202	17	2	106	9	1
	81-85	80	4	2	55	3	0
	>85	16	0	0	9	0	1
	Unspecified	6	1	0	7	0	0
	All	**1451**	**240**	**44**	**532**	**57**	**7**

Combined aortic & mitral valve surgery: Redo surgery; financial years 2004-2008 (n=2,266)



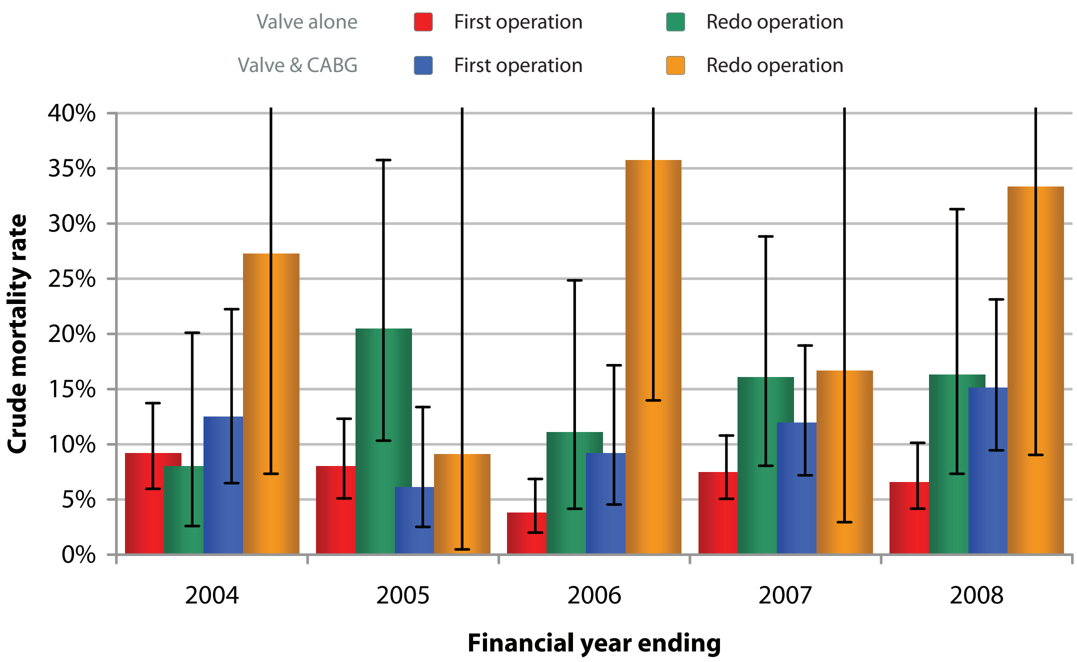
Mortality

The mortality for combined aortic & mitral valve surgery is high at 6.9% for first-time isolated valve procedures, and 11.2% when combined with CABG. The mortality for redo surgery is higher.

Mortality and procedure for combined aortic & mitral valve surgery; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

		Procedure			
		Valve alone		Valve & CABG	
		First operation	Redo operation	First operation	Redo operation
Financial year ending	2004	9.2% 240	8.0% 50	12.5% 80	27.3% 11
	2005	8.0% 249	20.5% 44	6.1% 98	9.1% 11
	2006	3.8% 291	11.1% 45	9.2% 98	35.7% 14
	2007	7.5% 362	16.1% 56	11.9% 134	16.7% 12
	2008	6..6% 304	16.3% 43	15.1% 119	33.3% 9
	All	**6.9%** **1,446**	**14.3%** **238**	**11.2%** **529**	**24.6%** **57**

Combined aortic & mitral valve surgery: Post-operative mortality (n=2,270)

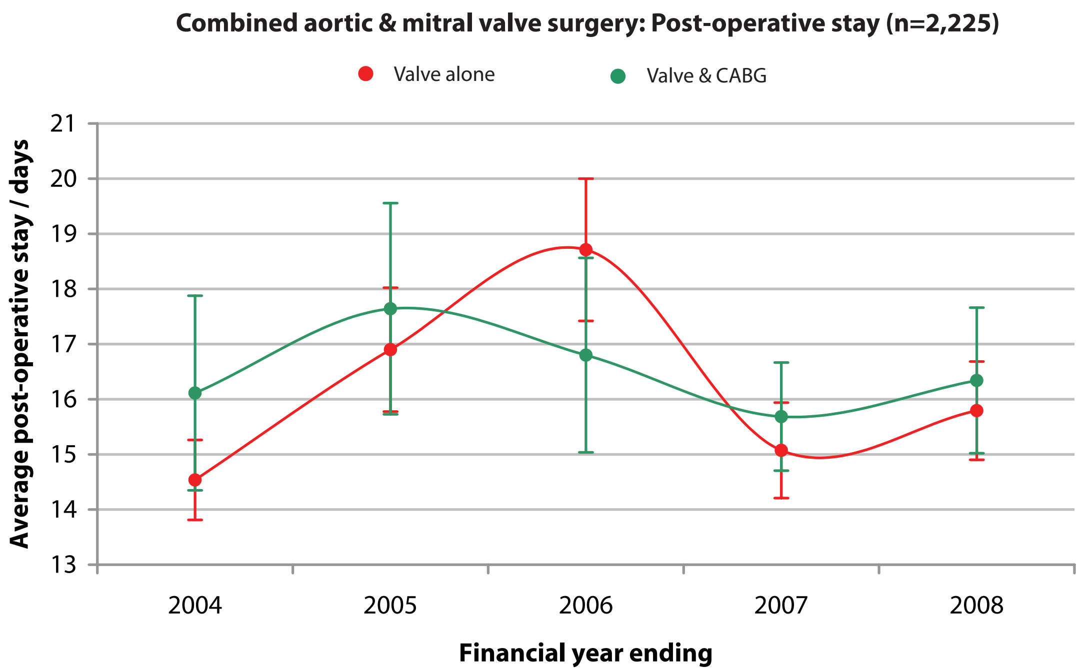


Post-operative stay

The average post-operative stay for these patients is long, but there is no difference between those having isolated AVR & MVR and those have concomitant CABG surgery as well.

Post-operative stay and procedure for combined aortic & mitral valve surgery; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

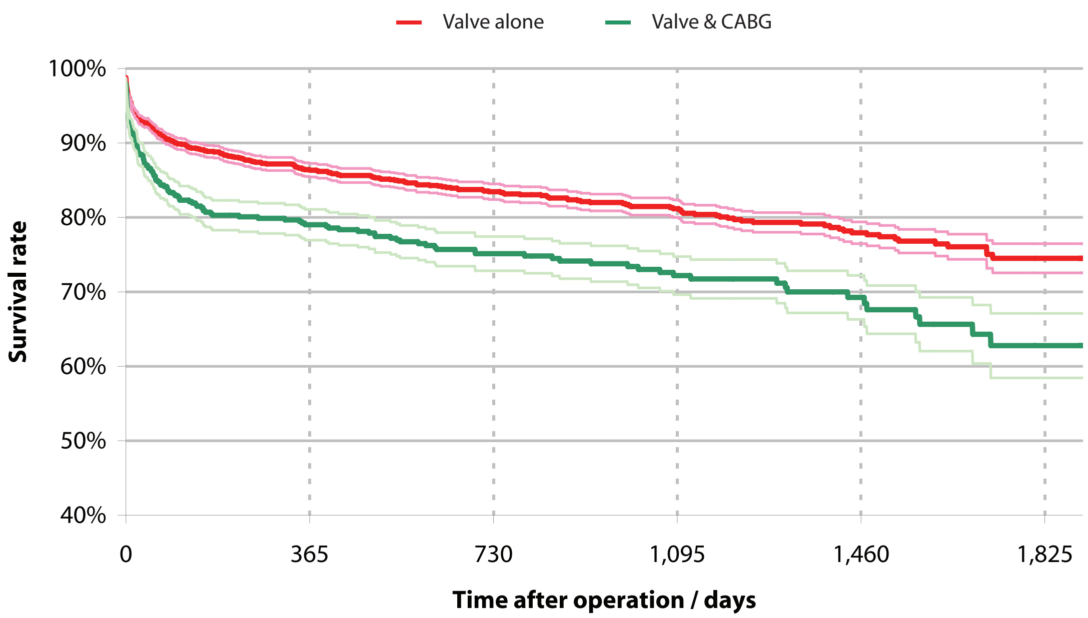
Financial year ending		Procedure		
		Valve alone	Valve & CABG	All
	2004	14.5 285	16.1 89	**14.9** **374**
	2005	16.9 289	17.6 106	**17.1** **395**
	2006	18.7 311	16.8 105	**18.2** **416**
	2007	15.1 409	15.7 146	**15.2** **555**
	2008	15.8 353	16.3 132	**15.9** **485**
	All	**16.1** **1,647**	**16.5** **578**	**16.2** **2,225**



Medium-term survival

Patients undergoing isolated AVR & MVR have a better medium-term survival than those undergoing concomitant CABG. The overall survival is not as good as for patients undergoing single valve replacements.

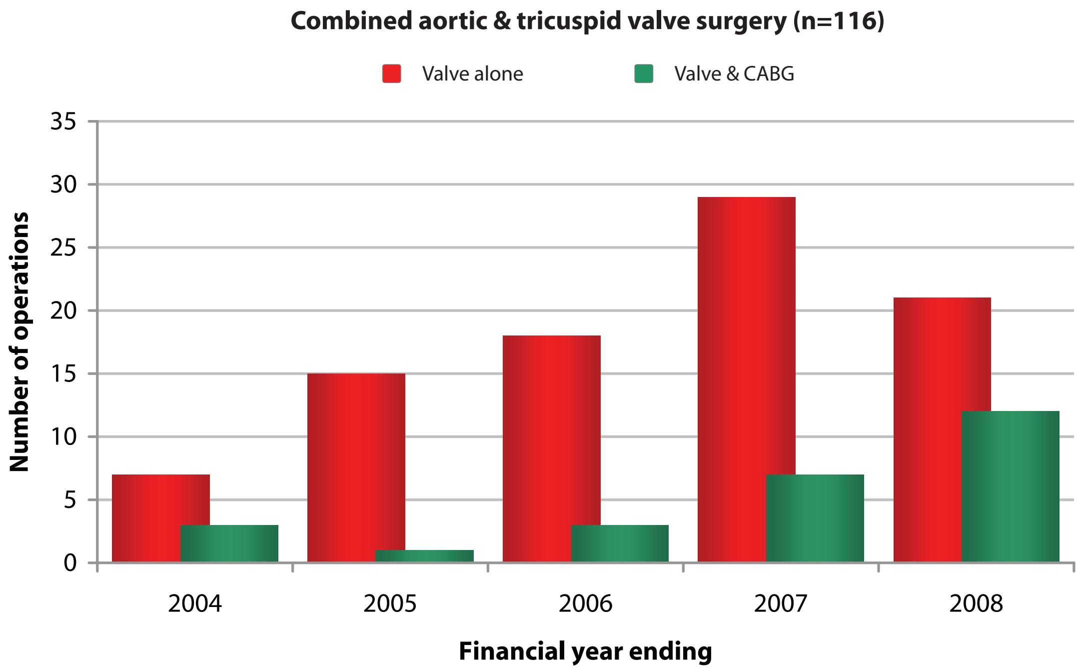
Combined aortic & mitral valve surgery: Medium-term survival; financial years 2004-2008 (n=1,875)



Aortic and tricuspid surgery

Number of operations

These operations are performed in small volumes and are included here to be complete and consistent with the previous reports form the United Kingdom Cardiac Surgical Register.



Outcomes

The mortality and length-of-stay are both high. The medium-term survival rate is lower than for isolated AVR surgery.

Outcomes for combined aortic and tricuspid valve surgery; financial years 2004-2008

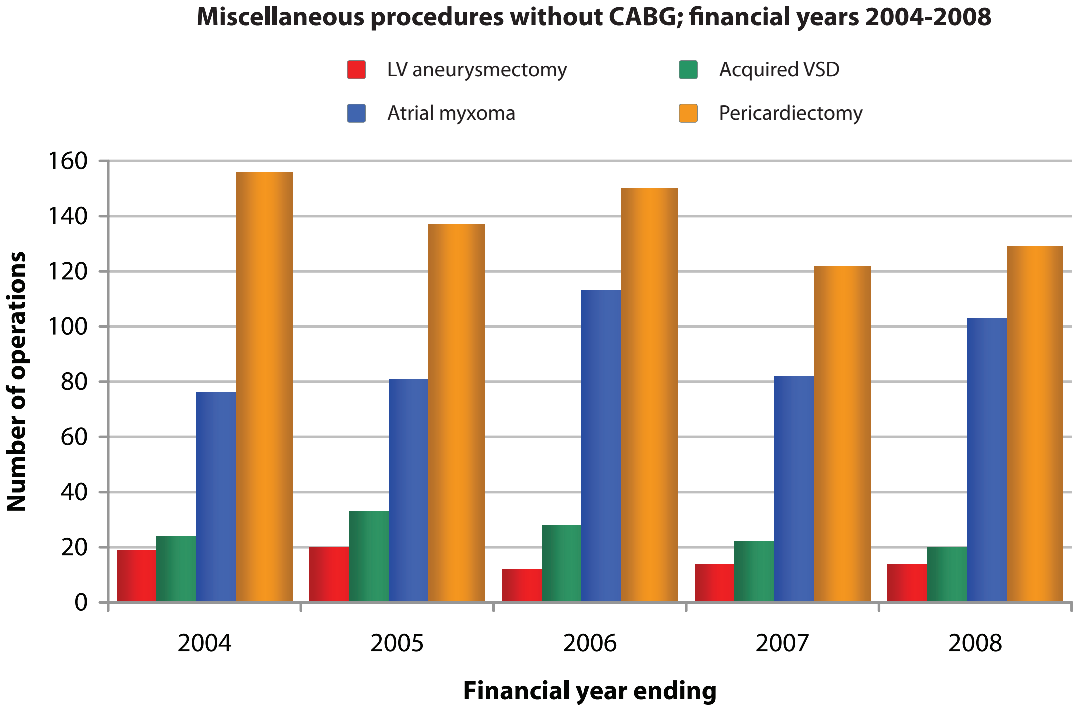
		Procedure	
		Valves alone	Valves and CABG
Outcome	Mortality	13.3% 90	23.1% 26
	Average post-operative stay / days	16.4 90	17.2 26
	Kaplan-Meier survival rate at 5 years	71.7% 73	77.8% 18

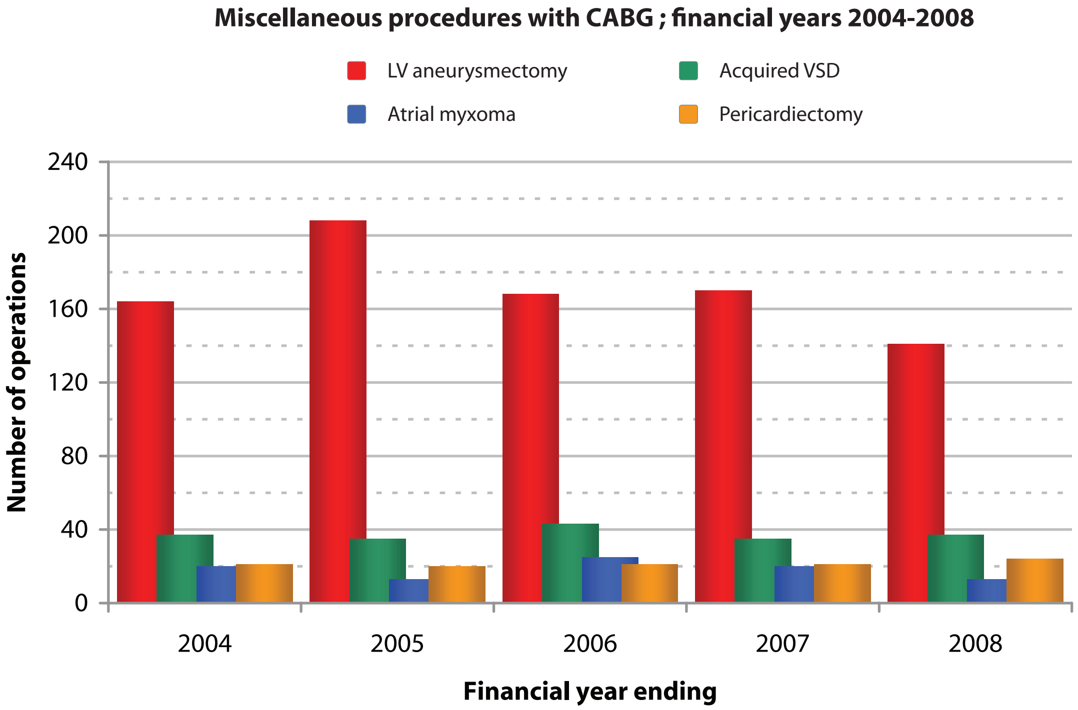
Miscellaneous procedures

The commoner miscellaneous procedures, with and without concomitant CABG surgery, are listed below. These are all carried out in relatively small numbers.

Miscellaneous cardiac procedures; major procedure grouping is either *CABG and other* or *Other*

			Financial year					
			2004	2005	2006	2007	2008	**All**
Procedures	Without CABG	LV aneurysmectomy	19	20	12	14	14	**79**
		Acquired VSD	24	33	28	22	20	**127**
		Atrial myxoma	76	81	113	82	103	**455**
		Pericardiectomy	156	137	150	122	129	**694**
	With CABG	LV aneurysmectomy	164	208	168	170	141	**851**
		Acquired VSD	37	35	43	35	37	**187**
		Atrial myxoma	20	13	25	20	13	**91**
		Pericardiectomy	21	20	21	21	24	**107**


Miscellaneous procedures without CABG; financial years 2004-2008
LV aneurysmectomy
Acquired VSD
Atrial myxoma
Pericardiectomy
Number of operations
0
20
40
60
80
100
120
140
160
2004
2005
2006
2007
2008
Financial year ending

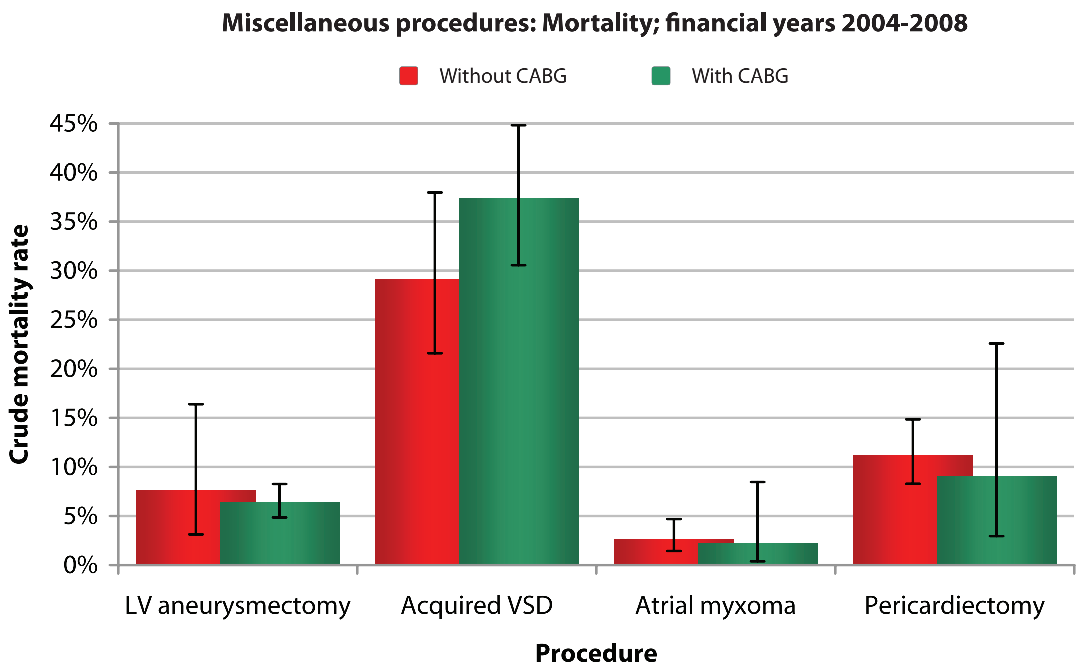

Miscellaneous procedures with CABG ; financial years 2004-2008
LV aneurysmectomy
Acquired VSD
Atrial myxoma
Pericardiectomy
Number of operations
0
40
80
120
160
200
240
2004
2005
2006
2007
2008
Financial year ending

Mortality

The mortality for the miscellaneous procedures is variable. Acquired VSD surgery has a high mortality of 1 in 3. Atrial myxoma surgery is unusual and has a low mortality of between 2 and 3%.

Mortality over time for miscellaneous cardiac procedures; major procedure grouping is either *CABG and other* or *Other*; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

			Financial year					
			2004	2005	2006	2007	2008	**All**
Procedures	Without CABG	LV aneurysmectomy	5.3% 19	15.0% 20	8.3% 12	7.1% 14	0.0% 14	**7.6% 79**
		Acquired VSD	41.7% 24	21.2% 33	39.3% 28	31.8% 22	10.0% 20	**29.1% 127**
		Atrial myxoma	2.6% 76	3.7% 81	2.7% 113	2.4% 82	1.9% 103	**2.6% 455**
		Pericardiectomy	15.3% 72	14.7% 75	13.5% 74	6.7% 75	6.7% 89	**11.2% 385**
	With CABG	LV aneurysmectomy	4.3% 164	5.3% 207	4.8% 168	10.6% 170	7.1% 141	**6.4% 850**
		Acquired VSD	43.2% 37	28.6% 35	30.2% 43	37.1% 35	48.6% 37	**37.4% 187**
		Atrial myxoma	10.0% 20	0.0% 13	0.0% 25	0.0% 20	0.0% 13	**2.2% 91**
		Pericardiectomy	0.0% 4	14.3% 7	20.0% 10	9.1% 11	0.0% 12	**9.1% 44**

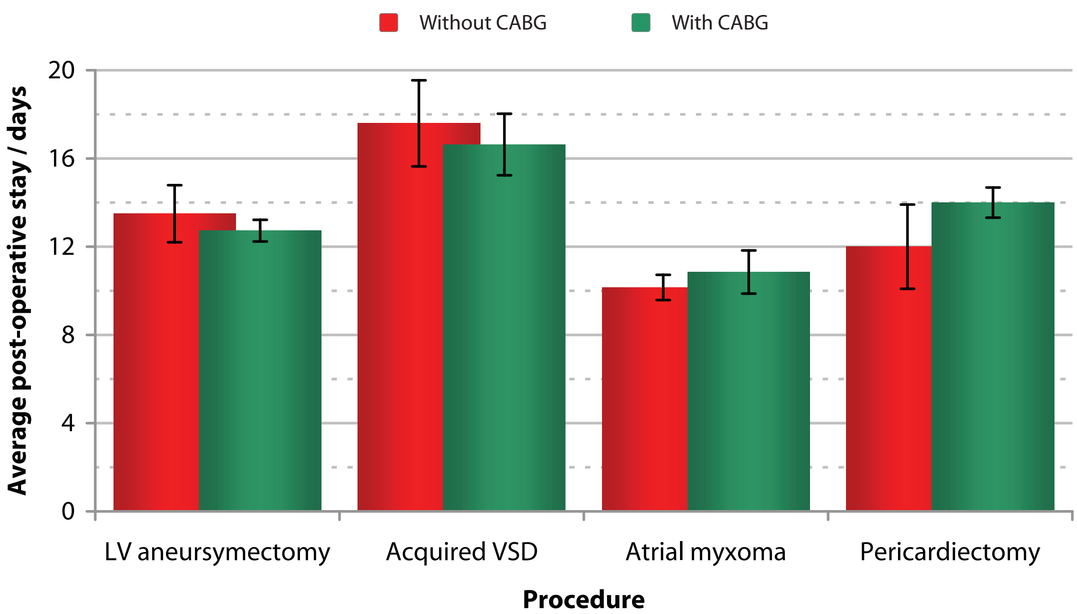


Post-operative stay

Post-operative stay over time for miscellaneous cardiac procedures; major procedure grouping is either *CABG and other* or *Other*; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

Procedures			Financial year					
			2004	2005	2006	2007	2008	**All**
Without CABG	LV aneurysmectomy		18.8 19	10.0 20	12.4 12	11.2 14	14.4 14	**13.5** **79**
	Acquired VSD		18.3 24	13.5 32	15.8 28	24.8 21	18.3 20	**17.6** **125**
	Atrial myxoma		9.2 72	10.8 80	8.9 108	12.6 74	9.9 102	**10.2** **436**
	Pericardiectomy		10.6 71	12.8 73	11.4 69	12.9 74	12.0 89	**12.0** **376**
With CABG	LV aneurysmectomy		13.0 154	12.0 205	14.3 162	12.5 166	12.0 141	**12.7** **828**
	Acquired VSD		16.7 35	18.3 35	15.9 40	18.7 35	13.8 37	**16.6** **182**
	Atrial myxoma		8.0 20	11.3 13	12.3 24	10.6 17	12.3 13	**10.9** **87**
	Pericardiectomy		8.5 4	9.2 6	17.9 10	12.8 10	16.0 12	**14.0** **42**

Miscellaneous procedures: Post-operative stay; financial years 2004-2008



Multiple operations within an admission

Numbers of procedures

These are unusual but important. As described above we have analysed and presented the data throughout this book according to the first recorded procedure within an admission, so if a patient has an AVR followed on the second post-operative day by an operation for an aortic dissection, that patient has been analysed in the section for isolated AVR, as it is assumed that the dissection will be as a result of the first operation. The operative groups and the numbers who have had multiple operations are given below. Whilst the numbers are small, these patients have a high mortality rate.

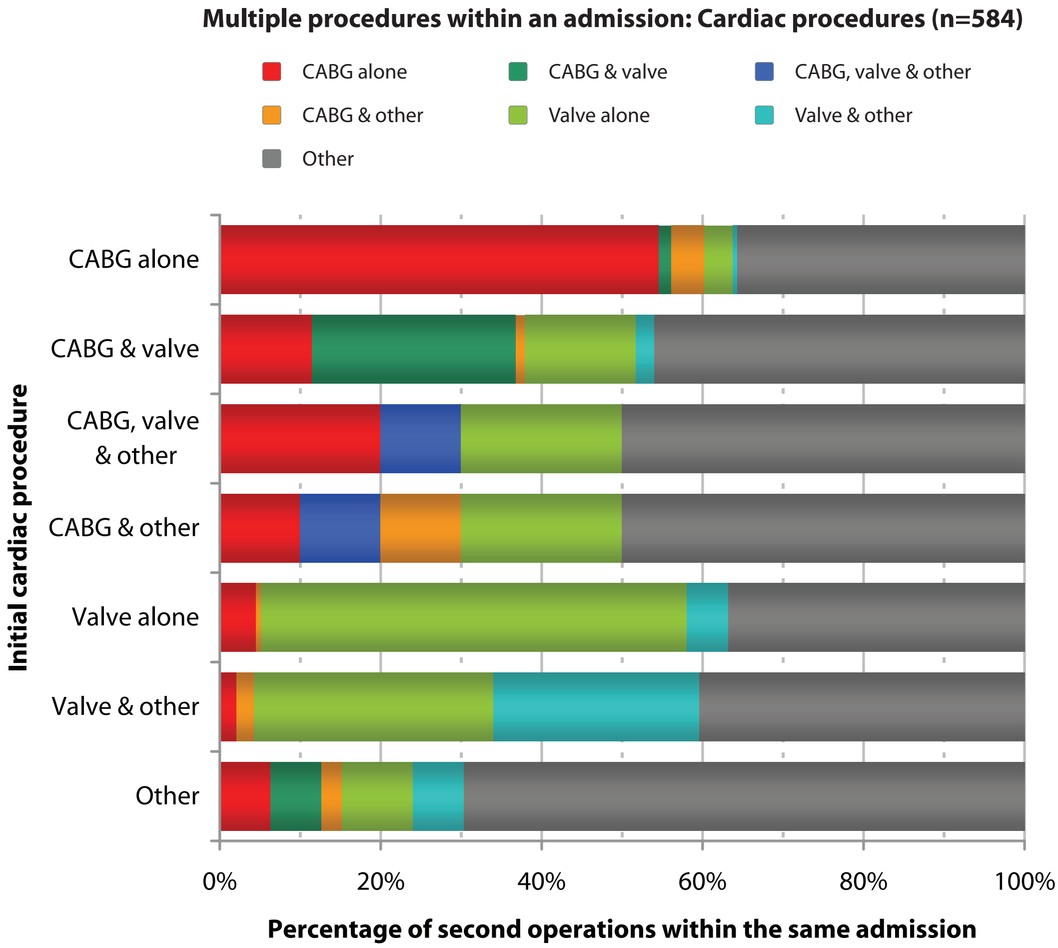
Multiple operations within an admission; financial years 2004-2008

First operation within admission	Number of subsequent operations in the same admission: 1	2	3	4	5	All
CABG alone	200	6				**206**
CABG and valve	87	6	1			**94**
CABG, valve and other	10					**10**
CABG and other	11					**11**
Valve alone	157	8	1	1		**167**
Valve and other	47	5				**52**
Other	79	10	1	1	1	**92**
Unspecified	5					**5**
All	**596**	**35**	**3**	**2**	**1**	**637**

The operative grouping for the first operation and the subsequent procedures are listed here. All of the different possible combinations only occur in small numbers.

The relationship between the first and second operations within an admission; financial years 2004-2008

First operation within admission	Second operation within the admission: CABG alone	CABG and valve	CABG, valve and other	CABG & other	Valve alone	Valve & other	Other	Unspecified	All
CABG alone	107	3	0	8	7	1	70	4	**200**
CABG and valve	10	22	0	1	12	2	40	0	**87**
CABG, valve and other	2	0	1	0	2	0	5	0	**10**
CABG and other	1	0	1	1	2	0	5	1	**11**
Valve alone	7	0	0	1	82	8	57	2	**157**
Valve and other	1	0	0	1	14	12	19	0	**47**
Other	5	5	0	2	7	5	55	0	**79**
Unspecified	2	0	0	0	1	1	1	0	**5**
All	**135**	**30**	**2**	**14**	**127**	**29**	**252**	**7**	**596**

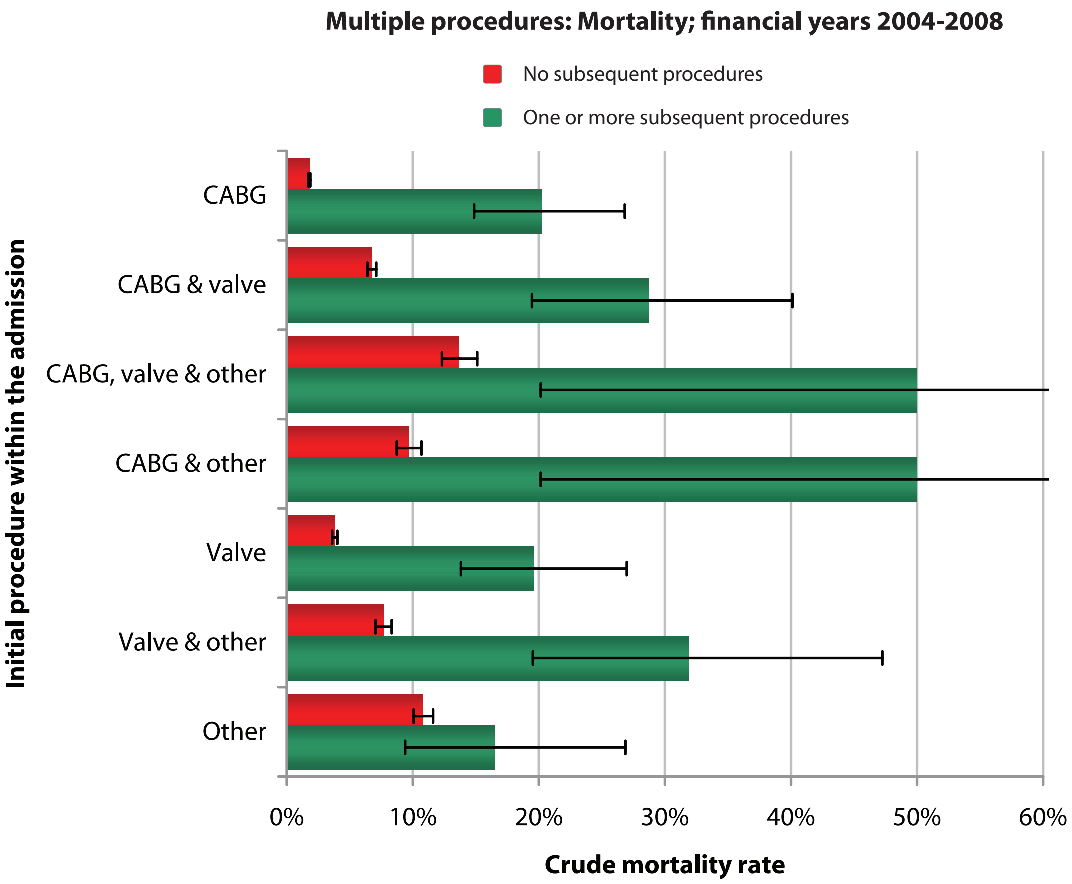

Multiple procedures within an admission: Cardiac procedures (n=584)
CABG alone
CABG & valve
CABG, valve & other
CABG & other
Valve alone
Valve & other
Other
Initial cardiac procedure
CABG alone
CABG & valve
CABG, valve & other
CABG & other
Valve alone
Valve & other
Other
0%
20%
40%
60%
80%
100%
Percentage of second operations within the same admission

Mortality

The necessity for a subsequent cardiac procedure in the same hospital admission is associated with a marked increased in observed mortality. This applies for all operative types.

Multiple operations within an admission and mortality; mortality rates, within sub-group counts and 95% confidence intervals are shown in parentheses; financial years 2004-2008

		Incidence of subsequent procedures and mortality			
		No subsequent operation		One or more subsequent operations	
First operation within admission	CABG alone	1.8%	(114,300; 1.7-1.9%)	20.2%	(188; 14.9-26.8%)
	CABG and valve	6.7%	(20,309; 6.4-7.1%)	28.8%	(80; 19.5-40.1%)
	CABG, valve and other	13.7%	(2,388; 12.3-15.1%)	50.0%	(10; 20.1-79.9%)
	CABG and other	9.7%	(3,592; 8.7-10.7%)	50.0%	(10; 20.1-79.9%)
	Valve alone	3.8%	(33,263; 3.6-4.0%)	19.6%	(153; 13.8-27.0%)
	Valve and other	7.7%	(6,827; 7.0-8.3%)	31.9%	(47; 19.5-47.3%)
	Other	10.8%	(6,335; 10.1-11.6%)	16.5%	(97; 9.4-26.9%)
	Unspecified	17.6%	(85; 10.5-27.8%)	50.0%	(2; 2.7-97.3%)
	All	**3.5%**	**(187,099; 3.4-3.6%)**	**22.8%**	**(569; 19.5-26.6%)**

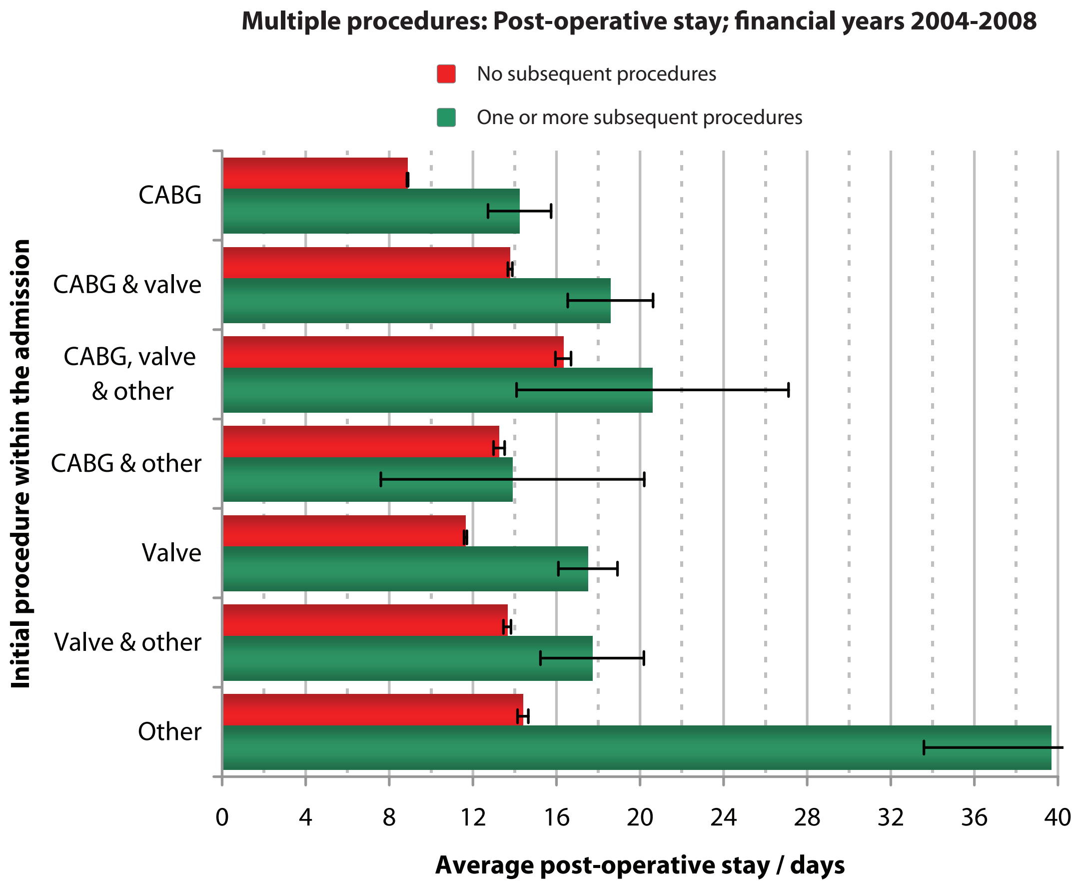


Post-operative stay

In general, multiple procedures are associated with long in-hospital stay.

Multiple operations within an admission and post-operative stay; average post-operative stay and within sub-group counts are shown; financial years 2004-2008

		Incidence of subsequent procedures	
		No subsequent operation	One or more subsequent operations
First operation within admission	CABG alone	8.9 (109,315)	14.2 (179)
	CABG and valve	13.8 (19,607)	18.6 (86)
	CABG, valve and other	16.3 (2,340)	20.6 (10)
	CABG and other	13.3 (3,487)	13.9 (10)
	Valve alone	11.6 (32,056)	17.5 (146)
	Valve and other	13.6 (6,674)	17.7 (45)
	Other	14.4 (6,174)	39.7 (5)



Endocarditis

Endocarditis

Native valve endocarditis

Distributions

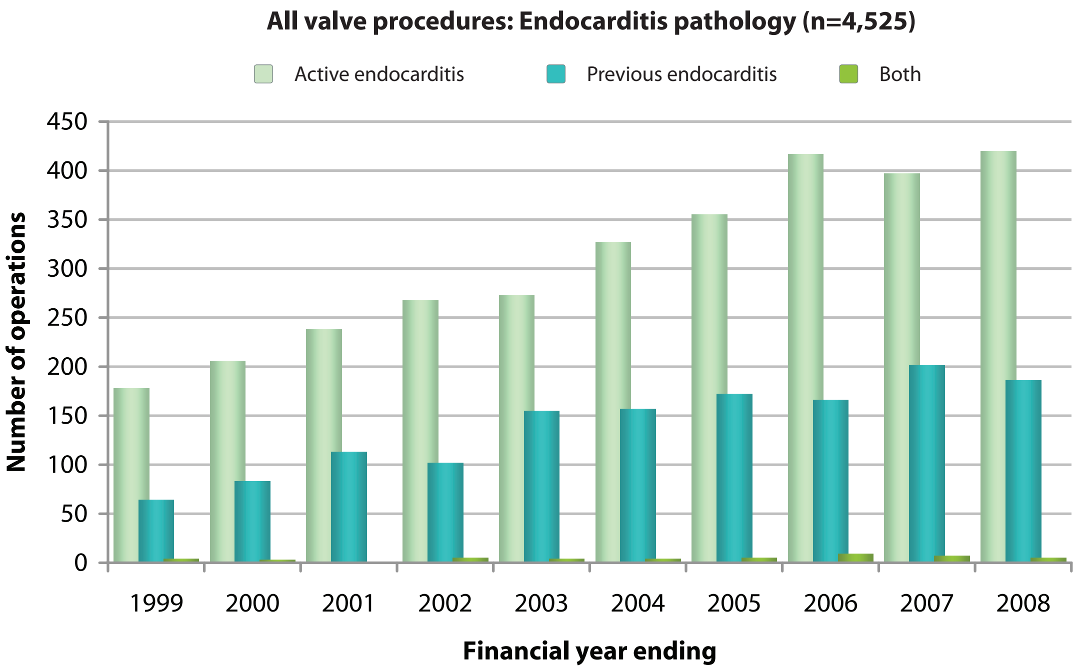
Infective endocarditis is when heart valves become infected, and it may affect either native or artificial valves. Infection may be acute and active, and need urgent surgery for cure or to prevent further complications, or a previous infection may have damaged heart valves so that they no longer function properly (usually with valvular regurgitation) so that they require surgery. In the SCTS database it is possible to record two types of infection: *active infective endocarditis* and *prior endocarditis*. We have analysed the patients in the database who have either diagnosis. In addition there are a further series of fields that become relevant if the patient has a valve explanted, and one of these fields is *reason for repeat valve replacement* with one of the options being *infection*. We have also examined the data for these patients.

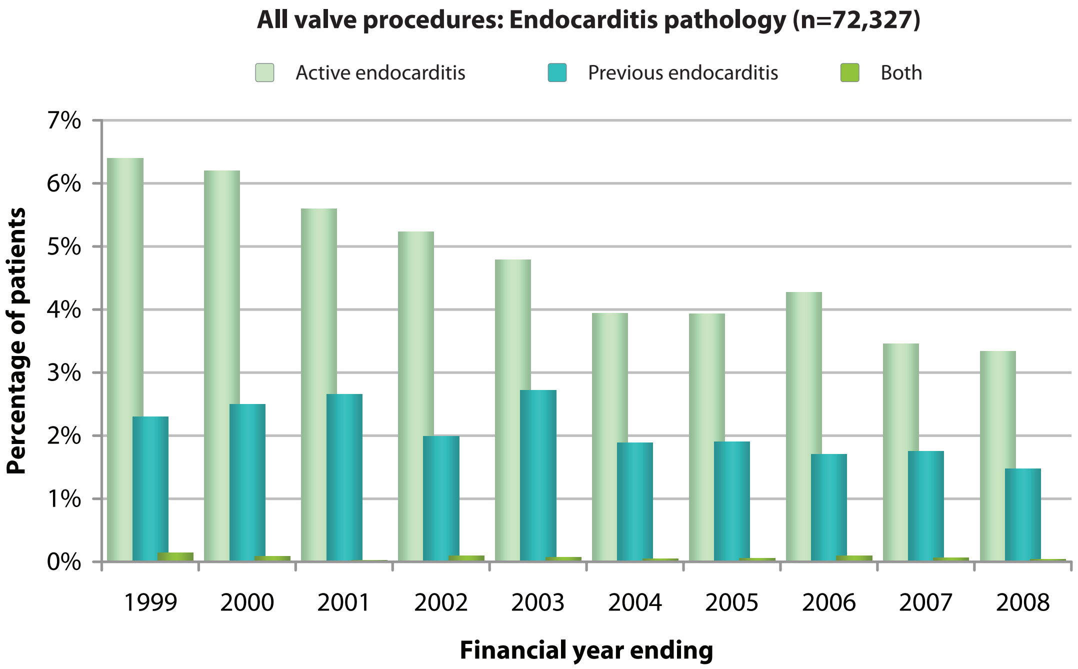
Valve surgery and native valve endocarditis; financial years 2004-2008

			Endocarditis					
			No	Active	Previous	Both	Unknown	**All**
Procedure groups	Aortic (±CABG)		28,323	720	266	8	1,126	**30,443**
	Mitral (±CABG)		9,096	455	385	7	383	**10,326**
	Aortic & Mitral (±CABG)	Aortic pathology	1,977	243	48	1	62	**2,331**
		Mitral pathology	1,981	236	52	1	61	**2,331**
		Overall pathology	1,945	253	62	6	65	**2,331**
	Others		8,958	488	169	9	237	**9,861**

The number of patients undergoing surgery for active endocarditis each year is now stable at around 400. This is an important *baseline* as NICE issued guidance in March 2008 [i] about the use of antibiotics to prevent endocarditis in at-risk patients undergoing dental and a variety of other procedures. Some observers have commented that the new guidance may lead to an increased incidence of endocarditis, and we will use the database to monitor carefully the incidence in the future.

i http://www.nice.org.uk/Guidance/CG64/Guidance/pdf/English


All valve procedures: Endocarditis pathology (n=4,525)
Active endocarditis
Previous endocarditis
Both
Number of operations
450
400
350
300
250
200
150
100
50
0
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Financial year ending


All valve procedures: Endocarditis pathology (n=72,327)
Active endocarditis
Previous endocarditis
Both
Percentage of patients
7%
6%
5%
4%
3%
2%
1%
0%
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Financial year ending

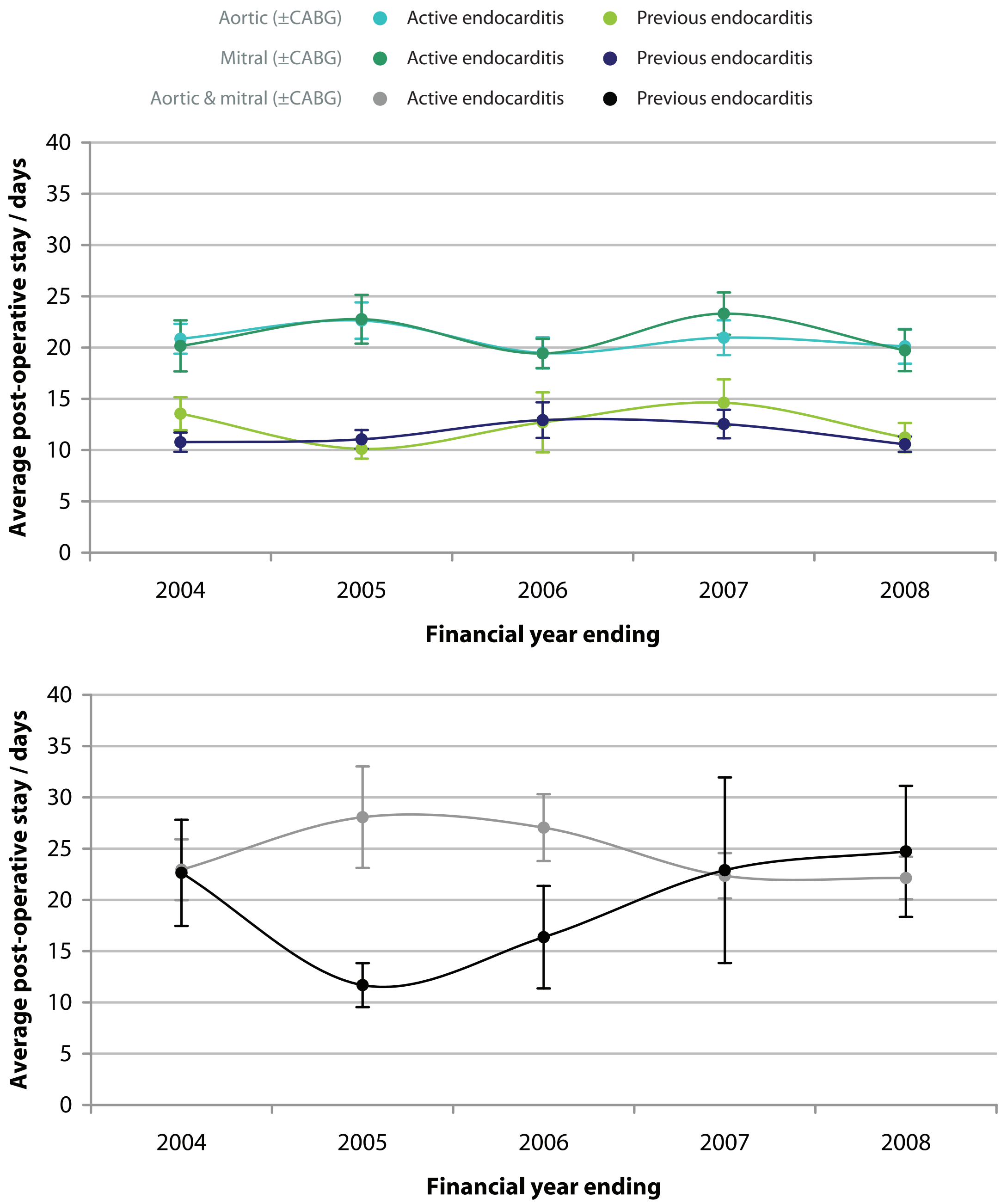
Post-operative stay

Surgery for active endocarditis is associated with an increased length-of-stay for 2 reasons: many of these patients are very unwell and develop complications after surgery, and almost all will require a prolonged course of intravenous antibiotics post-operatively, and will also need to stay in hospital for at least some of the course to be given. The length-of-stay is influenced by the presence of active endocarditis, but not by which valve is involved with infection.

Post-operative stay, pathology and financial year; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

			Financial year				
			2004	2005	2006	2007	2008
Valve and valve pathology	Aortic	Active endocarditis	20.9 154	22.6 134	19.5 140	21.0 114	20.1 155
		Previous endocarditis	13.6 49	10.1 60	12.7 41	14.6 55	11.2 49
	Mitral	Active endocarditis	20.2 67	22.8 77	19.4 108	23.3 90	19.7 97
		Previous endocarditis	10.8 70	11.0 66	12.9 66	12.5 88	10.6 82
	Aortic & mitral	Active endocarditis	22.9 35	28.1 46	27.0 46	22.4 54	22.1 61
		Previous endocarditis	22.6 11	11.7 16	16.4 11	22.9 10	24.7 11

Patients with endocarditis: Post-operative stay; bars denote standard errors (n=2,063)



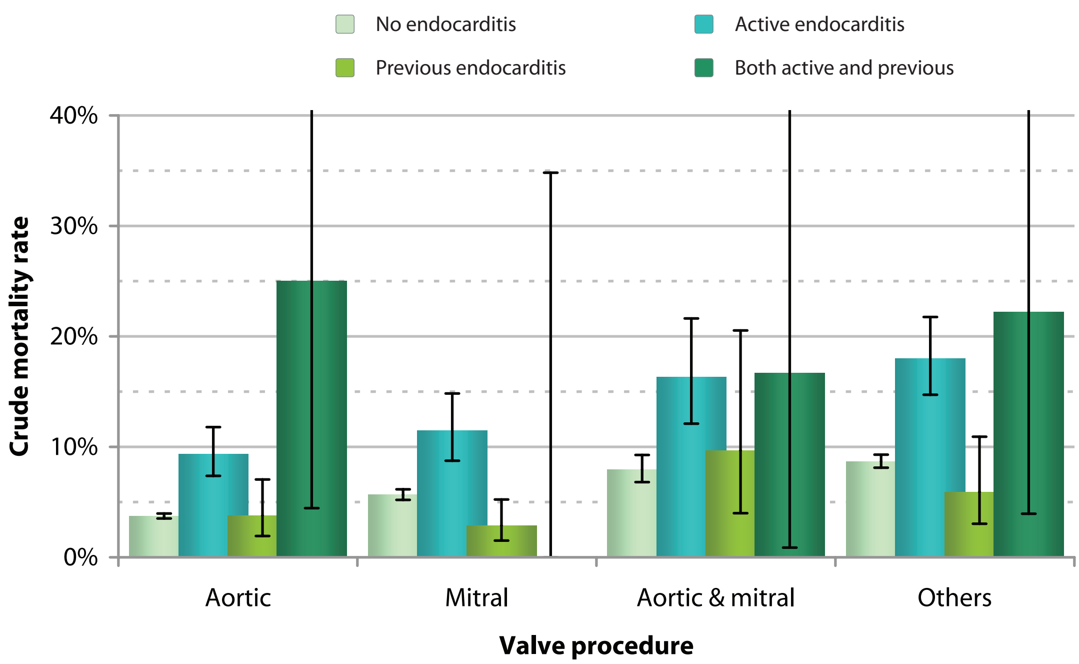
Mortality

Active endocarditis is associated with increased hospital mortality. Patients with previous endocarditis have a mortality that is similar to patients undergoing surgery for all other diagnoses. The mortality rate for surgery for active endocarditis on both the mitral & aortic valves is around 10%; for combined AVR & MVR it is higher. These results are similar to those recently published in a large multi-centre, multi-national study (Murdoch *et al*. 2009).

Mortality and native valve pathology for all valve operations; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

Procedure groups	Endocarditis: No	Active	Previous	Both	Unknown	**All**
Aortic (±CABG)	3.7% 28,196	9.4% 716	3.8% 265	25.0% 8	3.1% 1,117	**3.9% 30,302**
Mitral (±CABG)	5.7% 9,069	11.5% 454	2.9% 383	0.0% 7	7.9% 379	**5.9% 10,292**
Aortic & Mitral (±CABG)	8.0% 1,937	16.3% 251	9.7% 62	16.7% 6	15.4% 65	**9.1% 2,321**
Others	8.7% 8,922	18.0% 484	5.9% 169	22.2% 9	10.2% 235	**9.1% 9,819**

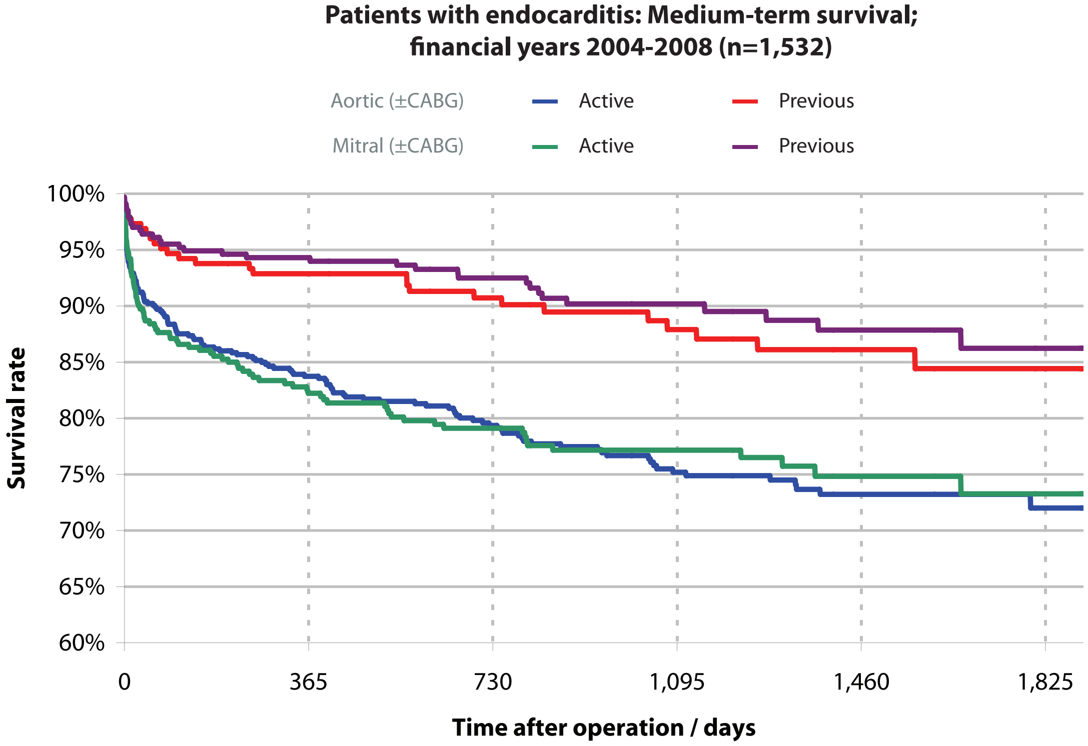
All valve procedures: Mortality and endocarditis; financial years 2004-2008 (n=50,938)



i Murdoch DR, Corey GR, Hoen B, Miró JM, Fowler VG Jr, Bayer AS, Karchmer AW, Olaison L, Pappas PA, Moreillon P, Chambers ST, Chu VH, Falcó V, Holland DJ, Jones P, Klein JL, Raymond NJ, Read KM, Tripodi MF, Utili R, Wang A, Woods CW, Cabell CH. International Collaboration on Endocarditis-Prospective Cohort Study (ICE-PCS) Investigators. Clinical presentation, etiology, and outcome of infective endocarditis in the 21st century: the International Collaboration on Endocarditis-Prospective Cohort Study. *Arch Intern Med.* 2009; **169(5):** 463-73

Medium-term survival

Medium-term survival is adversely affected by a diagnosis of active endocarditis.



Infection in a previous implant

Rules for inclusion in this group are that the patient must have had one or more known valves treated where both the *valve explant* is listed as a prior implant (autograft, homograft, biological or mechanical) **and** the reason for repeat valve surgery is *infection*.

The number of patients in the database recorded as having infection on a previous implant in this way is low. We can be confident that these patients truly did have prosthetic valve endocarditis (PVE), but it is probable that this is an underestimate of the total number. The mortality associated with surgery for PVE is high, and higher than for native valve endocarditis described above. The mortality, at around 20%, is similar to that reported in a large multi-centre, multi-national study published in 2007 (Wang *et al*. 2007).

Valve surgery and pathology in prior implants; financial years 2004-2008

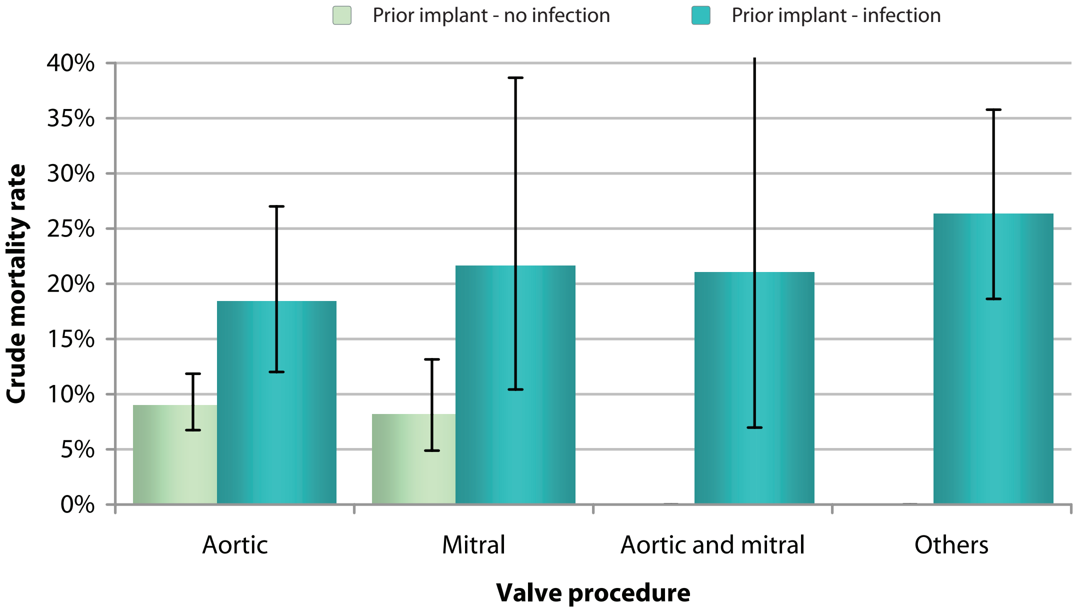
			Infection pathology in previously implanted valve					
			No	Yes	Pathology not specified	No prior implant	Explant unspecified	All
Procedure groups	Aortic (±CABG)		526	115	905	22,695	6,202	**30,443**
	Mitral (±CABG)		196	37	179	5,484	4,430	**10,326**
	Aortic & Mitral (±CABG)	Aortic pathology	65	14	76	1,742	434	**2,331**
		Mitral pathology	30	9	61	1,466	765	**2,331**
	Others			111				**9,861**

Mortality and pathology in prior implants; financial years 2004-2008; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group

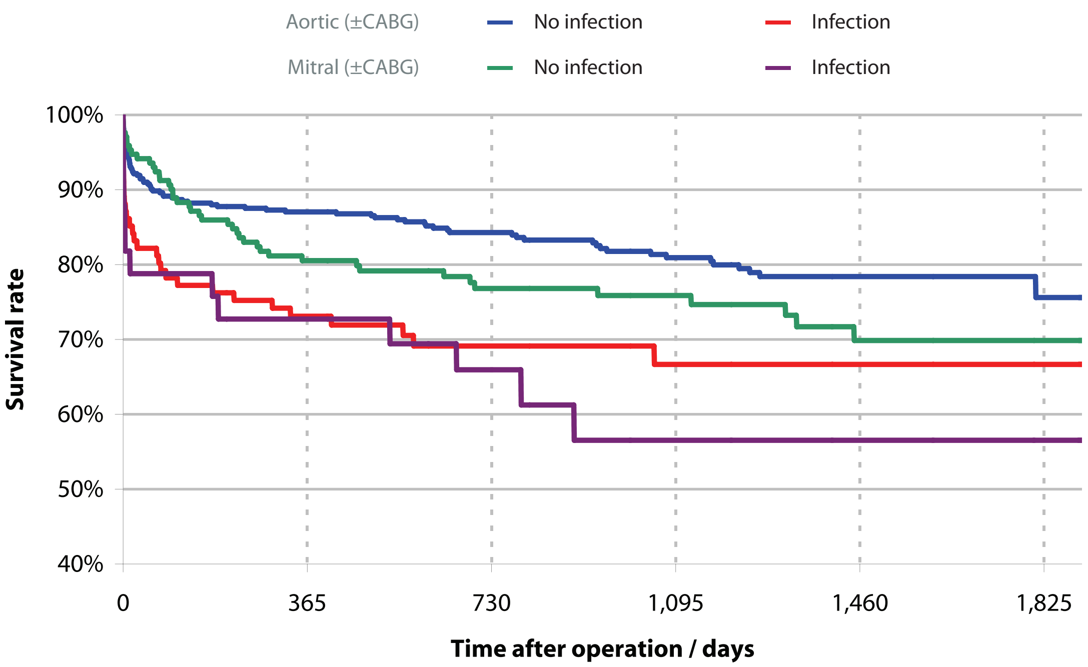
		Prior implant infection	
		No	Yes
Procedure groups	Aortic (±CABG)	9.0% 523	18.4% 114
	Mitral (±CABG)	8.2% 196	21.6% 37
	Aortic & Mitral (±CABG)	nd	21.1% 19
	Others	nd	26.4% 110

i Wang A, Athan E, Pappas PA, Fowler VG Jr, Olaison L, Paré C, Almirante B, Muñoz P, Rizzi M, Naber C, Logar M, Tattevin P, Iarussi DL, Selton-Suty C, Jones SB, Casabé J, Morris A, Corey GR, Cabell CH. International Collaboration on Endocarditis-Prospective Cohort Study Investigators. Contemporary clinical profile and outcome of prosthetic valve endocarditis. *JAMA*. 2007; **297(12):** 1354-61.

All valve procedures: Mortality and infection in prior valve implants; financial years 2004-2008



Patients with prior valve implants: Medium-term survival; financial years 2004-2008 (n=738)



Cardiac surgery in the elderly

Cardiac surgery in the elderly

Foreword

In writing the foreword for the chapter on cardiac surgery for the older person, I have to declare a vested interest! I am in the *older age* group - though as yet a healthy occupant of that group – but who knows when a heart that has worked well for decades could decide that it was not as good as it was, but could do better again with modern cardiac surgery.

The data tables in this book demonstrate clearly that older patients can now be optimistic about the outcomes of cardiac surgery. Two decades ago a surgeon's list would have had relatively few patients in this group. Too high risk, or maybe just not referred by their general practitioner for assessment. Today the technology is vastly improved as shown by the statistical results and, according to cardiac surgeons I have spoken to, one consequence is that nowadays wards are wall-to-wall with the elderly and aged.

In today's world, the image of the older person has changed dramatically. In general many older people are increasingly active after retirement – the carpet slipper syndrome has hopefully been banished along with the gold watch retirement party. Of course some succumb to illness, but, in the main, older people are active, live longer and make more effort to have a healthier lifestyle. Often physically fit and mentally alert, many engage in voluntary work or continue to work in private or public service.

The changing approach to treating this age group is, in my lay view, reflected in three areas:

- assessment
- the management of expectation
- trust

Firstly, assessment. Accepting that one cannot function at quite the pace that one did twenty years earlier, today when a previously active and healthy person decides to visit their GP complaining of *slowing down,* this is no longer attributed automatically as a sign of getting old for which, by implication, nothing can be done. Thankfully NHS commissioners now fully accept this. So a full assessment of the older person must be the order of the day, as with any younger patient, because the likelihood is that something positive can be done for the patient. Thus treatment options will be discussed. And importantly, the older patient will expect to be fully involved in any decisions about their future management. As attributed to the late Harvey Picker:

No decisions about me without me.

A very great friend of mine, an 80-year-old lady, told me she had been aware of her heart problem for years, but was too frightened to go into hospital. However, just recently she has had a mitral valve replacement with a very good result. Earlier her general practitioner had provided good care, understanding and respecting her reluctance to go for operative treatment partly because of fear and partly because her first priority was to look after her invalid husband. After her husband died, her doctor persuaded her to let him refer her to a cardiac surgeon. In the event the surgeon's sympathetic exploration of her background in the assessment stage, and the understanding he showed was, she felt, really important in the successful management of her case. It was certainly fundamental in building her trust in him.

We older people tend to be realistic about our expectations. We recognize that we are not going to live forever. Hence the natural pragmatism of the elderly, which recognizes that unwanted side effects – even death – might occur. That said, we hope for a positive improvement in the quality of life. So how encouraging it is for older patients that the results presented in this book show such impressive medium-term survival following heart surgery. My friend never imagined that she would be so much better in a matter of weeks after her operation, well enough to let her tackle a five-mile walk over rough ground with her beloved dog, something she had not been able to do for many years.

In older people serious surgery can conjure up strong fears of loss of independence. As they got older they will have assiduously guarded their personal independence as they coped with the adjustment to retirement and an altered lifestyle, and perhaps the loss of a life-partner through bereavement. For them this fear – whether justified or not – of semi-permanent dependence following surgery can be a very difficult thing to face up to. Younger people, on the other hand, are less likely to dwell on this because they can feel more certain about a healthy future.

I think it is therefore very important that surgeons and their clinical teams fully recognize just how powerful this fear can be. Much encouragement and practical thought need to go into the immediate post-operative care, emphasizing positive progress. And that needs to tie in with the arrangements on discharge. For example my elderly friend, who had no immediate family, was looked after when she went home by someone from her village who had helped her in the house two mornings a week for years. At no time was this person included in discharge planning. So the unofficial carers need to be engaged by the team. And don't forget to ask who would be looking after the pets!

Finally, and most importantly, there is trust. I questioned my friend closely about how she approached her much -feared hospital admission. She recounted the engaging manner and the thoughtful – and never patronizing – explanations given to her by her consultant at every stage. He made her feel that she was at the forefront of his mind, the most important person in discussions that proceeded at a pace she felt comfortable with. And so, quite quickly, she developed a relationship with him, and through that trust. She felt that she was in his safe hands and was confident that he would use all his skills to achieve a positive outcome. That feeling of trust extended, through him, to the clinical team until, through their later involvement, she got to know individual members in their own right.

For patients everywhere trust in their doctors is fundamental. For me the significance of this book lies in the commitment of British and Irish heart surgeons to be as sure as they possibly can be, and to show everyone openly, that their patients' trust in them is well-founded. That's an achievement of which they should be justly proud.

Lady Irvine, MBE

Lady Irvine has worked in the NHS for 30 years. Her roles include previous Director of Midwifery in Sunderland and, most recently, Chairman of the South of Tyne and Wearside Mental Health NHS Trust and Chair of the Sunderland Carers Centre. Since 2006 she has been involved with the SCTS Birmingham Professional Development course and she has chaired the National Registrar Selection and Recruitment process into Cardiothoracic Surgery in 2008 and 2009.

Introduction

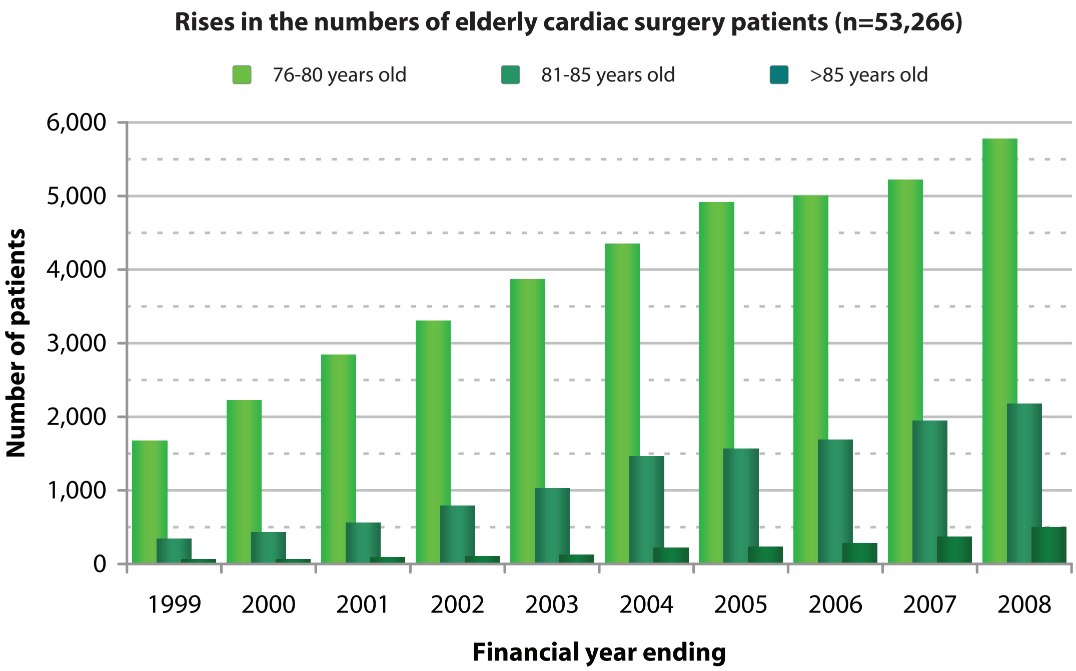
Key points on cardiac surgery in the elderly

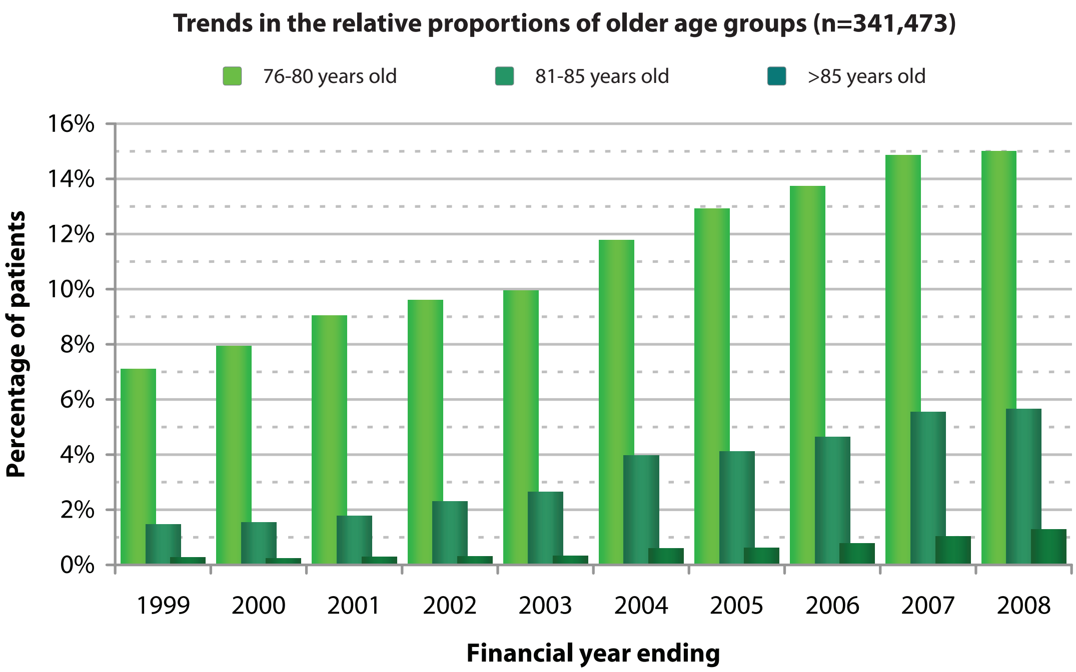
- The proportion of patients who are elderly or very elderly has increased consistently over time. Patients over the age of 75 now make up more than 20% of all cardiac surgery.
- The proportion of patients who undergo isolated CABG surgery decreases with increasing age, and the proportion of valve surgery increases; more than two-thirds of operations on patients over 85 are valve operations.
- The in-hospital mortality rate increases with increasing age, but for octogenarian patients undergoing isolated CABG or valve surgery the rate is under 10%. This needs to be seen against the severity of cardiac disease and the adverse affect on the overall quality-of-life for these patients if they should not undergo surgery.
- The overall mortality rates for patients between 81 and 85 is 7.8% and for patients over 85 is 9.2%.
- Length-of-stay, re-exploration rates for bleeding, post-operative stroke and new post-operative renal intervention rates all increase with increasing age.
- Medium-term survival is also affected by increased age, but the Kaplan-Meier survival rate for patients over the age of 80 undergoing CABG surgery is nearly 70% at 5 years post-surgery.
- Elderly patients admitted directly from home have better outcomes. These outcomes are given in detail and should be of use for providing informed consent for elderly patients, where the relative risks and benefits of cardiac surgery may be hard to assess.

The data displayed on page 51 clearly show that patients coming to coronary artery bypass surgery are increasing in age, and the graphs on page 167, 253 and 277 show the increasing proportion of elderly and very elderly patients coming to cardiac surgery of all types. These findings need to be seen in the context of an overall aging of the population in the United Kingdom; people are living longer and have a greater expectation of good quality-of-life throughout. However, from the perspective of cardiac surgery, it is important to recognise that increasing age remains an important risk factor for operative mortality, morbidity and resource utilisation, as described in the earlier sections.

We have explored these issues a little further in this section, and have looked in detail at all patients undergoing cardiac surgery who are over the age of 75, explored how they differ from younger patients and described their current outcomes following surgery.

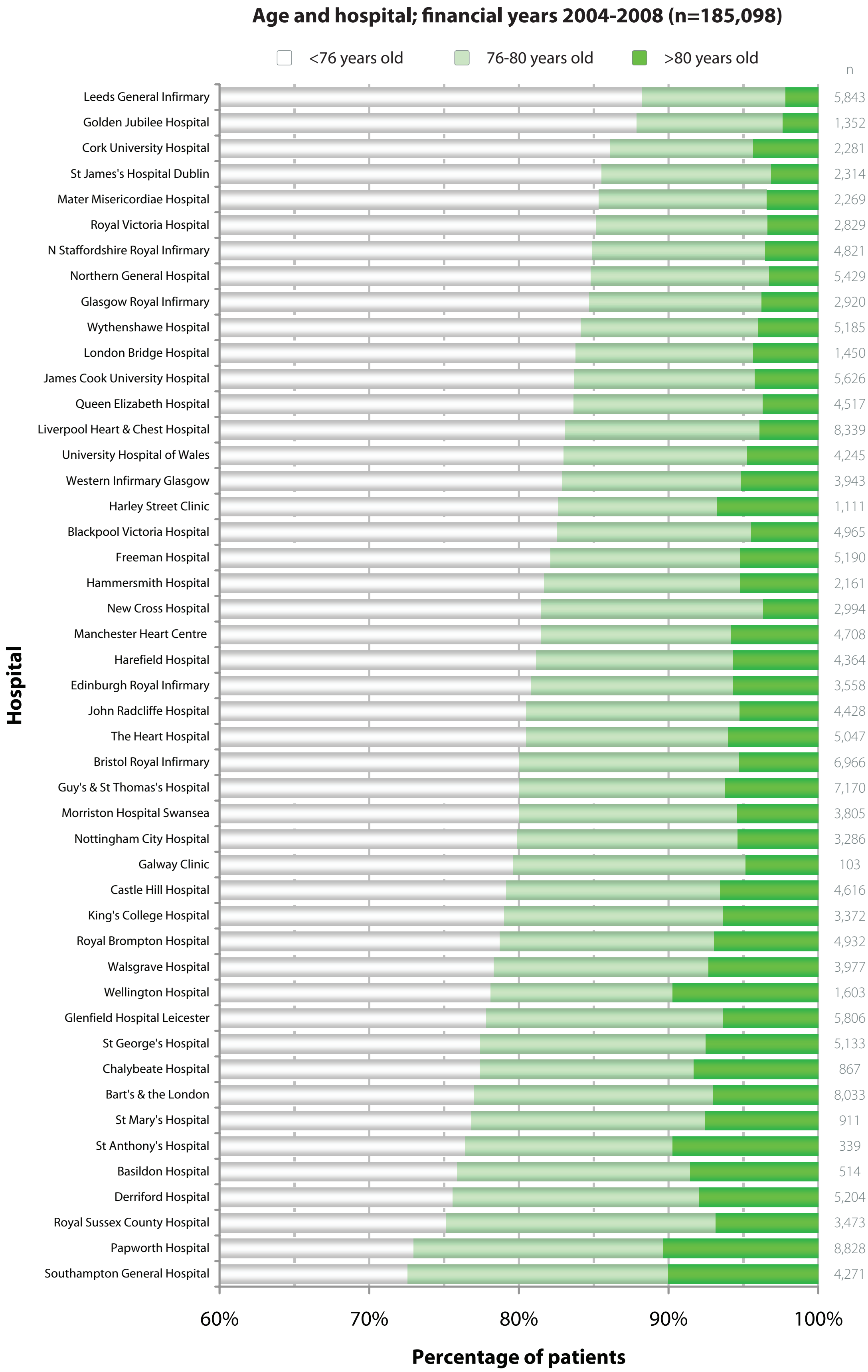
The number and proportion of patients in the various age bandings over the age of 75 are all increasing. Elderly patients now form a sizeable proportion of total cardiac surgery. The proportion of patients who are elderly and very elderly varies markedly across the different centres submitting data to the database. In England and Scotland there is an apparent *North-South divide*, with the hospitals in the South generally having a greater proportion of more elderly patients.





Inter-hospital variation in age profiles

There are marked variations in the proportion of elderly and very elderly patients in the various units around the country.



Procedures performed at each hospital sub-divided by age group; financial years 2004-2008

		Age at surgery / years				
		<=75	76-80	>80	Blank	All
Hospital	Bart's & the London	6,187	1,281	565	0	**8,033**
	Blackpool Victoria Hospital	4,100	643	222	0	**4,965**
	Bristol Royal Infirmary	5,574	1,024	368	0	**6,966**
	Castle Hill Hospital	3,654	659	303	0	**4,616**
	Chalybeate Hospital, Southampton	671	124	72	0	**867**
	Cork University Hospital	1,964	218	99	0	**2,281**
	Derriford Hospital	3,934	857	413	0	**5,204**
	Edinburgh Royal Infirmary	2,876	480	202	0	**3,558**
	Essex Cardiothoracic Centre, Basildon	390	80	44	0	**514**
	Freeman Hospital, Newcastle	4,262	659	269	0	**5,190**
	Galway Clinic	82	16	5	0	**103**
	Glasgow Royal Infirmary	2,473	337	110	9	**2,929**
	Glasgow Western Infirmary	3,268	471	204	0	**3,943**
	Glenfield Hospital, Leicester	4,518	918	370	0	**5,806**
	Golden Jubilee Hospital, Glasgow	1,188	132	32	1	**1,353**
	Guy's & St Thomas's Hospital, London	5,736	989	445	0	**7,170**
	Hammersmith Hospital, London	1,765	283	113	3	**2,164**
	Harefield Hospital, Middlesex	3,542	574	248	0	**4,364**
	Harley Street Clinic, London	918	118	75	0	**1,111**
	James Cook University Hospital, Middlesbrough	4,708	680	238	2	**5,628**
	John Radcliffe Hospital, Oxford	3,564	632	232	1	**4,429**
	King's College Hospital, London	2,665	493	214	0	**3,372**
	Leeds General Infirmary	5,157	558	128	0	**5,843**
	Liverpool Heart & Chest Hospital	6,930	1,082	327	107	**8,446**
	London Bridge Hospital	1,215	172	63	2	**1,452**
	Manchester Heart Centre	3,836	598	274	0	**4,708**
	Mater Misericordiae Hospital, Dublin	1,936	255	78	0	**2,269**
	Morriston Hospital, Swansea	3,044	554	207	1	**3,806**
	New Cross Hospital, Wolverhampton	2,440	444	110	0	**2,994**
	N Staffordshire Royal Infirmary, Stoke-on-Trent	4,093	557	171	0	**4,821**
	Northern General Hospital, Sheffield	4,604	647	178	0	**5,429**
	Nottingham City Hospital	2,625	484	177	0	**3,286**
	Papworth Hospital, Cambridge	6,442	1,474	912	0	**8,828**
	Queen Elizabeth Hospital, Birmingham	3,779	571	167	0	**4,517**
	Royal Brompton Hospital, London	3,883	706	343	0	**4,932**
	Royal Sussex County Hospital, Brighton	2,610	625	238	0	**3,473**
	Royal Victoria Hospital, Belfast	2,410	323	96	0	**2,829**
	Southampton General Hospital	3,099	744	428	0	**4,271**
	St Anthony's Hospital, London	259	47	33	0	**339**
	St George's Hospital, London	3,974	774	385	0	**5,133**
	St James's Hospital, Dublin	1,979	262	73	0	**2,314**
	St Mary's Hospital, London	700	142	69	0	**911**
	The Heart Hospital	4,062	681	304	0	**5,047**
	University Hospital of Wales, Cardiff	3,523	521	201	0	**4,245**
	Walsgrave Hospital, Coventry	3,115	571	291	0	**3,977**
	Wellington Hospital, London	1,252	195	156	0	**1,603**
	Wythenshawe Hospital	4,362	616	207	0	**5,185**
	All	**149,368**	**25,271**	**10,459**	**126**	**185,224**

i We are unable to present age data for Aberdeen Royal Infirmary. Age data were collected in the unit and transferred to CCAD; however, due to technical issues within CCAD, the age data were not transferred to the analytical unit at Dendrite Clinical Systems.

Age and procedure

For the following tables and charts in this section, we have allocated patients into 4 groups: CABG alone, valve & CABG, valve alone and all other operations.

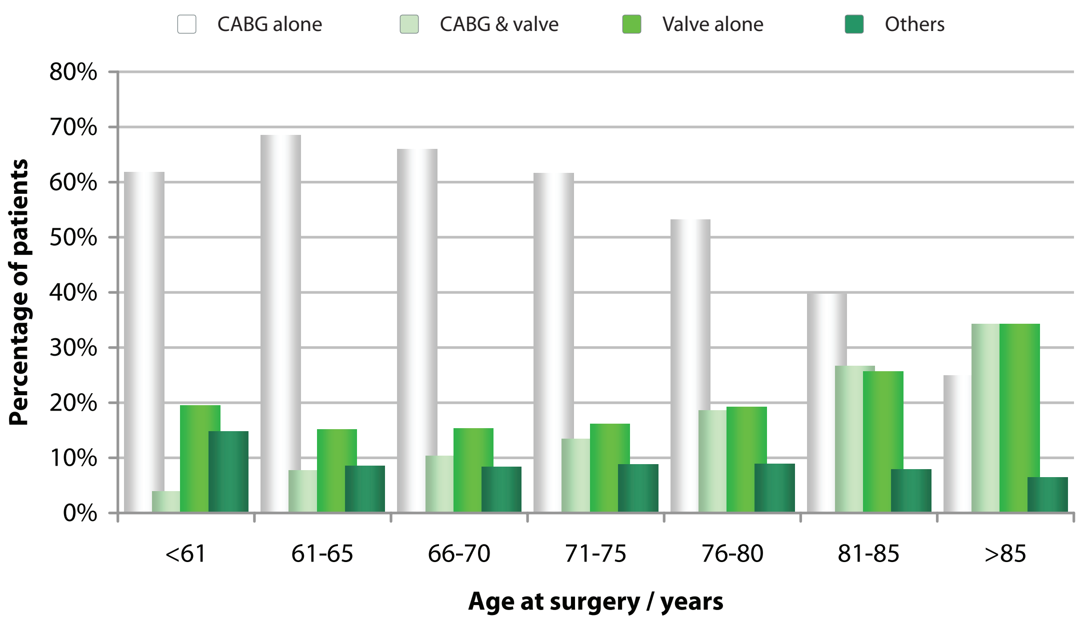
The proportion of the different operative groups changes as patients get older: CABG becomes less predominant and valve surgery increases in incidence.

Coronary artery bypass grafting operations comprise nearly 70% of surgery for patients aged between 61 and 65 years of age; for those over the age of 85, more than two-thirds of patients have valve surgery.

Procedure groupings for each of the age groups; financial years 2004-2008

		Procedure groupings					
		CABG alone	CABG & valve	Valve alone	Others	Unspecified	**All**
Age / years	<61	31,677	2,004	10,006	7,567	42	**51,296**
	61-65	19,335	2,189	4,283	2,424	13	**28,244**
	66-70	22,727	3,576	5,287	2,881	6	**34,477**
	71-75	21,785	4,732	5,701	3,120	13	**35,351**
	76-80	13,452	4,695	4,858	2,259	7	**25,271**
	81-85	3,510	2,362	2,272	701	4	**8,849**
	>85	402	552	552	104	0	**1,610**
	Unspecified	1,688	294	407	164	5	**2,558**
	All	**114,576**	**20,404**	**33,366**	**19,220**	**90**	**187,656**

Procedure grouping and age group; financial years 2004-2008 (n=185,013)



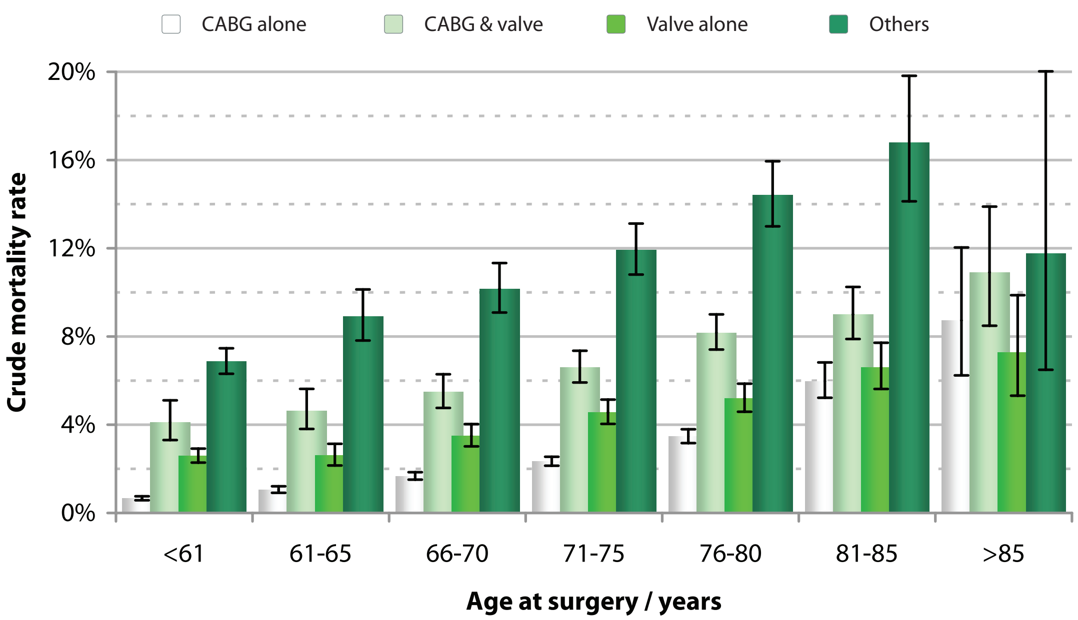
Mortality and age

Mortality increases with increasing age for all operative groups. However, the mortality rates for isolated CABG and isolated valve surgery remain low. It should be remembered that patients coming to cardiac surgery who are elderly almost always have severe disease that would adversely affect their life expectancy, and their operative mortality rate needs to be seen in that context. The mortality rates for patients undergoing combined operations are consistently higher, and this should be remembered when decisions are made about the relative risk and benefits for individual patients.

Mortality, age and procedure groupings; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group; financial years 2004-2008

		Procedure groupings					
		CABG alone	CABG & valve	Valve alone	Other	Not known	**All**
Age / years	<61	0.7% 31,609	4.1% 1,993	2.6% 9,988	6.9% 7,543	17.5% 40	**2.1% 51,173**
	61-65	1.1% 19,294	4.6% 2,179	2.6% 4,267	8.9% 2,413	13.4% 13	**2.2% 28,166**
	66-70	1.7% 22,671	5.5% 3,560	3.5% 5,271	10.2% 2,876	0.0% 5	**3.1% 34,383**
	71-75	2.3% 21,734	6.6% 4,173	4.6% 5,683	11.9% 3,105	23.1% 13	**4.1% 35,248**
	76-80	3.5% 13,405	8.2% 4,675	5.2% 4,838	14.4% 2,242	28.6% 7	**5.7% 25,167**
	81-85	6.0% 3,498	9.0% 2,345	6.6% 2,260	16.8% 697	0.0% 3	**7.8% 8,803**
	>85	8.7% 401	10.9% 550	7.3% 549	11.8% 102	0.0% 0	**9.2% 1,602**
	Unspecified	2.4% 1,688	9.5% 294	3.4% 407	20.7% 164	25.0% 4	**4.6% 2,557**
	All	**1.8% 114,300**	**6.7% 20,309**	**3.8% 33,263**	**9.8% 19,142**	**17.6% 85**	**3.5% 187,099**

Mortality, procedure and age group; financial years 2004-2008 (n=184,461)



Mortality, age and procedure groupings for isolated, single valve procedures; the upper numbers represent the crude percentage mortality rate and the lower numbers the procedure count within the sub-group; financial years 2004-2008

		Procedure groupings					
		AVR		MV repair		MVR	
		Valve alone	Valve & CABG	Valve alone	Valve & CABG	Valve alone	Valve & CABG
Age / years	<61	1.7% 4,700	2.2% 999	1.0% 1,261	5.2% 345	4.1% 1,258	5.3% 208
	61-65	1.7% 2,188	2.9% 1,284	0.8% 508	6.3% 285	4.5% 538	10.9% 193
	66-70	1.9% 2,733	4.1% 2,116	1.6% 489	7.5% 371	6.4% 660	7.7% 272
	71-75	3.2% 3,130	5.0% 2,866	3.0% 503	9.4% 467	8.5% 601	12.1% 347
	76-80	3.8% 2,919	6.1% 3,069	5.3% 396	10.9% 432	8.5% 414	15.9% 226
	81-85	5.8% 1,546	7.9% 1,725	4.0% 101	10.5% 105	9.8% 112	23.3% 73
	>85	5.5% 420	10.7% 431	11.1% 18	16.7% 12	28.6% 14	14.3% 7
	Unspecified	3.3% 92	13.1% 84	0.0% 7	0.0% 4	5.9% 17	0.0% 11
	All	**2.8%** **17,728**	**5.3%** **12,574**	**2.0%** **3,283**	**8.3%** **2,021**	**6.1%** **3,614**	**11.1%** **1,337**

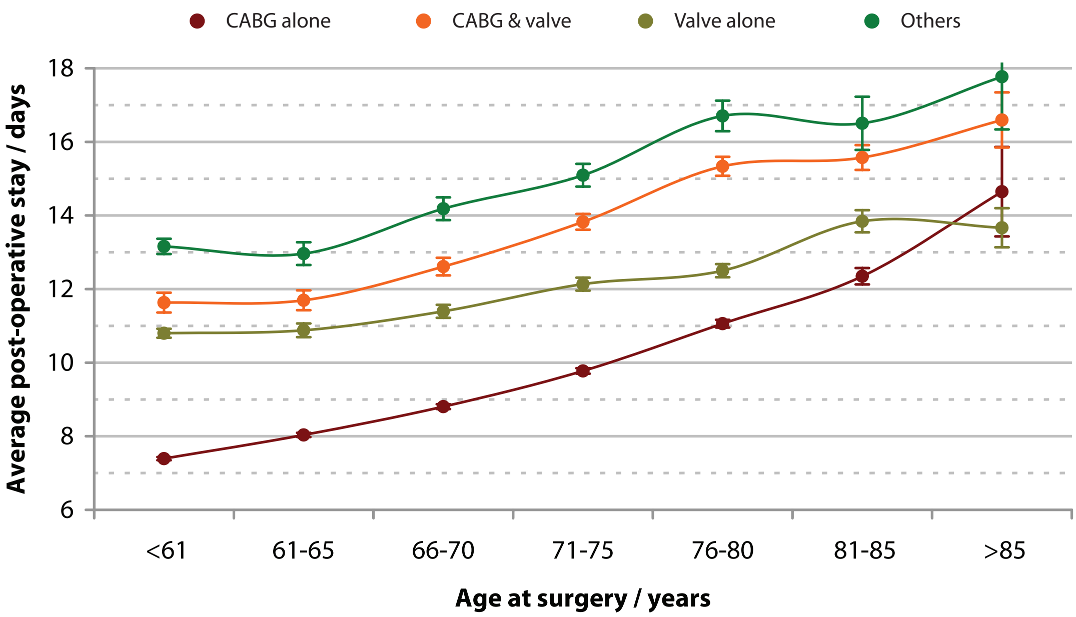
Post-operative stay and age

Post-operative length-of-stay rises with increasing age. The increasing proportion of elderly patients undergoing surgery will, therefore, be associated with a concomitant increase in the consumption of resources.

Post-operative stay, age and procedure; financial years 2004-2008; the upper numbers represent the average post-operative stay in days and the lower numbers the procedure count within the sub-group

Age / years	Procedure groupings				
	CABG alone	CABG & valve	Valve alone	Other	**All**
<61	7.4 30,212	11.6 1,906	10.8 9,572	13.2 7,336	**9.1** **49,053**
61-65	8.0 18,423	11.7 2,096	10.9 4,118	13.0 2,360	**9.2** **27,007**
66-70	8.8 21,608	12.6 3,429	11.4 5,069	14.2 2,783	**10.1** **32,892**
71-75	9.8 20,807	13.8 4,536	12.1 5,495	15.1 3,050	**11.2** **33,896**
76-80	11.1 12,836	15.3 4,527	12.5 4,691	16.7 2,196	**12.7** **24,256**
81-85	12.3 3,362	15.6 2,281	13.8 2,178	16.5 685	**13.9** **8,507**
>85	14.6 385	16.6 539	13.7 528	17.8 101	**15.2** **1,553**
Unspecified	9.4 1,682	12.5 293	11.6 405	11.7 164	**10.3** **2,548**
All	**8.9** **109,315**	**13.8** **19,607**	**11.6** **32,056**	**14.2** **18,675**	**10.5** **179,712**

Post-operative stay and age for the various procedure groups; bars denote standard errors; financial years 2004-2008 (n=177,109)



Other outcomes

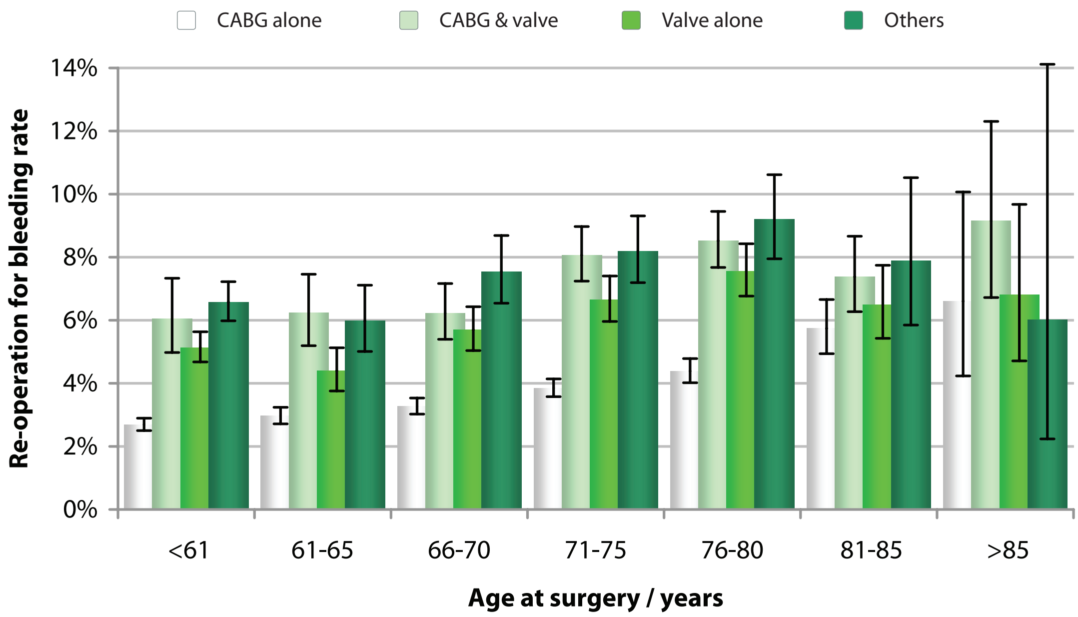
Re-operation for post-operative bleeding and age

Re-operations for bleeding, in general, increase as patients become older.

Re-operation for post-operative bleeding, age & procedure; the upper numbers represent the percentage re-operation rate and the lower numbers the procedure count within the sub-group; financial years 2004-2008

Age / years	Procedure groupings: CABG alone	CABG & valve	Valve alone	Others	All
<61	2.7% 26,754	6.1% 1,669	5.1% 8,393	6.6% 6,295	**3.9%** **43,141**
61-65	3.0% 16,388	6.2% 1,845	4.4% 3,596	6.0% 2,058	**3.7%** **23,895**
66-70	3.3% 19,021	6.2% 2,989	5.7% 4,425	7.5% 2,425	**4.3%** **28,865**
71-75	3.8% 18,239	8.1% 3,931	6.6% 4,724	8.2% 2,674	**5.2%** **29,576**
76-80	4.4% 11,264	8.5% 3,908	7.6% 4,024	9.2% 1,881	**6.2%** **21,084**
81-85	5.7% 2,944	7.4% 1,924	6.5% 1,833	7.9% 558	**6.5%** **7,260**
>85	6.6% 318	9.2% 448	6.8% 441	6.0% 83	**7.5%** **1,290**
Unspecified	23.4% 77	25.0% 40	26.9% 52	36.4% 11	**25.0%** **184**
All	**3.4%** **95,005**	**7.4%** **16,754**	**5.9%** **27,488**	**7.3%** **15,985**	**4.7%** **155,295**

Re-operation for post-operative bleeding, procedure and age group; financial years 2004-2008 (n=155,052)



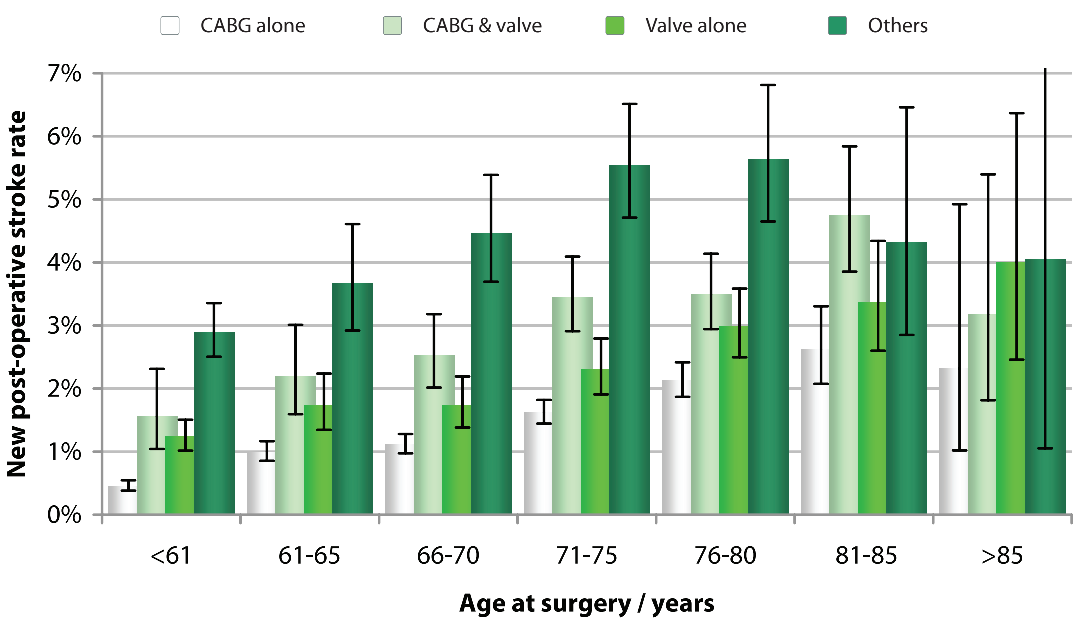
New post-operative stroke and age

Stroke rates also increase with increasing age. This is a much-feared complication of cardiac surgery and conveying likely post-operative stroke rates to patients is an important facet of providing informed consent; many elderly patients fear a stroke more than death. As shown on page 136 stroke is associated with high in-hospital mortality, a prolonged length-of-stay and worse medium-term survival.

New post-operative stroke, age and procedure groupings; the upper numbers represent the crude percentage rate & the lower numbers the procedure count within the sub-group; financial years 2004-2008

Age / years	Procedure groupings				
	CABG alone	CABG & valve	Valve alone	Others	**All**
<61	0.5% 26,895	1.6% 1,666	1.2% 8,322	2.9% 6,239	**1.0% 43,159**
61-65	1.0% 16,322	2.2% 1,820	1.7% 3,566	3.7% 2,044	**1.4% 23,759**
66-70	1.1% 18,886	2.5% 2,998	1.7% 4,304	4.5% 2,418	**1.6% 28,611**
71-75	1.6% 18,005	3.5% 3,851	2.3% 4,675	5.5% 2,597	**2.3% 29,139**
76-80	2.1% 11,054	3.5% 3,808	3.0% 3,974	5.6% 1,845	**2.9% 20,688**
81-85	2.6% 2,783	4.8% 1,873	3.4% 1,782	4.3% 555	**3.5% 6,995**
>85	2.3% 302	3.2% 441	4.0% 450	4.1% 74	**3.3% 1,267**
Unspecified	0.1% 816	4.0% 175	0.4% 232	3.7% 81	**0.9% 1,308**
All	**1.2% 95,063**	**3.1% 16,632**	**2.0% 27,305**	**4.1% 15,850**	**1.8% 154,926**

New post-operative stroke, procedure and age group; financial years 2004-2008 (n=153,549)



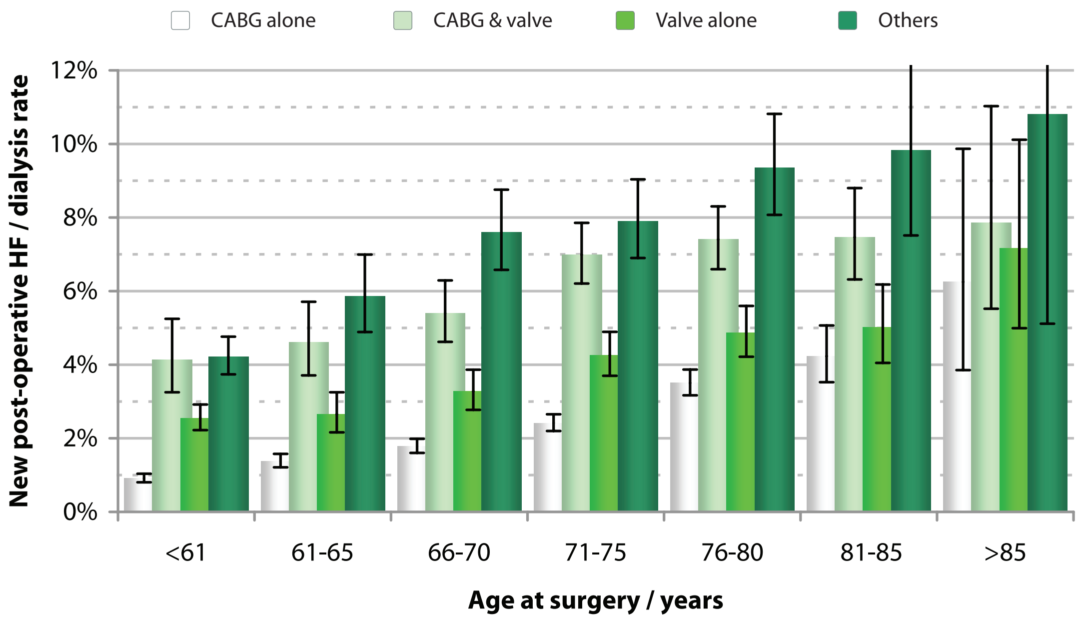
New post-operative HF / dialysis and age

New post-operative renal intervention also becomes more likely as patients become older.

New post-operative HF / dialysis, age & procedure; the upper numbers represent the crude percentage HF / dialysis rate and the lower numbers the procedure count within the sub-group; financial years 2004-2008

Age / years	Procedure groupings: CABG alone	CABG & valve	Valve alone	Others	All
<61	0.9% 28,827	4.1% 1,643	2.5% 8,200	4.2% 6,135	**1.8% 42,842**
61-65	1.4% 16,267	4.6% 1,800	2.7% 3,542	5.9% 2,015	**2.2% 23,634**
66-70	1.8% 18,779	5.4% 2,946	3.3% 4,274	7.6% 2,369	**2.9% 28,373**
71-75	2.4% 179,261	7.0% 3,807	4.3% 4,580	7.9% 2,543	**3.8% 28,864**
76-80	3.5% 10,906	7.4% 3,741	4.9% 3,887	9.4% 1,806	**5.0% 20,346**
81-85	4.2% 2,765	7.5% 1,808	5.0% 1,716	9.8% 539	**5.7% 6,830**
>85	6.3% 288	7.9% 407	7.2% 433	10.8% 74	**7.4% 1,202**
Unspecified	81.7% 464	58.7% 126	66.0% 14	82.5% 63	**75.1% 798**
All	**2.3% 94,219**	**6.7% 16,278**	**3.9% 26,773**	**6.7% 15,544**	**3.5% 152,889**

New post-operative HF / dialysis, procedure and age group; financial years 2004-2008 (n=152,020)



Medium-term survival

Medium-term survival is not as high for older patients, but the figures here are remarkably good. The medium-term survival rate in patients over the age of 80 undergoing isolated CABG surgery is nearly 70% 5 years after surgery.

Medium-term survival rates and age; the upper numbers represent the percentage Kaplan-Meier survival rate at 5 years after surgery and the lower numbers the procedure count within the sub-group; where numbers are small and the data do not extend as far as 5-years, the last known survival rate is reported

		Age at surgery / years			
		<76 years	>75 years	>80 years	>85 years
Procedure	Isolated CABG	90.8% 74,426	76.6% 13,669	69.2% 3,053	68.6% 296
	CABG & valve	78.1% 9,701	63.4% 5,909	56.6% 2,214	44.6% 408
	CABG & AVR	80.7% 5,722	64.7% 4,116	55.8% 1,660	44.2% 328
	CABG & MV repair	76.2% 889	75.0% 448	73.3% 93	72.9% 8
	CABG & MV replacement	69.4% 594	60.3% 250	58.9% 64	85.7% 7
	CABG, valve & other	69.1% 1,058	62.3% 562	54.6% 152	56.9% 20
	CABG & other	75.1% 1,737	61.7% 575	54.2% 121	25.4% 11
	Isolated valve	86.0% 19,572	67.7% 5,973	61.6% 2,174	57.5% 404
	Isolated AVR	87.3% 10,002	69.6% 3,849	65.1% 1,526	59.1% 310
	Isolated MV repair	92.1% 1,808	75.3% 426	72.0% 96	68.4% 13
	Isolated MV replacement	83.1% 1,863	65.8% 416	33.9% 93	25.0% 8
	Valve & other	83.7% 3,778	60.4% 917	58.4% 264	66.1% 43
	Other	78.1% 3,855	53.8% 439	53.8% 121	40.4% 13

Elective surgery in the elderly

Rates of elective surgery

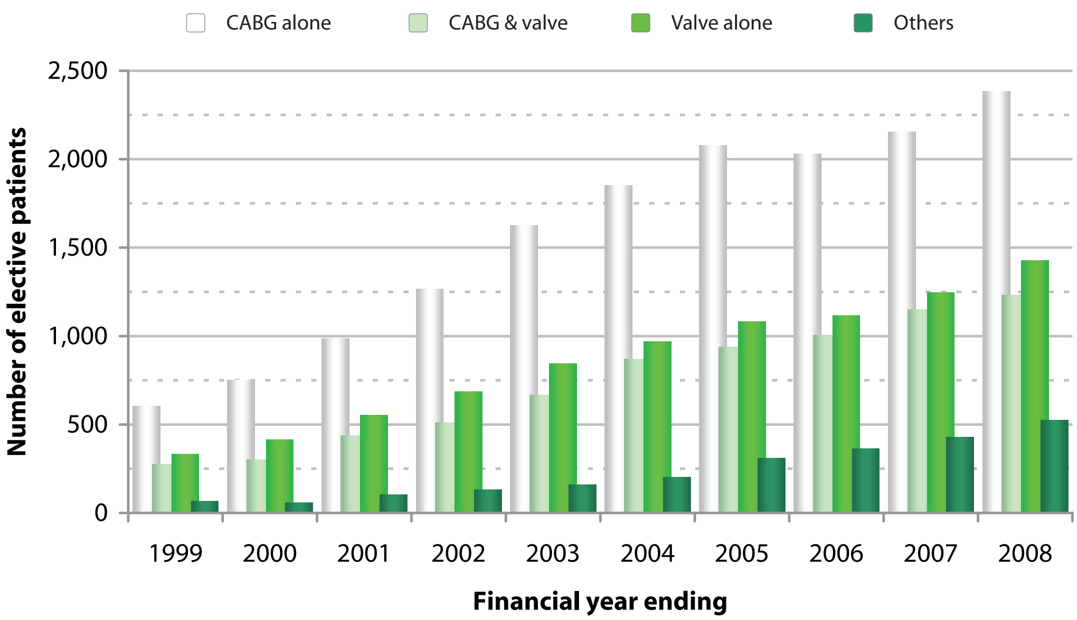
Some elderly patients are admitted to hospital for surgery, and it may be difficult for them to get home without it. Others are living at home but are limited by symptoms, which could potentially be alleviated by cardiac surgery. These patients will be assessed in the outpatient clinic and a decision will need to be made by the patient, their relatives, friends and carers and the surgical team about the likely benefits and risks of surgery . The following section outlines the outcomes of these elective elderly patients in more detail.

Elective operation rates according to age and procedure groupings; financial years 2004-2008; the upper numbers represent the percentage elective-operation rate and the lower numbers the procedure count within the sub-group

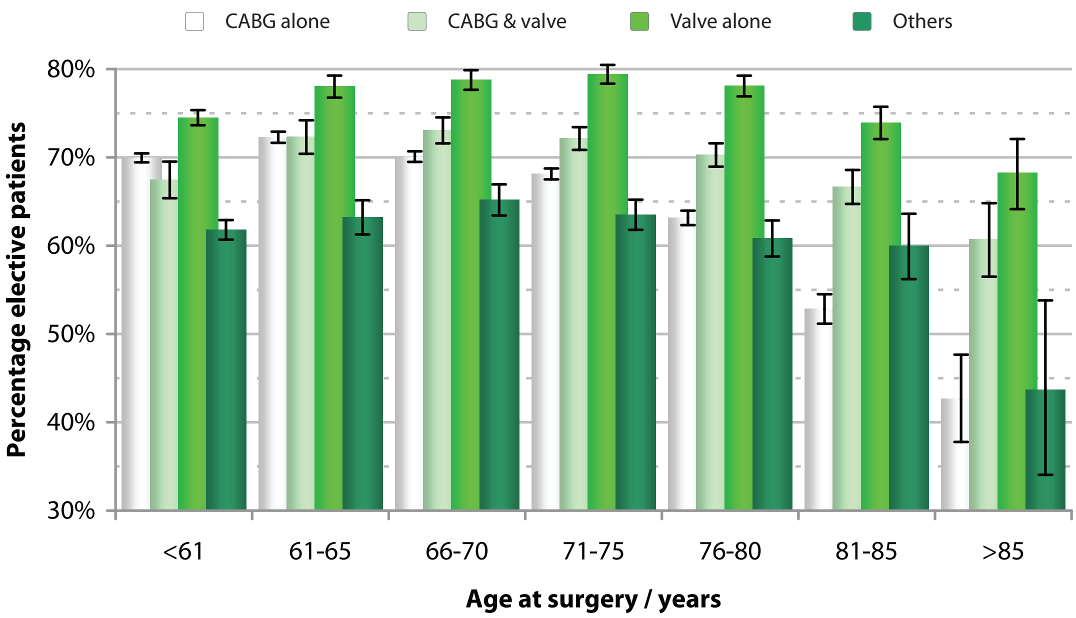
		Procedure groupings				
		CABG alone	CABG & valve	Valve alone	Others	**All**
Age / years	<61	69.9% 31,603	67.5% 1,996	74.5% 9,990	61.8% 7,489	**69.5%** **51,114**
	61-65	72.3% 19,294	72.3% 2,184	78.0% 4,272	63.2% 2,415	**72.4%** **28,176**
	66-70	70.1% 22,674	73.1% 3,566	78.8% 5,270	65.2% 2,865	**71.3%** **34,378**
	71-75	68.1% 21,721	72.2% 4,719	79.4% 5,683	63.5% 3,103	**70.1%** **35,236**
	76-80	63.2% 13,423	70.3% 4,682	78.1% 4,850	60.8% 2,252	**67.1%** **25,213**
	81-85	52.8% 3,507	66.7% 2,356	73.9% 2,268	60.0% 697	**62.5%** **8,830**
	>85	42.6% 401	60.7% 550	68.2% 551	43.7% 103	**57.7%** **1,605**
	Unspecified	75.9% 1,688	86.1% 294	86.0% 407	61.3% 163	**77.7%** **2,556**
	All	**68.7%** **114,311**	**70.7%** **20,347**	**77.0%** **33,291**	**62.5%** **19,087**	**69.8%** **187,108**

In younger patients about 70% undergo surgery as elective cases; in the very elderly a different pattern is seen. Less than 50% of patients aged over 85 undergoing isolated CABG are elective patients, but the proportion of patients undergoing valve surgery who are admitted from home is somewhat higher.

Trends in the number of elective patients aged >75 years over time (n=34,149)

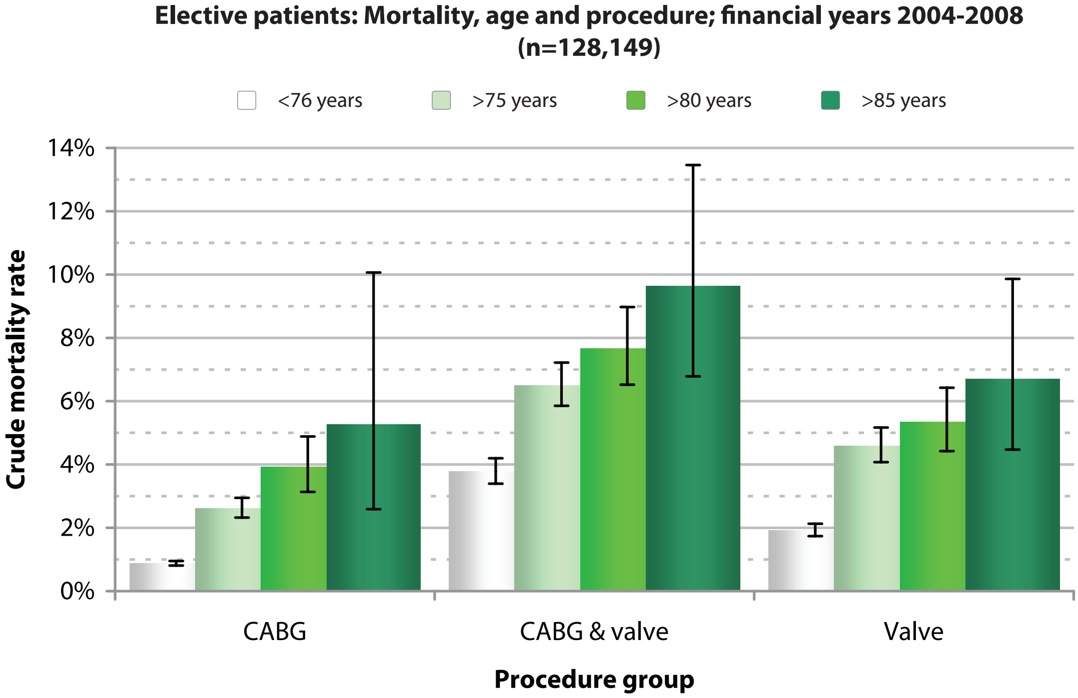


The proportion of elective patients and age group (n=184,484)



Mortality following elective surgery

The mortality for elective patients again increases with increasing age. However, the mortality rate for isolated valve & CABG surgery, even in patients over 85 years of age, is less than 7%. The complication and medium-term survival rates are also given in the following tables. These are the figures that should be quoted to elderly elective patients who are seen in the surgical out patient clinic.



Other outcomes following elective surgery

The other *non-mortality* outcomes and medium-term survival for patients in different age categories undergoing the various operations are given below. These data should provide useful information for patient consent processes.

Post-operative outcomes for elective patients according to age & procedure; financial years 2004-2008; the upper numbers represent the outcome rate & the lower numbers the procedure count within the sub-group

Outcome class and procedure		Age at surgery / years: <76 years	>75 years	>80 years	>85 years
Re-operation for bleeding	Isolated CABG	2.7% 56,740	4.1% 8,893	4.7% 1,717	7.4% 135
	CABG & valve	6.2% 7,550	7.9% 4,377	7.7% 1,593	11.0% 281
	CABG, valve & other	8.8% 967	9.1% 386	6.1% 99	10.0% 10
	CABG & other	3.6% 1,553	5.5% 290	0.0% 50	0.0% 4
	Isolated valve	4.7% 16,387	7.1% 4,872	6.4% 1,691	6.5% 307
	Valve & other	6.7% 3,571	9.8% 683	11.0% 182	4.5% 22
	Other	3.6% 2,486	5.9% 185	0.0% 48	0.0% 3
New post-operative stroke	Isolated CABG	0.8% 55,753	2.0% 8,509	2.1% 1,590	2.4% 123
	CABG & valve	2.7% 7,373	3.8% 4,182	4.5% 1,515	3.7% 271
	CABG, valve & other	4.4% 958	6.1% 380	7.9% 101	0.0% 7
	CABG & other	3.0% 1,448	3.0% 266	0.0% 46	0.0% 4
	Isolated valve	1.4% 16,004	3.1% 4,694	3.0% 1,616	3.9% 307
	Valve & other	1.7% 3,563	3.0% 672	2.8% 179	0.0% 20
	Other	2.3% 2,428	8.7% 172	2.2% 45	0.0% 3
New post-operative HF / dialysis	Isolated CABG	1.2% 55,822	2.7% 8,495	3.2% 1,599	3.3% 121
	CABG & valve	4.0% 7,339	5.6% 4,142	5.9% 1,485	6.3% 256
	CABG, valve & other	5.9% 956	9.8% 368	9.6% 94	0.0% 6
	CABG & other	4.6% 1,445	3.4% 266	0.0% 45	0.0% 4
	Isolated valve	1.9% 15,922	4.2% 4,630	4.6% 1,582	8.3% 300
	Valve & other	3.1% 3,491	5.7% 663	7.3% 177	4.8% 21
	Other	3.0% 2,418	5.7% 174	2.2% 46	0.0% 3

Medium-term survival following elective surgery

Medium-term survival rates and age; the upper numbers represent the percentage Kaplan-Meier survival rate 5 years after surgery and the lower numbers the procedure count within the sub-group; where numbers are small and the data do not extend as far as 5 years the last known survival rate is reported

		Age at surgery / years			
		<76 years	>75 years	>80 years	>85 years
Procedure	Isolated CABG	92.1% 52,347	80.4% 8,270	74.3% 1,521	73.8% 119
	CABG & valve	81.3% 6,901	66.1% 4,030	61.3% 1,446	53.7% 239
	CABG & AVR	83.8% 4,087	67.8% 2,796	60.3% 1,073	52.4% 192
	CABG & MV repair	77.3% 810	79.9% 279	82.9% 52	100.0% 3
	CABG & MV replacement	74.4% 555	56.5% 174	65.1% 42	100.0% 3
	CABG, valve & other	73.2% 944	64.8% 388	56.0% 101	54.5% 11
	CABG & other	78.5% 1,485	70.8% 282	70.6% 48	100.0% 3
	Isolated valve	88.9% 14,971	70.0% 4,511	63.9% 1,576	59.2% 271
	Isolated AVR	89.9% 7,610	72.0% 2,834	67.6% 1,095	60.6% 205
	Isolated MV repair	91.7% 1,886	77.9% 350	73.6% 71	58.3% 10
	Isolated MV replacement	87.1% 1,714	69.4% 319	33.5% 64	0.4% 5
	Valve & other	860.% 3,345	65.6% 670	59.5% 190	73.0% 23
	Other	85.7% 2,271	56.6% 173	52.3% 48	50.0% 2

Regression modelling

Procedure-specific regression modelling

The previous sections have shown that the outcomes of cardiac surgery depend on a number of factors including the type of operation performed and the presence or absence of a variety of patient risk factors. It is important to be able to adjust for these factors to help give accurate predictions about likely outcomes to patients and to allow fair comparisons to be made between surgeons or hospitals with differing casemix.

The first risk prediction model to find widespread use in cardiac surgery was the Parsonnet score, which was derived from a population of patients undergoing surgery in North America in the 1980s (Parsonnet 1989). Initially this was found to be a good predictor of operative mortality for cardiac surgery in the United Kingdom (Nashef *et al.* 1992), but it has subsequently been shown to over-predict observed mortality (Wynn Jones *et al.* 2000). The next important model in cardiac surgery was the ***EuroSCORE***. This was developed using data from a number of countries across Europe using the logistic regression modelling technique. The model was initially published in an additive format, in which the regression coefficients that transformed the presence of the various risk factors into a predicted mortality were allocated simple integer values so that they could be summed to give a mortality prediction (Roques *et al.*1999). This had the advantages that it was easily understood by surgeons and patients and the score could be calculated *at the end of the bed.*

The predictive ability of a risk model is usually assessed by 2 parameters:

- **Discriminatory ability:** which demonstrates how well the model differentiates between patients of higher and lower risk
- **Calibration:** which shows how well the numerical value from the model corresponds with observed mortality.

The additive ***EuroSCORE*** initially displayed both good discrimintory ability (which is usually assessed by measuring the value of the area below a *receiver characteristic operating* (ROC) *curve*) and calibration, but over time both the accuracy of the prediction in higher risk patients and the calibration were questioned. In 2003 the originators of the ***EuroSCORE*** responded by publishing the original logistic regression coefficients and equation of the ***EuroSCORE*** as the *logistic* ***EuroSCORE*** (Roques *et al.* 2003). It was claimed that this update to the model had better discriminatory ability and calibration than the additive model.

The logistic ***EuroSCORE*** found widespread use in the United Kingdom and around the world, and was initially accepted to be a useful and accurate model. However, from about 2004, some observers started to question its accuracy, because of a problem with *calibration drift* (Bhatti *et al.* 2006). As shown in the earlier sections of this book, the mortality associated with cardiac surgery has fallen over time, and this has happened in parallel with an increase in the predicted risk for patients coming to surgery. An inevitable consequence is that the logistic ***EuroSCORE*** now over-predicts observed mortality, both in the United Kingdom and around the world (Choong *et al.* 2009), and it is probably no longer useful in its originally published format, as shown by the analyses presented earlier in this report.

Calibration drift is not necessarily a problem if the model is being used to calculate risk-adjusted mortalities for comparative analysis, based on comparisons to a contemporary group average, but it can create major errors if a local mortality rate is simply compared to that predicted by the model; false reassurance can be gained when observed mortality is equivalent to predicted, when in reality all other hospitals or surgeons may have mortality significantly lower than predicted. The SCTS have responded to this by using the complex, re-calibrated logistic ***EuroSCORE*** for the analyses for the Healthcare Commission website (see page 466). Careful scrutiny of the methodology of the re-calibrated score shows that ***EuroSCORE*** does over-predict observed mortality, and it does so by a different amount for each of the different operative groups.

The logistic ***EuroSCORE*** was develop as a model to predict outcomes for **all** types of cardiac surgery and included in its matrix was a factor that split cardiac operations into two basic types: isolated coronary artery bypass procedures and all other procedures; additional points were given for all operations *other than isolated CABG.* Additional points could also be accrued for surgery on the thoracic aorta and post myocardial ventricular septal rupture. This type of model assumes 2 things:

1. All operations other than isolated CABG (with the exceptions given above) have the same operative risk, which we know from the data in previous sections is not the case
2. Each individual risk factor (such as poor left ventricular function) has the same *weighting* for all the different operation groups

To explore the validity of these assumptions we have performed an analysis to try and understand the association of the various risk factors with mortality for the different operative groups. We have examined the data for patients undergoing surgery between April 2004 and March 2008. For simplicity we have only considered isolated procedures (isolated CABG, isolated aortic valve surgery, isolated mitral valve surgery) and included the following risk factors in the logistic regression models:

- age (as a continuous variable)
- gender
- operative urgency (elective, urgent, emergency, salvage)
- previous cardiac surgery (no or yes)
- angina (0 to IV)
- dyspnoea (I to IV)
- diabetes (no or yes)
- hypertension (no or yes)
- previous MI (no or yes)
- renal disease (no or yes)
- pulmonary disease (no or yes)
- extra-cardiac arteriopathy (no or yes)
- ejection fraction (good, moderate, poor)
- heart rhythm (sinus rhythm or other)
- iv inotropes prior to anaesthetic (no or yes)
- ventilated pre-operatively (no or yes)
- cardiogenic shock pre-operatively (no or yes)
- BMI (<21, 21-25, 26-30, 31-35, >35 [i])

Binary variables were coded with *No* set equal to 0 *and Yes* set equal to 1; age was taken as a continuous variable, and models were adjusted so that the standardised age was 65.

We ran 2 classes of model:

- **Model 1:** All of the factors were entered into a logistic regression model. To eradicate the potential confounding influence of missing data we only included patients for whom all risk factors were recorded. We retained all risk factors in the model rather than eliminating factors with *non-significant* weightings (Harell 2001).
- **Model 2:** We ran further models in which we eliminated non-significant variables using successive backwards elimination, to retain only variables with t-ratios greater than 3 (the total number of patients remaining in the reduced models were higher than in the first models, because, with a smaller number of risk factors, the total number of patients with complete risk-factor data was higher).

All risks are compared with a 65-year-old man with a BMI between 25 and 30 and negative (*No*) values for the other key fields.

i Patients with a BMI <6 or >60 have been excluded.

The intrinsic risk of surgery

The constant from the logistic regression equation is effectively an indication of the intrinsic risk of the operation, *i.e.*, the risk of the operation if all risk factors apart from the operation itself are absent. The constants from the 3 reduced regression models along with their standard deviations are given in the table. The derived intrinsic risk (with 95% confidence intervals) for a 65-year-old man with no other risk factors undergoing the different operations is also given. The risk for CABG surgery is lower than that for aortic valve surgery, which is lower than that for mitral surgery. Whilst there is some overlapping of the confidence intervals between the groups, it does seem likely that these operations carry different intrinsic risk and from a clinical perspective it would seem sensible to include specific weighting for these factors in any future models.

Procedure-specific coefficients

		Constant	Standard deviation	Intrinsic risk	95% CIs	
					Lower	Upper
Procedure	Isolated CABG	-4.88	0.266	0.76%	0.45%	1.28%
	Isolated aortic surgery	-3.93	0.305	1.95%	1.08%	3.55%
	Isolated mitral surgery	-3.44	0.286	3.22%	1.84%	5.64%

Risk factors

The model parameters are given (*coefficients*), together with their uncertainties (standard deviations) along with the odds ratios and their ranges in the following tables and the odds ratios are also displayed in the graphs below. The main finding from these analyses where all risk factors are left in the model is that the various risk factors have different weightings between the operative groups. Some caution should be taken when describing *differences* in the coefficients in these risk factors, as to demonstrate any statistically significant difference between the factors requires a more complex analysis of the potential error in the models, as well as exploring the confidence intervals around the odds ratios of the risk factors, but an overview of odds ratios from the complete models suggests, for example, that age has a slightly different weighting for the different procedures, gender is a progressively less *important* risk factor for aortic and mitral valve surgery, than it is for coronary surgery. *Previous cardiac surgery* has a higher weighting for coronary artery bypass surgery than it does for either aortic or mitral valve surgery (but this difference is not significant) and extra-cardiac arteriopathy is a more important risk factor for coronary artery bypass surgery than it is for valve surgery.

The reduced models show those risk factors that have a t-ratio greater than 3, and we can be fairly certain that these risk factors are strongly associated with increased mortality. More factors remain in for coronary artery bypass surgery than for the valve surgery, which possibly represents the greater number of cases in the CABG group. Age remains a significant factor in all of the models, and has a stronger effect for CABG than for the valve procedures, but these differences do not carry statistical significance. Priority remains an important risk factor in all groups, with both emergency and salvage procedures carrying significant incremental risk for CABG and mitral operations, but only salvage status was significant in the AVR model. Renal disease is also a consistent risk factor across all the models. Previous cardiac surgery, poor left ventricular function, extra cardiac arteriopathy, NYHA class 4 symptoms and pre-operative ventilation were retained in the CABG model. Previous cardiac surgery and pre-operative inotropic support were retained in the AVR model, and previous myocardial infarction was retained in the mitral model, but not in the other models.

In summary, from these analyses, the various classes of cardiac operations seem to have a different levels of *intrinsic risk* and also the weightings for the specific risk factors are not the same across the operative groups. For these reasons its seems likely that *generic* risk models designed to predict outcome for all cardiac surgery, such as the ***EuroSCORE***, will always have limited ability to predict accurately for casemix. A full exploration of these issues, and development and testing of procedure-specific models from the SCTS database, including studying the incremental risk associated with concomitant coronary artery bypass surgery in addition to valve procedures, is outside the scope of this report.

The *new* Society of Thoracic Surgeons models

In line with the methodology described above, recent analyses by the Society for Thoracic Surgeons are working towards producing a series of new risk models. These have been developed from their large database using logistic regression, and separate models are been developed for predicting operative mortality for coronary artery bypass surgery, valve surgery and combined valve & graft surgery. In addition to models to predict mortality they are also producing separate models to predict stroke, prolonged length-of-stay and new post-operative renal failure.

These models will be made available for widespread use (D Shahian, personal communication), but have not yet been published. It seems likely that these procedure-specific models will be more accurate for predicting operative mortality than previous *generic* models, and we intend to validate the models on our dataset. Assuming the models have good predictive ability, it will be important to monitor closely their *calibration* over time.

Ben Bridgewater and Owen Nicholas

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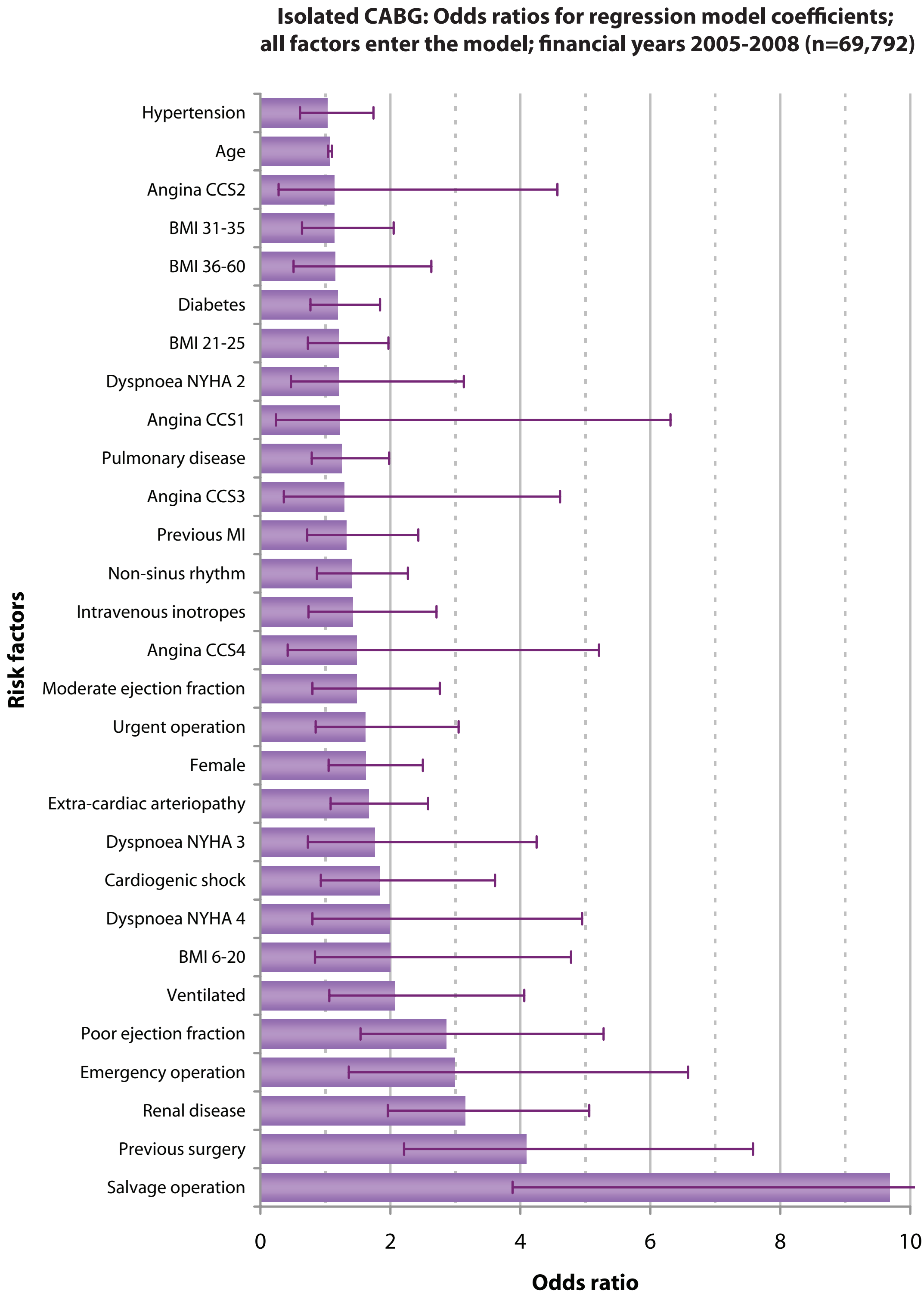
Coefficients, standard deviations, and odds ratios of 69,792 patients undergoing **isolated CABG surgery**

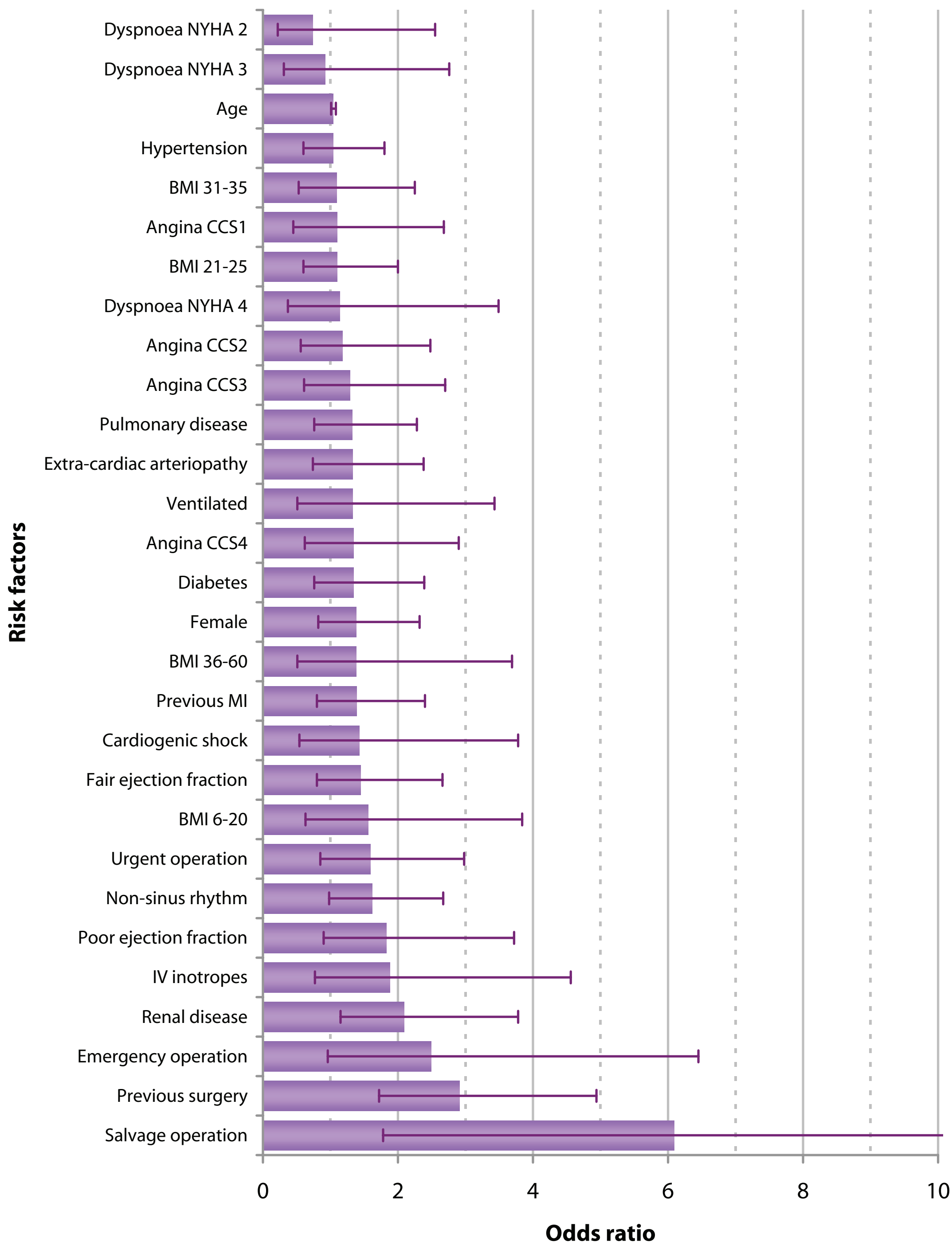
Risk factors		Coefficient	Standard deviation	Odds ratio	95% CI	
					Lower	Upper
Age	Continuous	0.06	0.01	1.07	1.04	1.10
Gender	Female	0.48	0.22	1.62	1.05	2.50
Operative urgency	Urgent	0.48	0.32	1.61	0.85	3.05
	Emergency	1.10	0.40	2.99	1.36	6.58
	Salvage	2.27	0.47	9.68	3.88	24.10
Previous surgery	Yes	1.41	0.31	4.09	2.21	7.58
Angina	CCS 1	0.20	0.84	1.22	0.24	6.31
	CCS 2	0.13	0.71	1.14	0.28	4.57
	CCS 3	0.26	0.65	1.29	0.36	4.61
	CCS 4	0.40	0.64	1.48	0.42	5.21
Dyspnoea	NYHA 2	0.19	0.48	1.21	0.47	3.13
	NYHA 3	0.57	0.45	1.76	0.73	4.25
	NYHA 4	0.69	0.46	1.99	0.80	4.95
Diabetes	Yes	0.17	0.22	1.19	0.77	1.84
Hypertension	Yes	0.03	0.27	1.03	0.61	1.74
Previous MI	Yes	0.28	0.31	1.32	0.72	2.43
Renal disease	Yes	1.15	0.24	3.15	1.96	5.06
Pulmonary disease	Yes	0.22	0.23	1.25	0.79	1.98
Extra-cardiac arteriopathy	Yes	0.51	0.22	1.67	1.08	2.58
Ejection fraction	Fair	0.39	0.32	1.48	0.80	2.76
	Poor	1.05	0.31	2.86	1.54	5.28
Heart rhythm	Non-sinus	0.34	0.24	1.41	0.87	2.27
IV inotropes	Yes	0.35	0.33	1.42	0.74	2.71
Ventilated	Yes	0.73	0.34	2.07	1.06	4.06
Cardiogenic shock	Yes	0.61	0.34	1.83	0.93	3.61
BMI	6-20	0.69	0.44	2.00	0.84	4.78
	21-25	0.18	0.25	1.20	0.73	1.97
	31-35	0.13	0.30	1.14	0.64	2.05
	36-60	0.14	0.42	1.15	0.51	2.63


Isolated CABG: Odds ratios for regression model coefficients; all factors enter the model; financial years 2005-2008 (n=69,792)
Risk factors
Hypertension
Age
Angina CCS2
BMI 31-35
BMI 36-60
Diabetes
BMI 21-25
Dyspnoea NYHA 2
Angina CCS1
Pulmonary disease
Angina CCS3
Previous MI
Non-sinus rhythm
Intravenous inotropes
Angina CCS4
Moderate ejection fraction
Urgent operation
Female
Extra-cardiac arteriopathy
Dyspnoea NYHA 3
Cardiogenic shock
Dyspnoea NYHA 4
BMI 6-20
Ventilated
Poor ejection fraction
Emergency operation
Renal disease
Previous surgery
Salvage operation
0
2
4
6
8
10
Odds ratio

Coefficients, standard deviations, and odds ratios of 20,509 patients undergoing **isolated aortic valve replacement surgery**

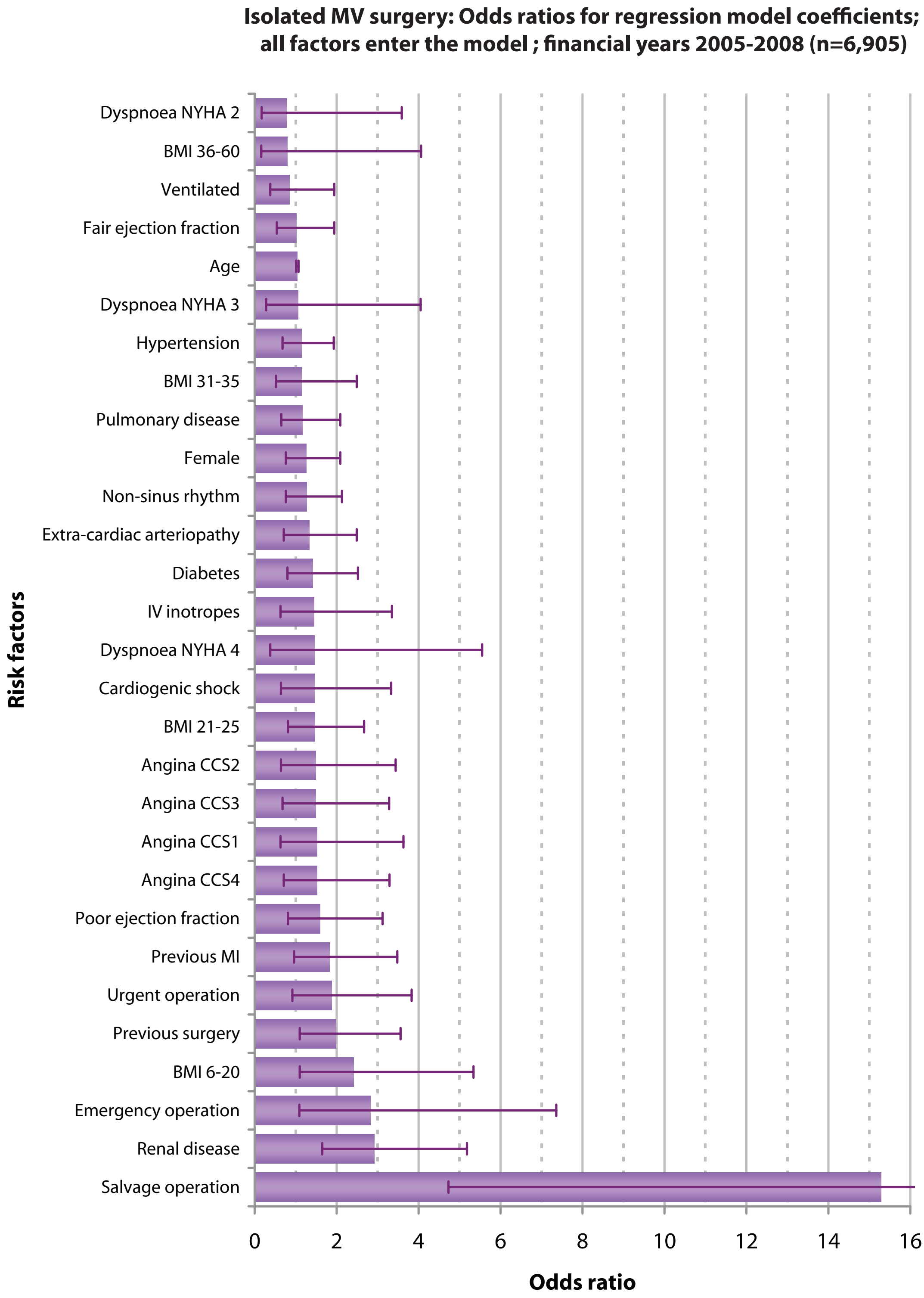
Risk factors		Coefficient	Standard deviation	Odds ratio	95% CI	
					Lower	Upper
Age	Continuous	0.04	0.02	1.04	1.01	1.08
Gender	Female	0.32	0.26	1.38	0.82	2.32
Operative urgency	Urgent	0.47	0.32	1.59	0.85	2.98
	Emergency	0.91	0.49	2.49	0.96	6.45
	Salvage	1.81	0.63	6.09	1.78	20.78
Previous surgery	Yes	1.07	0.27	2.91	1.72	4.94
Angina	CCS 1	0.10	0.45	1.10	0.45	2.68
	CCS 2	0.16	0.38	1.18	0.56	2.48
	CCS 3	0.25	0.38	1.29	0.61	2.70
	CCS 4	0.29	0.39	1.34	0.62	2.90
Dyspnoea	NYHA 2	-0.30	0.63	0.74	0.22	2.55
	NYHA 3	-0.08	0.56	0.92	0.31	2.76
	NYHA 4	0.13	0.57	1.14	0.37	3.49
Diabetes	Yes	0.30	0.29	1.34	0.76	2.39
Hypertension	Yes	0.04	0.28	1.04	0.60	1.80
Previous MI	Yes	0.33	0.28	1.39	0.80	2.40
Renal disease	Yes	0.74	0.30	2.09	1.15	3.78
Pulmonary disease	Yes	0.27	0.28	1.32	0.76	2.28
Extra-cardiac arteriopathy	Yes	0.29	0.30	1.33	0.74	2.38
Ejection fraction	Fair	0.37	0.31	1.45	0.80	2.66
	Poor	0.60	0.36	1.83	0.90	3.72
Heart rhythm	Non-sinus	0.48	0.26	1.62	0.98	2.67
IV inotropes	Yes	0.63	0.45	1.88	0.77	4.56
Ventilated	Yes	0.28	0.48	1.33	0.51	3.43
Cardiogenic shock	Yes	0.36	0.49	1.43	0.54	3.78
BMI	6-20	0.44	0.46	1.56	0.63	3.84
	21-25	0.09	0.31	1.10	0.60	2.00
	31-35	0.09	0.37	1.09	0.53	2.25
	36-60	0.32	0.50	1.38	0.51	3.69

Isolated AVR: Odds ratios for regression model coefficients; all factors enter the model ; financial years 2005-2008 (n=25,509)



Coefficients, standard deviations, and odds ratios of 6,905 patients undergoing **isolated mitral valve surgery**

Risk factors		Coefficient	Standard deviation	Odds ratio	95% CI	
					Lower	Upper
Age	Continuous	0.04	0.01	1.04	1.01	1.07
Gender	Female	0.23	0.26	1.26	0.76	2.09
Operative urgency	Urgent	0.63	0.36	1.88	0.92	3.83
	Emergency	1.04	0.49	2.83	1.09	7.36
	Salvage	2.73	0.60	15.29	4.73	49.39
Previous surgery	Yes	0.68	0.30	1.98	1.10	3.56
Angina	CCS 1	0.42	0.44	1.52	0.63	3.63
	CCS 2	0.40	0.43	1.49	0.64	3.44
	CCS 3	0.40	0.40	1.49	0.68	3.28
	CCS 4	0.42	0.39	1.52	0.71	3.29
Dyspnoea	NYHA 2	-0.25	0.78	0.78	0.17	3.59
	NYHA 3	0.06	0.69	1.06	0.28	4.05
	NYHA 4	0.38	0.68	1.46	0.38	5.55
Diabetes	Yes	0.35	0.29	1.42	0.80	2.52
Hypertension	Yes	0.14	0.27	1.14	0.68	1.93
Previous MI	Yes	0.60	0.33	1.83	0.96	3.48
Renal disease	Yes	1.07	0.29	2.92	1.65	5.18
Pulmonary disease	Yes	0.15	0.30	1.16	0.65	2.09
Extra-cardiac arteriopathy	Yes	0.29	0.32	1.33	0.71	2.49
Ejection fraction	Fair	0.02	0.33	1.02	0.54	1.94
	Poor	0.46	0.34	1.59	0.81	3.12
Heart rhythm	Non-sinus	0.24	0.26	1.27	0.76	2.13
IV inotropes	Yes	0.37	0.43	1.45	0.63	3.35
Ventilated	Yes	-0.16	0.42	0.85	0.38	1.94
Cardiogenic shock	Yes	0.38	0.42	1.46	0.64	3.33
BMI	6-20	0.88	0.40	2.42	1.10	5.34
	21-25	0.39	0.30	1.47	0.81	2.67
	31-35	0.13	0.40	1.14	0.52	2.49
	36-60	-0.22	0.83	0.80	0.16	4.06


Isolated MV surgery: Odds ratios for regression model coefficients; all factors enter the model ; financial years 2005-2008 (n=6,905)
Risk factors
Dyspnoea NYHA 2
BMI 36-60
Ventilated
Fair ejection fraction
Age
Dyspnoea NYHA 3
Hypertension
BMI 31-35
Pulmonary disease
Female
Non-sinus rhythm
Extra-cardiac arteriopathy
Diabetes
IV inotropes
Dyspnoea NYHA 4
Cardiogenic shock
BMI 21-25
Angina CCS2
Angina CCS3
Angina CCS1
Angina CCS4
Poor ejection fraction
Previous MI
Urgent operation
Previous surgery
BMI 6-20
Emergency operation
Renal disease
Salvage operation
0
2
4
6
8
10
12
14
16
Odds ratio

Coefficients, standard deviations, and odds ratios from the **reduced** model based on 78,741 patients undergoing **isolated CABG surgery**

Risk factors		Coefficient	Standard deviation	Odds ratio	95% CI	
					Lower	Upper
Constant		-4.88	0.27	0.0076	0.0045	0.0127
Age	Continuous	0.07	0.01	1.07	1.04	1.10
Operative urgency	Emergency	1.18	0.27	3.24	1.93	5.45
	Salvage	2.84	0.30	17.19	9.54	30.99
Previous surgery	Yes	1.45	0.29	4.27	2.40	7.59
Dyspnoea	NYHA 4	0.77	0.23	2.16	1.39	3.37
Renal disease	Yes	1.33	0.22	3.80	2.46	5.85
Extra-cardiac arteriopathy	Yes	0.69	0.21	1.99	1.33	3.00
Ejection fraction	Poor	1.19	0.22	3.29	2.15	5.04
Ventilated	Yes	0.93	0.30	2.53	1.40	4.56

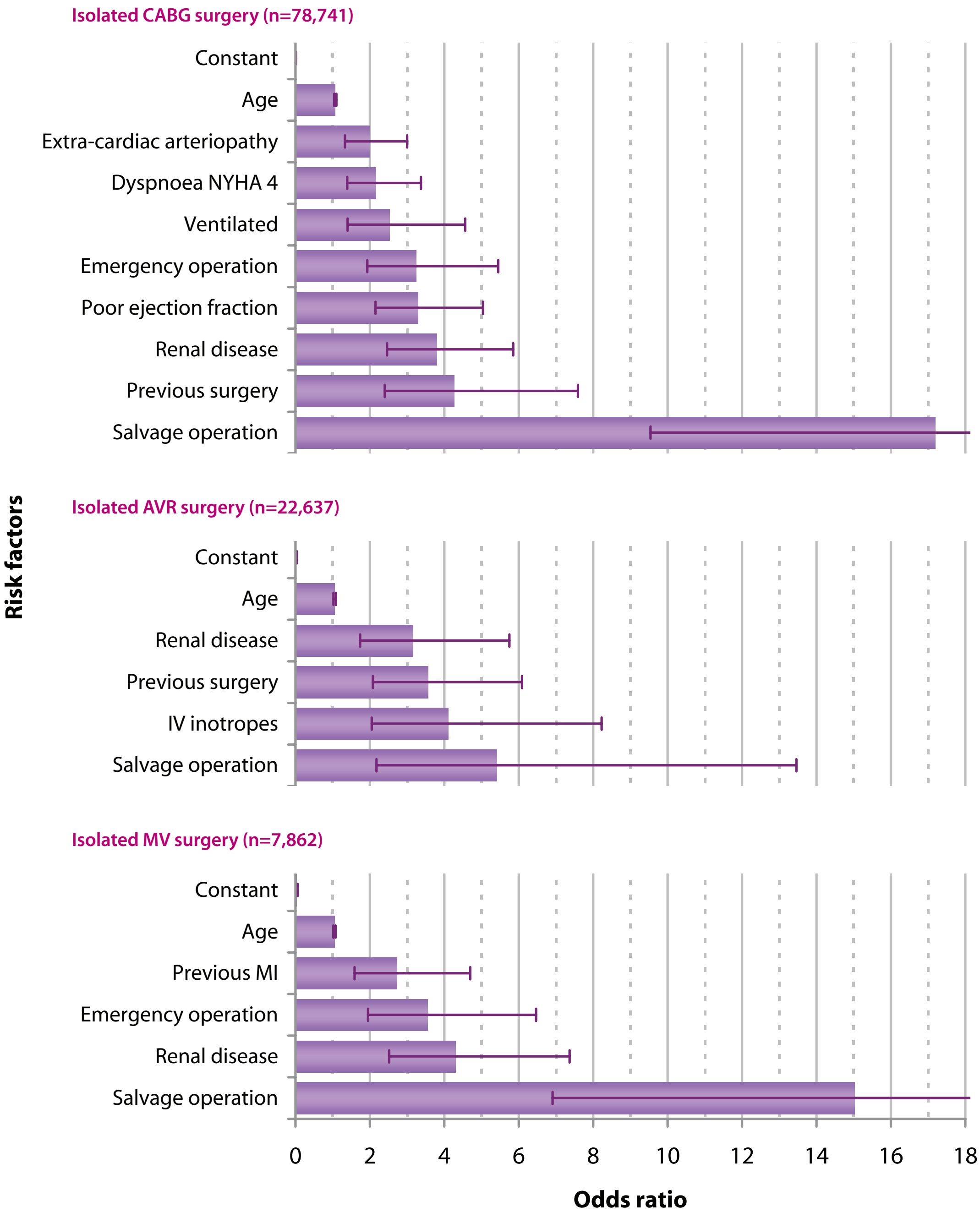
Coefficients, standard deviations, and odds ratios from the **reduced** model based on 22,637 patients undergoing **isolated AVR surgery**

Risk factors		Coefficient	Standard deviation	Odds ratio	95% CI	
					Lower	Upper
Constant		-3.93	0.30	0.019	0.0108	0.0355
Age	Continuous	0.05	0.02	1.05	1.02	1.09
Operative urgency	Salvage	1.69	0.46	5.41	2.18	13.46
Previous surgery	Yes	1.27	0.27	3.56	2.08	6.09
Renal disease	Yes	1.15	0.31	3.16	1.74	5.75
IV inotropes	Yes	1.41	0.35	4.11	2.05	8.23

Coefficients, standard deviations, and odds ratios from the **reduced** model based on 7,862 patients undergoing **isolated MV surgery**

Risk factors		Coefficient	Standard deviation	Odds ratio	95% CI	
					Lower	Upper
Constant		-3.44	0.29	0.03	0.02	0.06
Age	Continuous	0.05	0.01	1.05	1.02	1.08
Operative urgency	Emergency	1.27	0.31	3.55	1.95	6.46
	Salvage	2.71	0.40	15.03	6.91	32.68
Previous MI	Yes	1.00	0.28	2.73	1.59	4.70
Renal disease	Yes	1.46	0.27	4.31	2.52	7.37

Reduced models: Odds ratios for regression model coefficients; financial years 2005-2008



Geographical variation and Quality

Geographical variation in access to aortic valve surgery

For surgery to improve the health of the population it is as important for us to understand who would benefit from surgery but is not being referred, as it is for us to concentrate on what we currently do and striving to do it better.

Key points from geographical analyses

- It is possible to map patients in the SCTS database to their Strategic Health Authority (SHA) and Primary Care Trust (PCT) of residence.
- We have looked at 29,406 patients in England in the years ending March 2005 to March 2008 undergoing aortic valve replacement, either alone or in conjunction with any other surgery.
- The incidence of missing data on PCT attribution was low at less than 1%.
- More men undergo aortic valve surgery than women, even after adjusting for differences in gender within the general population, and the sex differential in epidemiology of aortic valve disease.
- Two SHAs have access rates for aortic valve surgery that are significantly higher than expected after adjusting for the age and sex of the population, and two SHAs have access rates that are significantly lower than expected.
- We have drilled down to PCT level to identify the areas of poor access, and have listed all PCT's access rates.
- We hope the data will be used to understand the reasons for poor access to aortic valve replacement and will stimulate strategies for improvement.

Introduction

The Central Cardiac Audit Database infrastructure gives the ability for data to be collected, and is the *engine room* for collating much of the SCTS database. Each hospital collects their records on one of a number of software systems as described on page 38. In addition to the clinical data, a variety of geographical identifiers of the place of residence of each patient are also submitted to CCAD. These enable patients to be attributed to the relevant geographical *units* such as Strategic Health Authority (SHA), Local Authority or Primary Care Trust (PCT). This potentially allows us to understand not only what cardiac surgery is being performed, but also what should be done but is not currently undertaken *i.e.*, the *unmet need* of the population.

In the following section we have used the data in the NACSD to map patients in England to their SHA and PCT of residence. We looked in detail at all patients undergoing aortic valve replacement (with or without coronary bypass artery surgery or concomitant other operations), but we could have applied a similar methodology to examine the data for any of the procedures described in this report. It will be of particular interest to look at rates of coronary revascularisation by both surgery and percutaneous coronary intervention in the future.

Aortic valve disease becomes increasingly common as patients get older, and so to understand the rates of aortic valve surgery, it is important to control for the population number within each geographical *unit* and to adjust for the age structure of those populations; it would, for example, be inappropriate to compare rates of aortic valve surgery between areas on the South Coast where the population is elderly, with those from some PCTs in the North-West where the average age may be much lower, without making the appropriate adjustments. We have used data on PCT population estimates from 2007 for the following analyses.

The data on PCT attribution for patients undergoing surgery at all centres in England is relatively complete. We have looked for the presence of a PCT code in each record and whether that code maps to that of an English PCT (see page 477). There is a small amount of missing data from Basildon; these data were taken very shortly after the unit opened and the numbers are so small they will not have any significant effect on our analysis. With this *caveat* we feel the incidence of missing PCT attribution is low with an overall incidence of around 1%. The incidence of missing data for age and sex in the database is also low, as described on page 39.

The total number of patients undergoing isolated aortic valve surgery with and without coronary surgery each year in the database, along with the changes in age profile, have been described previously on page 167. The dataset for the following analysis is slightly different and contains all patients who have had an aortic valve operation, with or without any other concomitant procedure.

Aortic valve operations performed and gender

		Gender		
		Male	Female	**All**
Financial year	2004	4,182	2,528	**6,710**
	2005	4,518	2,633	**7,151**
	2006	4,722	2,755	**7,477**
	2007	5,142	2,926	**8,068**
	All	**18,564**	**10,842**	**29,406**

For the following analyses we have examined the *pooled* 4 years of data, which gives us more statistical power to detect any significant variations. The number of aortic valve operations per million population for the four financial years, based on population estimates from 2007, subdivided by sex and age show that the highest rate is seen for patients between 75 and 84, with reducing numbers in the younger age groups, and a smaller number in patients 85 years of age or older. Of interest, the rates of aortic valve surgery for men are consistently higher across all age groups than for women. However, because there are almost 3 times as many women as men aged over 84 in the general population, the total number of aortic valve operations undertaken in the female population in this group is higher than it is in the male population, but the rate **per million** is much lower. Epidemiological studies have suggested that, overall, aortic stenosis is about 1.5 times more common in men than it is in women, and there is no difference in the incidence of aortic regurgitation (Nkomo *et al*. 2006). The finding that men undergo almost twice as many aortic valve replacements as women raises intriguing questions about the different ways the sexes access cardiac surgical care.

Aortic valve operations performed; rates per million population in England; financial years ending 2005-2008; adjustments made for age and gender structures of the local population

		Gender		
		Male	Female	**All**
Age at surgery / years	<45	83	28	**56**
	45-54	455	165	**309**
	55-64	1,240	508	**868**
	65-74	3,144	1,639	**2,354**
	75-84	4,568	2,454	**3,334**
	>84	1,724	901	**1,154**
	All	**750**	**420**	**582**

We have used the data on the age and gender structure of the population for each SHA to calculate the expected number of aortic valve operations over the 4-year period and then compared that to the actual number performed. This shows that some SHAs have commissioned more than expected, and some less.

i Vuyisile T Nkomo, Julius M Gardin, Thomas N Skelton, John S Gottdiener, Christopher G Scott, Maurice Enriquez-Sarano. Burden of valvular heart diseases: a population-based study. *Lancet*. 2006; **368:** 1005-11

Predicted and observed numbers of aortic valve procedures in the various English Strategic Health Authorities; financial years ending 2005-2008; adjustments made for age and gender structures of the local population

Strategic Health Authority	4-year data Predicted	Observed	Variance
East Midlands	2,576	2,601	25 ↑
East of England	3,394	3,624	230 ↑
London	3,371	3,503	132 ↑
North East	1,559	1,581	22 ↑
North West	4,044	4,164	120 ↑
South Central	2,238	2,131	-107 ↓
South East Coast	2,660	2,816	156 ↑
South West	3,376	3,445	69 ↑
West Midlands	3,186	2,895	-291 ↓
Yorkshire & Humber	3,002	2,646	-356 ↓
England	**29,406**	**29,406**	

We have used these data to calculate a rate per million population over the 4 years for each SHA after adjusting for the age and gender structures of the local population. We have used 99% confidence limits to calculate an upper and lower confidence limit for the observed rates to compare to that expected from the national average. In the East of England and South East Coast SHAs the rates are significantly higher than predicted. In West Midlands and Yorkshire and Humber SHAs the rates are significantly lower.

Predicted and observed numbers of aortic valve procedures in the various English Strategic Health Authorities; financial years ending 2005-2008; adjustments made for age and gender structures of the local population

Strategic Health Authority	Data per million population: Significant	Observed Rate	Observed LCL [i]	Observed UCL [ii]	Predicted	Variance
East Midlands	No	606	576	637	600	6 ↑
East of England	Yes	653	625	681	611	41 ↑
London	No	466	446	487	448	18 ↑
North East	No	620	580	661	611	9 ↑
North West	No	605	581	630	588	17 ↑
South Central	No	537	508	568	564	-27 ↓
South East Coast	Yes	668	636	702	631	37 ↑
South West	No	679	649	709	665	14 ↑
West Midlands	Yes	540	515	567	594	-54 ↓
Yorkshire & Humber	Yes	516	490	542	585	-69 ↓

i Lower confidence limit

ii Upper confidence limit

Of all the SHAs, Yorkshire and Humber has the greatest variation from predicted for the rates of aortic valve replacements and we have *drilled down* into this in more detail. There are 14 PCTs within that SHA and we have again looked at the rates per million for each of these over the 4 years under consideration after adjusting for the age and gender structures of the local population. The variation is much greater, because the populations are smaller, but 6 of the PCTs have a rate that is significantly lower than the national average, again using 99% confidence intervals. Bradford and Airdale, the PCT with the greatest variance, had 40% fewer aortic valve replacements than would be predicted over the 4-year period.

Predicted and observed numbers of aortic valve procedures in the various English Primary Care Trusts; financial years ending 2005-2008; adjustments made for age and gender structures of the local population

		Data per million population						
		Significant	Observed			Predicted	Variance	
			Rate	LCL [i]	UCL [ii]		count	rate
Primary Care Trust	Barnsley	No	573	453	714	597	-24	-4%
	Bradford & Airedale	Yes	306	246	376	511	-204	-40%
	Calderdale	Yes	422	313	556	565	-143	-25%
	Doncaster	No	567	460	691	612	-45	-7%
	E Riding of Yorkshire	Yes	842	713	988	694	148	21%
	Hull	No	520	415	641	544	-25	-5%
	Kirklees	Yes	380	305	469	543	-162	-30%
	Leeds	Yes	397	340	459	532	-135	-25%
	N Yorkshire & York	No	678	604	759	661	18	3%
	NE Lincshire	No	475	348	632	614	-139	-23%
	N Lincshire	No	621	471	802	639	-18	-3%
	Rotheram	No	636	512	780	595	41	7%
	Sheffield	No	536	458	624	568	-32	-6%
	Wakefield	Yes	400	316	498	585	-185	-32%

Summary

Aortic valve replacement is known to be an excellent operation; untreated aortic valve disease, particularly severe aortic stenosis, is associated with unpleasant symptoms and reduced life-expectancy. Successful surgery returns patients to a quality-of-life that is similar to an aged-matched healthy population and increases life-expectancy dramatically. However, for patients to undergo what is essentially a curative procedure, they need to access appropriate medical care, have the correct diagnosis secured and be referred on, and accepted for, aortic valve replacement. The data from this analysis suggest that there are significant variations around the country in access rates for this type of surgery. A number of SHAs and PCTs have rates that are significantly higher than the national average. This requires further consideration. It is likely that all these patients have robust indications for surgery (the indications for aortic valve replacement have been clearly defined; Bonow *et al.* 2006) and as such these areas probably reflect a current appropriate standard for all others to aim at. However, for this analysis, we have compared all SHAs and PCTs to the current national average but still found areas that have significantly lower access rates than predicted after adjusting for age and sex.

We hope that the data provided here and in the appendices will stimulate further considerations of these issues. Cardiac surgery for aortic valve disease is a definitive procedure, which occurs at the end of a sometimes long and complex diagnostic and investigation pathway. There are a number of possible reasons for low rates that include:

- variations in the incidence of the disease in the population due to environmental, genetic, racial, socio-economic or other factors
- failure of the population to access healthcare for any reason
- shortcomings in diagnosis or referral in primary care
- problems with diagnosis or referral in secondary care including shortcoming in echo services, general medicine, cardiology or care of the elderly
- patients being referred for surgery but not being accepted for a particular reason

To understand which of these factors are important in the PCTs with poor access rates for surgery would require further scrutiny that could initially entail more detailed examination of the profiles of patients coming to surgery compared to pooled national data. A deeper understanding may require more detailed studies of the populations and healthcare systems in the appropriate areas. If no obvious justification for low access rates is apparent, it is likely that the areas of current under-provision will require attention with possible system re-design and investment to ensure that more patients are referred and accepted for appropriate and effective treatment. A complete analysis of these issues is outside the scope of this report, but could be partially facilitated by information from the SCTS database, and we would encourage clinicians, cardiac networks and commissioners to develop action plans to explore and close possible gaps in service provision that have been identified here.

These analyses on aortic valve surgery are meant as an illustration of what can be achieved by analysing a large clinical database linked to geographical identifiers of residence. Possibly of more importance than the data presented here are issues about variations of access to appropriate revascularisation for coronary artery disease. In future we hope to use similar methodology to link together data from the SCTS database with data on percutaneous coronary intervention from the British Cardiac Intervention Society audit, to better understand current patterns and access rates to revascularisation for patients with ischaemic heart disease. We hope that, by producing regular reports on these issues, we may be able to help drive and track improvements in equity of access to appropriate cardiac care.

Stephen Green and Ben Bridgewater

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Quality

Public disclosure or public exposure?

Crossing the Rubicon: The aftermath of public disclosure of named-surgeon outcomes

James Roxburgh

Consultant Cardiothoracic Surgeon, St Thomas's Hospital;

Past Honorary Secretary of the Society for Cardiothoracic Surgery in Great Britain & Ireland

For many years cardiac surgeons had wandered alone along the quiet country road and through the sunlit uplands that were data collection until they came upon the Bristol Inquiry. The storm clouds gathered and the road became increasingly difficult to navigate, ahead there appeared to be a precipice beyond which many feared was the abyss of surgeon-specific data. What were cardiac surgeons to do? They could not change direction as the way back was blocked by two new companions on their journey, the Government and the Media, and both were armed with copies of the *Bristol Report* and the *Freedom of Information Act*; nor could they stand still. The Government and the Media were slowly but surely coming down the road towards them, the precipice was getting dangerously close. The only question remaining was whether cardiac surgeons jumped or waited until they were pushed …

In discussing the complex issues that surrounded the decision by the specialty to publish unit- and surgeon-specific data it is important to understand the background, and for this we must return to 1977. At this time the cardiac surgical community agreed that mortality data for a wide variety of adult cardiac surgical procedures should be collected at a unit level. Since electronic data collection was for all intents and purposes non-existent, each unit was sent a set of paper forms (Annual Returns) upon which they were required to enter the volume of cases performed and the mortality for all the prescribed operative groups. The completion of the *Annual Returns* was usually delegated to a Senior Registrar who then had to spend many hours trawling through the theatre logs and operation notes. The matter was compounded by the fact that 30-day mortality was required, but one suspects that in most cases only in-hospital deaths were counted. Those of us involved in this process would be the first to agree that in many cases the data produced by this exercise were an approximation, albeit a good one, to the mortality associated with adult cardiac surgery in the United Kingdom. The data were anonymised prior to central analysis and no unit identifiable data were available for any form of quality control or unit comparison. However, it was a huge step forward and the first time information about the overall raw mortality of cardiac surgery in the United Kingdom was available and units were able to compare their mortality figures with that of the United Kingdom as a whole. No other medical or surgical specialty, at this time, had even considered such a form of self-analysis. Throughout the 80s and 90s the quality of data collection improved and, indeed, in many cases units developed sophisticated electronic methods of data collection, and the concepts of risk adjustment were introduced. However, *Clinical Governance* was not embedded in everyday practice as it is now and the idea of monitoring unit performance was simply not part of cardiac surgical or even NHS culture. In the mid-1990s the SCTS dataset was developed with a view to collecting risk-adjusted mortality data and, at the same time, the *Annual Returns* started to collect mortality data (risk adjustment was optional) for so-called marker procedures, which in the case of adult cardiac surgery was first-time CABG. The concept of *base-hospital* mortality was agreed upon for reasons of simplicity and increased accuracy. Initially this was anonymous, but within a few years surgeons had agreed to submit these data under their own names rather than using an unique code known only to the lead surgeon responsible for data submission within that unit. The paper collection of simple raw mortality data was being replaced by the centralised collection of the SCTS dataset in a variety of electronic formats; the first analysis of these data was published in 1996 and very quickly became known as *the Blue Book*.

The publication in 1999 of a European-based risk model for adult cardiac surgery, the ***EuroSCORE*** (Roques, *et al*. 1999), was a major stimulus to data collection in the United Kingdom and there is no doubt that by this time the intention was to collect detailed risk profile data on all patients undergoing cardiac surgery in the United Kingdom. The first Blue Book contained data from 14 units, but by the time the fifth report was published in 2004, data were available to a greater or lesser extent from 37 units. However, this gradual development, some would use the terms *sedate* and *gentlemanly,* was rudely interrupted by the publication of the Bristol Inquiry in 2001 (Bristol Inquiry 2001). In its conclusions it stated that patients should have access to *the relative performance of the Trust… and the consultant units within the Trust.* In the same year the Dr Foster organisation, using HES data sourced from the NHS, published mortality data for coronary artery bypass surgery for named cardiac surgical units within the United Kingdom. At a meeting with Dr Foster the profession left the senior members of that organisation in no doubt that they felt such a publication did a disservice to both patients and the profession.

In his response to the Bristol Inquiry the Minister of State for Health, the Rt Hon Alan Milburn, MP, stated that the performance data should not be made available until they were *reliable, robust and risk adjusted.* Although the data available at that time met none of these criteria, there was increasing pressure for publication, both from the media and the Government, despite the reassurances that had been given in the Houses of Parliament. The Society felt they had no option but to release some form of surgeon-specific outcome data. In order to avoid the inevitable construction of league tables by the media and other organisations it was felt appropriate to analyse the data available and allocate each surgeon a *star rating* based on pre-determined statistical levels. This coincided with the publication of the fifth Blue Book, but did little to stem the rising tide of criticism from the media that cardiac surgeons simply did not wish to release these data. There was criticism from within the speciality; in an editorial entitled *Statistics for the Rest of Us,* Eugene Blackstone called the use of 99.99% Confidence Intervals *shocking* (Blackstone 2004). In conversations with journalists it was clear that they did not accept our reassurances that the profession would release the data when they met the criteria laid down by the Minister of State for Health. The time-frame quoted was, they felt, another example of the surgeons hiding behind the complexities of risk analysis. The fact that all of this data-collection was undertaken on a voluntary basis with no dedicated central funding and required the collation, cleaning and analysis of several hundred thousand pieces of patient-data was met with little sympathy.

Eloquent arguments were made by cardiac surgeons, quoting the US experience, against the publication of individual-surgeon data; they were not lone mavericks as their concerns were shared by the BMA and the Royal College of Surgeons of England. However, many units already published surgeon-specific data, which were freely available *via* their own hospitals' web sites and this combined with introduction of The Freedom of Information Act (in January 2005) led the Guardian newspaper to publish surgical mortality data (first-time CABG) for individual surgeons in March 2005. Although it was a landmark publication and handled sensitively, the fact that the data published used a wide variety of risk- and non-risk-adjusted mortalities meant that it was of little practical use to patients, hospitals or indeed individual surgeons. It was now clear that, despite the very grave reservations held by many surgeons within the profession, the publication of detailed surgeon-specific outcome data was now inevitable, the only question that remained was whether it was to be controlled by the profession using our data or we simply acquiesced to the use of administrative NHS data. In late 2003 it was agreed that the Society should undertake a pilot project to collect the SCTS dataset by means of a direct link to the Central Cardiac Audit Database (CCAD). The intention was to show that the collection of high-quality risk profile data was possible and that these could be used to produce meaningful performance data for individual surgeons and Trusts. This was led by the Society supported by the Health Care Commission and Professor Roger Boyle, National Director for Heart Disease and Stroke. The position of the Society was that risk-adjusted mortality would be published for all units in England and Wales and it was hoped that units in Scotland and Northern Ireland would wish to contribute. The publication of individual surgeon data was to be entirely voluntary and would only occur if all the surgeons within that unit agreed. In the first year (2006) 93 surgeons agreed for their figures to be published and this year (2008) data will be available for 264 surgeons. The data presented throughout this book pay testimony to the vision and success of the CCAD data collection concept. Risk-adjusted mortality data were published by the Healthcare Commission in April 2006 and were generally well received by patients, politicians and the press.

The five years from the publication of the Bristol Report to the launch of the *Public Portal,* as the HCC website became known, were extremely difficult ones for our specialty. One should not, nor indeed can one, dismiss the very real concerns that cardiac surgeons still have regarding the publication of outcome data in this way. The fact that not all surgeons are happy that their outcome data are published must force us to question whether this is the right way to proceed in the future or indeed whether it provides the information that patients need. With the fourth, and indeed final, iteration of the Public Portal under the auspices of the Healthcare Commission (now the Care Quality Commission) it is perhaps an appropriate time to consider the effect of this unique national project.

All those who support the public release of outcome measures, be they mortality figures or other quality measures such as medication upon discharge, base their argument on the premise that by making information public it will lead to an improvement in the quality of healthcare that is delivered. There are several mechanisms by which it is thought that publication can drive improvement in healthcare. It is argued that if patients are provided with this information it will allow them to choose those doctors with the best results. However, for this to happen patients must know about the information that is published, they must be able to understand it and perhaps most importantly they must believe it. In a review entitled *The Unintended Consequences of Publicly Reporting Quality Information* the Kaiser Foundation reported on a national survey undertaken in 2004 that only 35% of patients were aware of publicly available quality information (Kaiser Family Foundation and Agency for Health Care Research & Quality 2004). Concerns have also been raised that the information is not easily understandable and it has also been noted that many patients have stated they trust information given to them by their own doctors, as well as family and friends, more than they do the information that is publicly available (Werner and Asch 2005; Kaiser Family Foundation and Agency for Health Care Research and Quality 2004). In the United Kingdom the Public Portal was designed with the help of a variety of patient groups in an attempt to try and minimise the concerns over misunderstanding or misinterpretation of the data presented. The HCC cardiac surgery website continues to receive a high number of *hits* in excess of 20,000 visits *per* month, and one must conclude that this is not simply generated by surgeons and cardiologists keeping an eye on their colleagues! However, to date, no formal survey has been undertaken to assess the actual benefit that patients have received from this process. In the United States of America it is, of course, easy for a patient to choose their hospital and surgeon but in the United Kingdom, despite the protestations by the government that *Patient Choice* is the engine of the new NHS, the reality is that as far as cardiac surgery is concerned, the patients have very little choice. A significant proportion, around 35%, of patients requiring cardiac surgery are urgent admissions to hospital and the logistics involved in ensuring that they are operated on with the appropriate degree of clinical urgency will often override any preferences as to the surgical unit or the operating surgeon. Although the potential for choice may be greater for the elective patient, the processes in place to meet the 18-week targets are such that these patients are often managed on some form of *common waiting list* and thus once again choice is limited.

It has also been suggested that outcomes data can be used by referring physicians to direct their patients to the surgeons with the best outcomes. In one study (Scheider and Epstein 1996) 82% of cardiologists in Pennsylvania knew of the surgical outcome data (report cards) but were not convinced by the risk-adjustment processes or the validity of the ratings. Only 13% reported that this information played a part in their referral and 62% stated that these report cards had no influence on their referral recommendations.

Perhaps the strongest argument made by the protagonists of the public release of surgeon-specific data is that the public release of coronary artery bypass surgery mortality has led to an overall reduction in mortality. It was reported that following the publication by the New York State Department of Health (Hannan, *et al*. 1994) there was a 41% (3.52% to 2.78%) decrease in risk-adjusted mortality for CABG and that, in addition, the publication resulted in 27 low-volume surgeons discontinuing their practice. There was considerable debate as to validity of the claims that the publication of the mortality figures was the sole driver of the improvement. It was suggested that there had been an increase in the reported risk profile of the patients, a sharp and unexpected rise in the incidence of severe airways disease and unstable angina are the two most commonly quoted examples; and it was also suggested that high-risk patients were either being denied surgery or referred to out-of-state surgical units (Omoigui, Miller and Brown 1996). Concerns have also been raised that at this time certain ethnic groups, such as blacks and hispanics, who were perceived to have worse outcomes following CABG, were being avoided (Werner, Asch and Polsky 2005).

However, to counter this argument studies have shown similar falls in mortality following CABG in various states in the United States of America that do not participate in the publication of mortality tables and it has been argued that the change was simply due to an improvement in the management of patients undergoing coronary artery bypass surgery. Interestingly another region had the same fall in mortality over the same period (1987 to 1992) but using a confidential reporting system (New England Cardiovascular Disease Study Group). Shahian argues that it is the *institution of a formal quality improvement process that is the key, irrespective of whether this effort is public or confidential* (Shahian, *et al*. 2001). Although the vast majority of the publications regarding the use and publication of *report cards* emanates from the United States of America, a relatively recent study from Canada sheds light on the effect of these two reporting modalities. Over an 11-year period they assessed crude, expected and risk-adjusted 30-day mortality rates for 67,693 patients undergoing isolated CABG (Guru, *et al*. 2006). The study covered three distinct periods and practices (no reporting, confidential reporting, and public reporting). There was a marked (29%) reduction in risk-adjusted mortality when confidential reporting was introduced, but there was no further decrease following the introduction of public reporting of outcome measures.

Perhaps the most important reason for the publication of unit- and surgeon-specific outcomes, regardless of whether they are trusted or understood, is that they enhance trust and provide accountability. Patient feedback from the HCC website has strongly supported the cardiac surgeons and as one patient put it:

> *I have enormous respect for the cardiac surgeons … who have led the way and published this information*

There is also the argument that although patients may not look at individual surgeons' data they are very reassured that it is collected and analysed by a professional organisation. Simply put it is this:

> *the fact that it is reported is much more important than the facts that are reported.*

With all the publications from the United States of America there was concern within the United Kingdom cardiac surgical community that the publication of surgeon-specific results would result in high-risk patients being denied surgery. A BBC Newsnight survey in 2000 found that although 80% of surgeons were in favour of the public disclosure of mortality data, 90% thought that high-risk cases were already being avoided in anticipation of that event. There was also considerable concern about the validity of the risk adjustment algorithms in use. In 2007 a study by Bridgewater and colleagues (Bridgewater, *et al.* 2007) from the North-West quality improvement programme, analysing over 25,000 patients undergoing isolated CABG over an eight-year period, concluded that there was no evidence that fewer high-risk patients were undergoing surgery as a result of the publication of mortality rates. An analysis of the mortality data from CCAD for the financial years 2001 to 2008, and the data included in this book, shows a persistent fall in crude mortality rates with a concomitant rise in the logistic ***EuroSCORE***. This raises two interesting questions: firstly, how low can mortality become and, secondly, how valid is the current risk algorithm? In an editorial in the New England Journal of Medicine entitled *Is Zero the Ideal Death Rate?* (Lee, Torchiana and Lock 2007) Lee argues that:

> … *public performance measures that push providers towards apparent perfection in these areas can have unintended perverse consequences.*

The proportion of surgeons within the United Kingdom who have had a zero mortality rate for isolated CABG for the period covered by the HCC website is any order of 20-25%. Although a rise in this proportion would seem to be a worthy goal it must not be at the expense of a high-risk patient. An examination of the ratio actual mortality to predicted mortality (based upon logistic ***EuroSCORE***) obtained from the CCAD data shows a steady improvement in performance over this period, actual mortality has fallen from 64% of predicted to 32% of predicted. Although the risk algorithm can, and indeed has been, recalibrated for the purpose of analysis and publication, there comes a point where one must consider whether it is time to develop a new model. A survey of the 38 cardiac surgical units in the United Kingdom found that of the 32 who responded over 90% felt that risk-adjusted mortality for isolated CABG was a good outcome measure, at unit level, but this was not felt in the case for more complex procedures (combined MVR & CABG). Since the surgeon-specific mortality information that is published covers not only isolated CABG but also the totality of the surgeon's practice it seems that we need to consider one that better reflects current surgical practice. Indeed we may need several risk models (see page 392).

Since it was the surgeons who took the lead in the publication of individual results we were able to use clinically appropriate risk algorithms rather than have our performance analysed using NHS administrative data. As has been described above this required a massive investment of time and effort by cardiac surgeons to ensure that we had meaningful data. Over time, the completeness and volume of data have increased considerably: in 2003 there were less than 2,000 patients on CCAD and at the time of writing, as described in this book, there are over 315,000 patients' records with a low incidence of missing data. A significant and perhaps unexpected benefit of mortality publication has been the ability to use the data we have collected for wide variety of research and quality improvement initiatives, a number of which are described throughout this report. We are now in a position to provide up-to-date information to a wide variety of organisations, and this puts us in a strong position when it comes to introducing and assessing new techniques such as percutaneous valve implantation, on the basis of evidence of effectiveness and risk.

It would seem therefore that the United Kingdom experience following the publication of individual surgeon's outcomes has been, on the whole, beneficial to both patients and surgeons. However, there is an *elephant in the room* and we cannot ignore it. To date there has been no surgeon nor any unit found to be a poorly performing outlier and although this may disappoint some sections of the media we can reassure the patients that surgeons and units in the United Kingdom perform surgery to a high standard. Indeed the purpose of the Public Portal was not to produce league tables, but to demonstrate that results for all surgeons met an internationally acceptable standard and to help drive quality. In any quality assurance program the aim is to detect the trends towards a significant deviation from acceptable practice by means of *early warning alerts* rather than waiting for the *alarm bells to ring.* For several years before the public release of data in the United Kingdom confidential review of isolated CABG results for all surgeons was undertaken by SCTS and although this was not ideal nor very statistically sophisticated it was considerably more advanced than any other specialty. Hand-in-hand with the development of the HCC website has been a *near real-time* analysis of individual and unit outcome data. The vast majority of surgeons have no problem with the development of an early warning monitoring system, but the elephant in the room is the response by Medical Directors and Chief Executives upon being informed that one of their surgeons has triggered an *early warning alert*. There must not be, although it is feared there will be, a knee-jerk response by those in positions of responsibility that results in inappropriate suspension and possibly public humiliation. All those involved must act in a mature, responsible and supportive way realising that the outcome from cardiac surgery is not solely attributable to the surgeon, but that it is multi-factorial. If this does not happen the chances of the analysis and publication of outcome measures not only in cardiac surgery but across all specialties will be put in jeopardy, and this cannot be of benefit to the patients in this country.

To conclude, I would suggest that cardiac surgery did indeed jump, but that it was not from the precipice that we initially feared. We must though move on from mortality as a marker of quality since over 98% of patients survive isolated CABG, we must ensure that these patients do so with a minimum of complications and the best long-term outcomes. Since patients are managed at a unit level we must move towards much wider-ranging markers of unit level performance and we have made progress along this route with the analyses presented elsewhere in this report. To do this will not only require increasing levels of data collection, as well as analysis and risk profiling, but will also require a greater degree of commitment and support by hospitals. In the recent NPSA publication (National Patient Safety Agency 2009) on the WHO Surgical Safety Checklist the 10th essential objective is:

> *Hospitals and public health systems will establish routine surveillance of surgical, capacity, volume and results.*

Cardiothoracic surgery continues to lead the way, but we hope others will follow for now there is no excuse not to.

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Selection, training and re-certification in Cardiothoracic Surgery

For patients to get excellent treatment you have to select the best candidates into the specialty, train them well and, after they are appointed to consultant posts, continue to monitor their outcomes to assure quality and support improvements.

Introduction

In the mid- and late-1990s there were several serious, well-publicised failures of healthcare delivery in the United Kingdom involving problems with both hospital and general practice systems and a small number of individual doctors. These failures revealed shortcomings in personal, professional and institutional healthcare regulation. In 1995, in the immediate aftermath of the GMC hearing of the *Bristol case,* both the government and the medical profession acted to address these issues. The government signalled an important new framework for quality and safety. Clinical governance was introduced at the workplace. The profession proposed standards-based professional regulation with, critically, a new duty on doctors to demonstrate their continuing fitness to practise through the new process of revalidation.

In 2005, following the report of the Shipman Inquiry, the Chief Medical Officer published *Good Doctors, Safer Patients* (2006). He developed detailed proposals that are now becoming Law through the White Paper about regulation of Healthcare professionals: *Trust Assurance and Safety.* The Chief Medical Officer's report discussed in detail the various failures, raised key questions about the functions of the General Medical Council as the doctor's regulator and made suggestions about how things should change. These recommendations are now being implemented. Revalidation is at the heart of the White Paper. For hospital specialists, like cardiothoracic surgeons, this will be by a two-stage process combining re-licensure (to continue to remain on the medical register and have a licence to practise medicine) and re-certification (to stay on the specialist register and continue to practise as a cardiothoracic surgeon).

Cardiothoracic surgery has been at the forefront of many of these developments. The Public Inquiry into events in Paediatric Cardiac Surgery at Bristol Royal Infirmary, which followed immediately after the GMC hearing, was one of the most significant events leading to the changes now taking place. The cardiac surgical community have responded by collecting comprehensive national audit data for comparing outcomes by hospital and surgical team in line with the recommendations in the Bristol report, in a way which has been praised in *Good Doctors, Safer Patients* (2006). The way in which initiatives within cardiac surgery have complied with recommendations from the various reports has been described on page 28.

Intensive scrutiny of patient outcomes down to an individual consultant level has focussed our specialty on developing systems to optimise those outcomes, and now we strongly believe in a *systems-based* approach. We have worked over recent years to put in place systems to select the best candidates for cardiothoracic surgical training, to improve the quality of training and assessment of those trainees and to instigate data collection and analysis to monitor and improve outcomes for surgeons in independent practice (with the joint aims of helping to drive quality improvements and *feeding* the professional re-certification agenda). We feel that selection, training and monitoring of outcomes should be integrated and complimentary to optimise patient care, and recognise that failings in any part of these processes can potentially lead to poor outcomes for patients. Training in any specialty is obviously essential for producing high-quality doctors for tomorrow, but it is also equally important that any training for surgeons is not at the expense of the quality of patient outcomes.

To explore these issues the following sections will describe in more detail the processes now in place for selecting and training cardiothoracic surgical trainees within the United Kingdom, and outline current thinking about how surgical outcomes will feed professional re-certification in cardiac surgery.

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iii The Shipman Inquiry. http://www.the-shipman-inquiry.org.uk/reports.asp.

iv The White Paper Trust, Assurance and Safety: The regulation of health professionals. http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_065946

National selection

Selecting the best trainees into the specialty of cardiothoracic surgery is critically important to ensure that, six years or so later, new consultants are of the highest standard, to be able to deliver excellent care for patients. Historically appointments in the United Kingdom have been made by regional committees, with inevitable local variation. Normally applicants have submitted their *curriculum vitae* with their application form to the regional committee. After short-listing against pre-defined criteria, candidates are interviewed by a panel consisting of medical, managerial, university and deanery representatives, along with someone from the Specialty Advisory Committee in cardiothoracic surgery (the SAC), which is the organisation responsible for surgical training.

Several years ago the SAC decided that it could improve the appointments process. It introduced national selection with a more robust process designed to allow fairer, more consistent, transparent decision-making using standardised techniques of measurement and assessment. The new arrangements were agreed by the bodies responsible for appointments and training and, since the end of 2007, national selection has been used to select all cardiothoracic surgical trainees.

The first round of appointments followed a comprehensive review of the speciality's manpower needs including an assessment of the number of doctors currently in training and the likely need for new and replacement consultants. The first intake was restricted to only five in England and one each in Scotland and Wales. Each training programme in England was asked to submit details of their training opportunities to the SAC, and slots were allocated only to the *best* programmes, to help to ensure optimum training for new entrants. The national appointments were made by a committee comprising the training programme directors from each of the United Kingdom programmes (or their representatives), academic surgical representatives, a representative from the Committee of Post-graduate Medical Education Deaneries and a lay Chairman. Initially, applications were put on a *long-list* if they fulfilled basic eligibility criteria after which a short-list was drawn up by a rigorous, robust, reproducible, calibrated process. The 18 best candidates were invited for interview.

These candidates went through a demanding assessment over two days. This included a structured interview, examination of a training portfolio, presentation of an audit project and objective structured assessment of technical skills. Scores from each part of the assessment were pooled and candidates ranked, references were checked and the highest ranking candidates were offered training posts.

This process is being repeated in 2009. Sixteen posts are available, of which 2 are dedicated academic training posts designed to promote and support academic training.

Training

Medical training has undergone a complete overhaul in recent years. The group now with overall responsibility for training in the United Kingdom is the Post-Graduate Medical Education and Training Board (PMETB), which is itself being brought under the umbrella of the General Medical Council (GMC). Surgical training is overseen by a Joint Committee on surgical training, which advises the four Royal Colleges of Surgery. Each surgical specialty has a Speciality Advisory Committee (SAC), which reports to the Joint Committee. The central aim of these committees is to drive up the quality-of-care for patients by improving post-graduate medical education and training. They are also tasked to ensure a transparent and effective career path for doctors in line with the government document *Modernising Medical Careers*. A key initiative underpinning these developments is the intercollegiate surgical curriculum programme, which incorporates the nine surgical specialties and was developed across all four United Kingdom Royal Colleges of Surgery by the specialist societies (including the SCTS) and the specialist advisory committees for each speciality.

The Intercollegiate Surgical Curriculum Programme

The aim of the ISCP is to provide a programme of first-class surgical training from the beginning through to the completion of specialist training that will ensure the highest standards of surgical practice. To achieve this, the nationally standardised curriculum is underpinned by clearly-defined standards and competency-based assessments for each stage of surgical training.

The key principles of the ISCP are:

- a common format and framework across all the specialties within surgery.
- systematic progression from the early (or foundation) years through to the end of surgical specialist training.
- curriculum standards that are underpinned by robust assessment processes, which must conform to the standards specified by PMETB.

- regulation of progression through training by the achievement of outcomes that are specified within the specialty curricula. These outcomes are competence-based rather than time-based.
- delivery of the curriculum by surgeons who are appropriately qualified to deliver surgical training.
- formulation and delivery of surgical care by surgeons working in a multi-disciplinary environment.
- collaboration with those charged with delivering health services and training at all levels.

The surgical curriculum has been designed around four broad areas:

- **content / syllabus:** what trainees are expected to know, and be able to do, at any point in their training;
- **teaching and learning:** how the content is communicated and developed, how trainees are supervised;
- **assessment:** how the attainment of outcomes are measured / judged, feedback to support learning;
- **systems and resources:** how the educational programme is organised, recorded and quality-assured.

In order to promote high-quality care of surgical patients, the curriculum specifies the parameters of knowledge, clinical skills, technical skills, professional skills and behaviour that are considered necessary to ensure patient safety throughout the training process and specifically at the end of training. The curriculum therefore provides the framework for surgeons to develop their skills and judgement and a commitment to life-long learning in line with the service they provide.

Operative surgical training

In addition to the acquisition of clinical knowledge, judgement and experience and professional skills, surgical training also requires the development of technical and operative skills. Traditionally these skills were gained in the operating theatre with varying levels of supervision. The level of supervision given to trainees whilst operating was addressed by the National Confidential Enquiry into Peri-operative Death (NCEPOD) during the early 1990s. Several NCEPOD reports investigated the circumstances of death following surgery and found that many of these patients had undergone out-of-hours surgery. They also found that much *out-of-hours* surgery was performed, not because of urgency, but for organisational and logistical reasons. Patients in this situation were more likely to be treated by unsupervised trainee surgeons and anaesthetists. The NCEPOD reports were instrumental in changing the culture of training so that the standard of care given to patients could no longer be compromised by lack of supervision of trainees who either did not have the appropriate level of ability or experience. This is now reflected by a curriculum that is competency-based.

Whilst trainees of the current generation are probably less experienced than their predecessors when they take up their consultant posts, it is thought that they are *better* trained. Absolute numbers of surgical procedures performed by trainees in cardiothoracic surgery are no longer seen as a measure of quality of training. Initially trainees perform the more straightforward parts of surgical procedure that they are competent to complete with supervision, and then progress gradually towards undertaking the more technically demanding parts. This constitutes an approach that is safe for the patient and better for the trainee. The introduction of the SAC cardiothoracic surgery training fields into data collection systems (see appendices) allows departments, trainers and trainees to collect more detailed and relevant information about operative training. Operations are broken down into their important composite parts and it can then be recorded which surgeon has performed each segment of the procedure.

Our existing database has some information about training included within its fields. For each operation it is recorded whether the *primary* operator is a consultant or a trainee and, if it is a trainee, the level of seniority of the trainee should be noted. Previous analyses of outcomes of patients undergoing cardiac surgery by surgeons in training have demonstrated that mortality is low, and, in general, results are as good as those when a consultant is the primary operator [i, ii].

Assessment

In addition to imparting knowledge and operative skills to trainees, it is essential that there is some form of regular assessment to ensure satisfactory progress, and to identify and rectify problems at an early stage. The assessment system is designed to:

- determine whether trainees are meeting the standards of competence and performance specified at various stages in the curriculum for surgical training.
- provide systematic & comprehensive feedback as part of the learning cycle.
- determine whether trainees have acquired the generic and specialty-based knowledge, clinical judgement, operative and technical skills and professional skills and behaviour required to practice at the level of completion of training in the designated surgical specialty.
- address all the domains of Good Medical Practice and conform to the principles laid down by the Post-graduate Medical Education and Training Board.

The individual components of the assessment system are:

- workplace-based assessments, covering skills, knowledge, behaviour and attitudes;
- a logbook of procedures undertaken that provides corroborative evidence of experience;
- examinations held at key stages; during the initial stage of training and towards the end of specialist training;
- the learning agreement and the assigned educational supervisors' report;
- an annual review of competence progression (ARCP).

A common framework of stages and levels is used by all the specialties. Trainees progress through the curriculum by demonstrating competence to the required standard for the stage of training. Within this framework each specialty has defined its structure and indicative length of training; the majority of trainees will be able to cover a level in the course of a year. The individual specialty syllabuses provide details of how the curriculum is shaped to the stages of training. In general terms, by the end of training, surgeons have to demonstrate:

- theoretical and practical knowledge related to their specialty practice;
- technical and operative skills;
- professional judgement;
- an understanding of the values that underpin the profession of surgery and the responsibilities that come with being a member of the profession;
- the special attributes needed to be a surgeon;
- a commitment to their ongoing personal and professional development and elective practice and other educational processes;
- an understanding and respect for the multi-professional nature of healthcare and their role in it;
- an understanding of the responsibilities of being an employee of an NHS trust, hospital and / or a private practitioner.

In Cardiothoracic surgery one of the *hurdles* for trainees is the intercollegiate specialty examination in Cardiothoracic Surgery. This is usually taken after the end of the fourth year of training and is a comprehensive

i Goodwin AT, Birdi I, Ramesh TP, Taylor GJ, Nashef SA, Dunning JJ, Large SR. Effect of surgical training on outcome and hospital costs in coronary surgery. *Heart.* 2001; **85(4):** 454-7.

ii Oo AY, Grayson AD, Rashid A. Effect of training on outcomes following coronary artery bypass graft surgery. *Eur J Cardiothorac Surg.* 2004; **25(4):** 591-6.

assessment of knowledge and application of knowledge using written, oral and clinical assessments. The level of knowledge that the test is pitched at is that expected of a new consultant as indicated by the intercollegiate specialty curriculum. Applicants must provide evidence of having reached the appropriate standard of clinical competence in the form of three structured references from those with direct experience of the individual's current clinical practice, one of whom must be the trainee's Programme Director. Once the examination is awarded and training is *signed off* the trainee can be awarded a certificate of completion of training (CCT) and be eligible to be placed on the specialist register and take up a consultant appointment.

Entry to the Specialist Register

Since 1st January 1997 only doctors on the specialist register of the GMC are eligible to take up an appointment as an NHS consultant. The standard model for getting on the register is as described above, but specialists with the appropriate qualifications from Europe can also apply, as can those from elsewhere in the world *via* a clause under the guidance of the General and Specialist Medical Practice (Education, Training and Qualification) Order 2003.

Re-certification

As described above, to respond to the new legislation in the White Paper *Trust, Assurance and Safety* (2007), hospital specialists such as consultant cardiothoracic surgeons will need to demonstrate that they maintain their competence and professionalism to continue to practice. Every five years they will have to undergo revalidation consisting of:

- re-licensure (where they will need to demonstrate that they are fit to remain on the medical register and be given an ongoing licence to practice) and
- re-certification (where they will have to demonstrate that they are fit to stay on the specialist register in their chosen field of practice).

Surgeons will be issued with the first *licences to practise* this year and re-certification will be introduced from 2010. Because of the evolved nature of our audit data and governance systems we expect that cardiothoracic surgery will be in the first wave of specialties that will introduce re-certification. The exact mechanisms by which this will happen have not been completely resolved at the time of publication, and will vary to some extent across the United Kingdom because of differing legislation, but the processes of regulation will have a number of generic components that will apply to all doctors and other areas that will be very much speciality-specific. The overall responsibilities are complex, but for surgery will involve the General Medical Council (the regulator), the Academy of the Medical Royal Colleges (who advise the GMC and will ensure consistency in approach and standards across all doctors), the Royal Colleges of Surgery (who will have some role in setting standards and implementing re-certification) and the specialist societies, which for cardiac surgery will be the SCTS. The SCTS is currently being asked to set the standards required for all cardiothoracic surgeons wishing to stay on the specialist register.

A doctor's roles are complex and varied and there have been extensive discussions about the various different *domains* of medical practice, and for the purposes of revalidation, evidence will need to be supplied to demonstrate competence and compliance with each domain. The domains with which most surgeons are familiar are those that are generally used for the annual appraisal process and are described in the GMC's document *Good Medical Practice*.

Domains in Good Medical Practice

- **Good clinical care**
- **Maintaining good medical practice**
- **Teaching and training, assessing and appraising**
- **Relationships with patients**
- **Working with colleagues**
- **Probity**
- **Health**

A number of these domains will be generic to all doctors, such as health and probity and supplying evidence of compliance with these will be necessary for re-licensure. Others will require different types of information for different specialties for re-certification. An alternative approach to domains for the purposes of re-certification has been produced by the Academy of the Medical Royal Colleges. The information and standards that will be required for re-certification within these domains will need to be described clearly by specialist associations such as the SCTS.

Academy template of domains for surgery

- **Knowledge, skills and performance**
- **Safety and quality**
- **Communication partnership and teamwork**
- **Maintaining Trust**

As described throughout this book, the SCTS has a long history of collecting, analysing and benchmarking cardiac surgical outcomes. Data on success rates of surgery will therefore be an important part of the information that will be needed for re-certification. Key to all of this will be the exact methodology that is used to benchmark clinical outcomes. The remainder of this section will describe how this might be performed using some examples from the SCTS database, outlining some potential controversies and pitfalls.

It is important to be clear that clinical outcomes are an important part of the evidence that surgeons will need to provide to demonstrate their competence for the purpose of professional re-certification. It is, however, also essential to be explicit that clinical outcomes are only one part of the evidence, which will also include information on the results of multi-source feedback (to give information about *communication, partnership and teamwork*), continuing professional development (probably including the use of appropriate e-based learning tools), other data about quality-of-care, reflective practice and involvement in other professional activities (including information on complaints and claims along with data from Morbidity & Mortality Meetings). Detailed discussion about these other issues is outside the scope of this database report.

It is also important to note that the fundamental building block of the revalidation process will be annual appraisal. Historically this has been a *formative* or development-based process for individuals. This will now change to being more *summative* or assessment-based. Any problems with performance or behaviour should be picked up through local clinical governance systems and resolved, locally where possible. Satisfactory annual appraisal will be an important part of demonstrating competence for the purposes of revalidation, as well as helping to develop individuals to improve quality-of-care and services for patients.

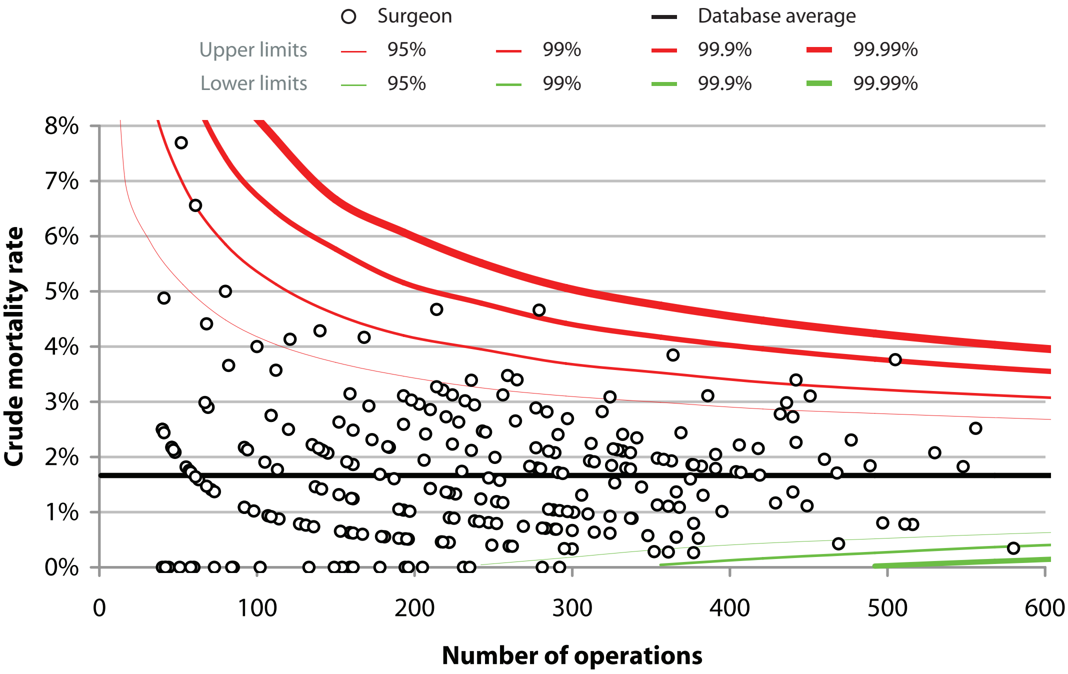
The following illustrate some of the principles that will be used to apply clinical outcomes data for cardiac surgery to professional re-certification. We have conducted an analysis for each surgeon in the United Kingdom, looking at in-hospital mortality for coronary artery bypass surgery during the 3 years to March 2007. Each plot contains the national mean, and every surgeon's mortality is plotted against the number of cases they have undertaken over that three-year period. The first plot shows crude in-hospital mortality with no adjustment made for casemix. Superficial scrutiny of this shows two apparent outliers at 99.9% control limits and four more at 99% limits.

The second plot displays the scatter of predicted mortality and shows that, whilst most surgeons are scattered around the national average, there are a small number of consultants who undertake a case-mix that is significantly higher that the average. Obviously if one of these surgeons with a complex case-mix had a high mortality in the previous graph, it is quite possible that could be easily explained.

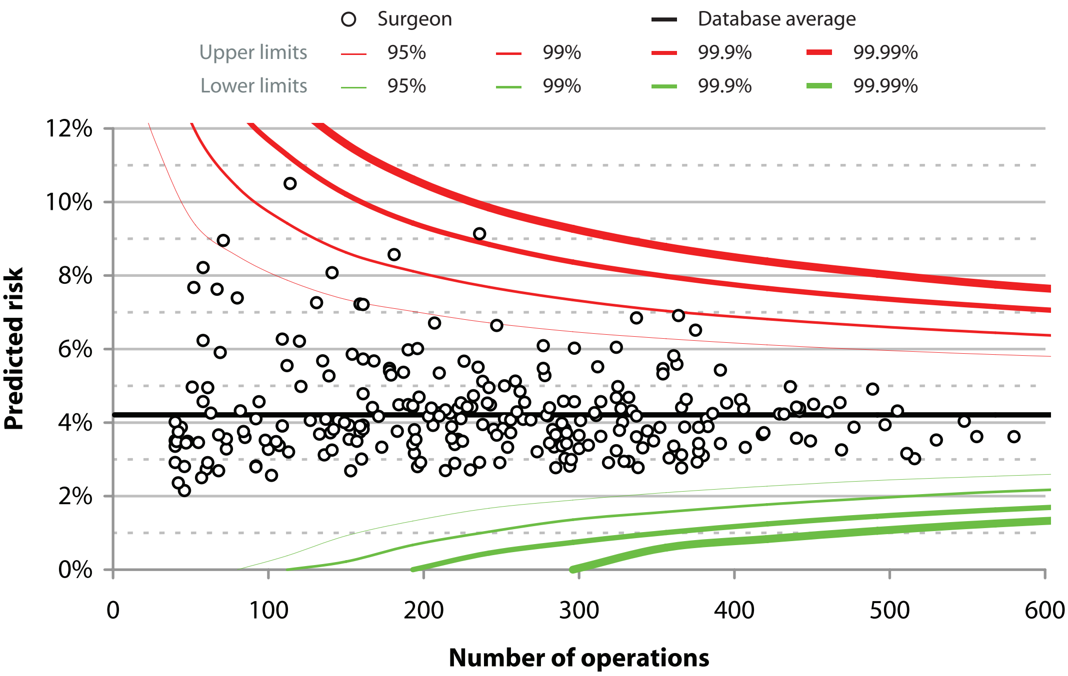
The next plot shows the risk-adjusted mortality using the logistic ***EuroSCORE*** in its originally published form.

This shows that almost all surgeons have a risk-adjusted mortality better than average, and these conclusions are obviously erroneous, because the ***EuroSCORE*** is now known significantly to over predict observed mortality (see page 392).

Isolated CABG: Funnel plot of mortality by consultant; financial years 2005-2007 (n=61,394)

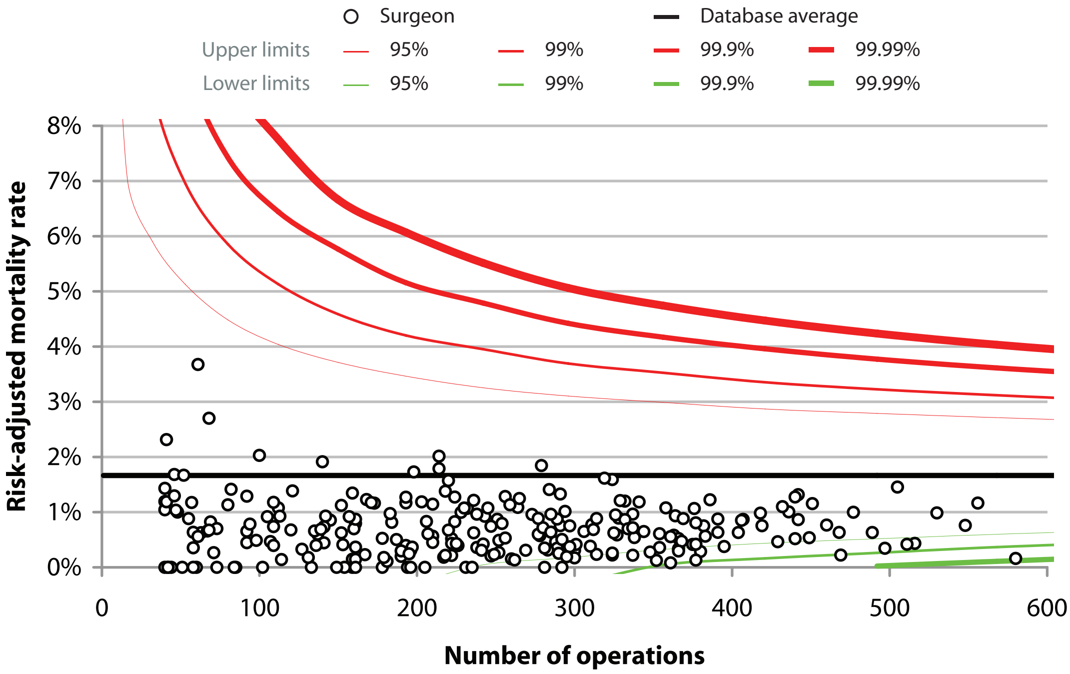


Isolated CABG: Funnel plot of the predicted risk of mortality by consultant; risk as per logistic *EuroSCORE*; financial years 2005-2007 (n=61,394)

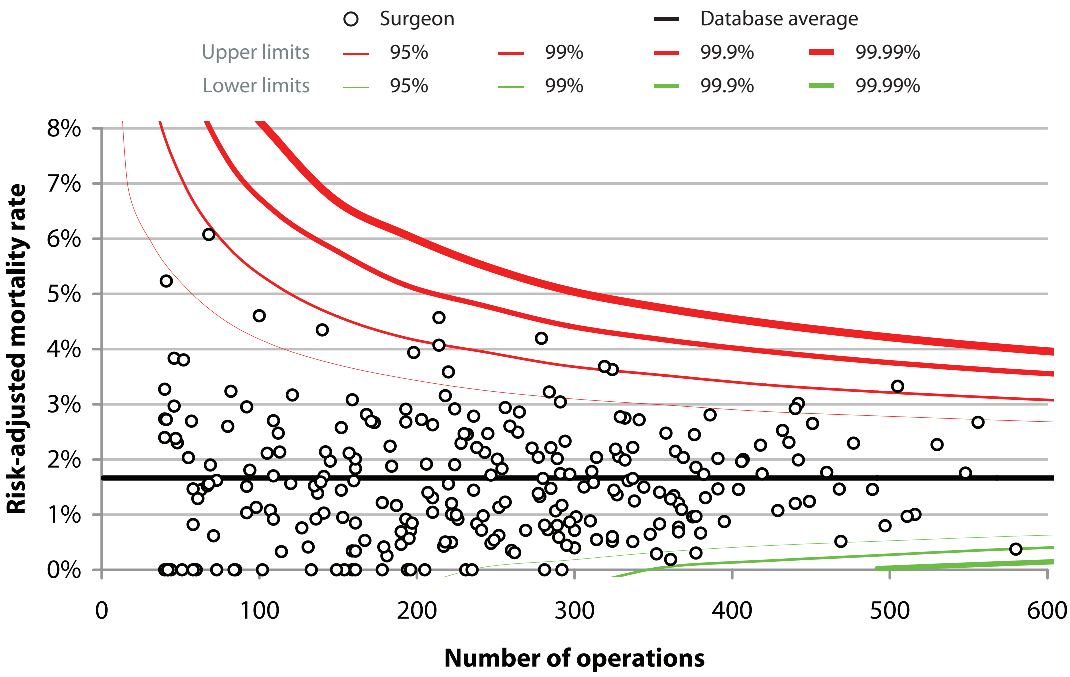


The final plot shows each surgeon's risk-adjusted mortality after adjusting for the logistic ***EuroSCORE*** using contemporary calibration (see page 466). This shows that the surgeons with a *high* mortality at 99.9% are now back within those control limits. There are a small number of surgeons who fall outside the 99 % control limits, but inside the 99.9% line, which is probably acceptable due to issues about multiple comparisons (see below), but it is also probably appropriate to subject these results to robust local scrutiny (see page 438).

Isolated CABG: Funnel plot of risk-adjusted mortality by consultant; risk according to logistic *EuroSCORE*; financial years 2005-2007 (n=61,394)



Isolated CABG: Funnel plot of risk-adjusted mortality by consultant; risk as per adjusted logistic *EuroSCORE*; financial years 2005-2007 (n=61,394)



Issues of controversy

Team *versus* individual outcomes: individual named cardiac surgeon's mortality data are now in the public domain, but there are critics of this initiative (see page 412). It is well accepted that safe and effective care for patients derives from good surgery taking place within robust systems and any weak link in the pathway can lead to poor outcomes. Problems can result from shortcomings in many areas including patient selection, the environment, anaesthesia, critical care, nursing, perfusion, lack of resources and the culture of the organisation. Evidence from within our speciality suggests that where mortality is high it is as likely to be due to issues other than the surgeon, as it is to be due to poor surgery. There are concerns within the profession that an individual's poor results may lead to difficulties with revalidation, where the causes of unsatisfactory outcomes are outside their control. Whilst this is a potential worry, it is also important to note that revalidation will take place over a 5-yearly cycle and will be underpinned by annual appraisal. Any concerns a surgeon may have about the various aspects of care, other than the surgery itself, should be addressed, documented and hopefully resolved through this process, and this evidence will from a part of the documentation that goes forward to decisions about re-certification.

Low-volume surgery: there are a number of operations that are performed in low numbers, and many them are described along with their outcomes in the section on page 350. These operations are done nationally only in small volume & each surgeon will perform only a few over a 5-year re-certification cycle. It will not be possible to demonstrate satisfactory outcomes for individual surgeons for these operations with any statistical *power.* However, these operations are important as they often have a high mortality and from the patient's perspective it is important that operations with the highest degree of risk are tightly regulated to ensure satisfactory quality. The methodology described above using funnel plots is not useful for small-volume operations. For the purposes of re-certification an analysis of *all* cardiac surgical practice for each surgeon may help to pick up overall concerns, but scrutiny of quality for the low-volume operations will rely on tight local governance processes within each hospital, including particular attention to potentially preventable adverse outcomes through Morbidity & Mortality meetings. All of these principles about low-volume operations apply to surgeons who are performing low volumes of overall surgery.

The risk model

No risk model is perfect but some are useful

The data shown above demonstrate that there are major variations between individual surgeons with respect to the predicted risk of the patients on whom they operate. It is important to adjust for these variations otherwise any comparative analysis might lead to the invalid conclusions and may particularly adversely affect surgeons taking on the highest-risk patients. It is also important to use risk-adjustment methods to help to minimise the possibility that higher-risk patients may be turned down because surgeons are concerned about their mortality outcomes. The analyses of crude mortality outcomes show some surgeons who are apparent *outliers* on initial scrutiny, but some of these surgeons fall comfortably back *into the pack* after adjusting for predicted risk. It has also been shown that the results of this type of analysis, as well as depending on whether risk-adjustment is applied or not, are critically dependent on which particular risk-adjustment model is used and on the way in which the risk model is calibrated (Grant *et al.* 2006). In other words a surgeon may be defined as an *outlier* if one risk model is chosen, but their outcomes may appear fine if a different one is used. It is thus important to stress that no risk model is perfect at predicting outcome. The way in which the predictive ability is assessed uses the area under the Receiver-Operating Characteristic (ROC) curve and most models achieve a score of between 0.7 and 0.8, which is only about as good as a long-range weather forecast. There are also a number of other potential problems in the way in which these models are applied, including issues about statistical distribution.

The implication of shortcomings in existing risk models is that any analysis of surgeon-outcomes based on risk-adjustment methodologies should only act as a guide to the level of performance. Any finding that any surgeon has mortality outcomes that are higher than predicted should trigger a rapid, supportive and sensitively-handled investigation, which should look at data-quality and accuracy, the environment, case-mix and mechanisms of adverse outcomes. Only at the end of this process should any judgements be made about the quality-of-care provided by an individual surgeon. It is also important to acknowledge that a risk model can potentially work to *hide* a surgeon whose mortality may be higher than is acceptable, and any analysis of risk-adjusted outcomes should be supplemented by rigorous and careful ongoing scrutiny and local governance systems.

i Grant SW, Grayson AD, Jackson M, Au J, Fabri BM, Grotte G, Jones M and Bridgewater B. Does the choice of risk-adjustment model influence the outcome of surgeon-specific mortality analysis? A retrospective analysis of 14,637 patients under 31 surgeons. *Heart.* 2008; **8:** 1044-9.

Multiple comparisons

There is a somewhat complex issue about the statistical analysis of the scrutiny of surgical outcomes data. Without going into depth about statistical theory, these analyses are designed to test a *hypothesis* such as:

Is Mr X's mortality as expected from his casemix?

Statistical techniques are applied, using predefined levels of probability, to either accept or reject that hypothesis. So, if the usual 95% limits are chosen and the appropriate test demonstrates significance, the hypothesis can be rejected (and Mr X's mortality is **NOT** as expected), but there remains a 1 in 20 probability that the high mortality is due to chance alone. This is straightforward if you are just analysing one surgeon's outcomes against the national average, but becomes more complex when you make comparisons of many surgeons.

The simplest example of this would be the comparison of 20 surgeons against a group mean. If the usual 95% limits are used, there would be a 1 in 20 chance that, if high mortality was detected, it would be due to chance alone. However, because one is effectively repeating that test on 20 separate occasions there is a high probability, due to chance alone, that more than one surgeon will be identified as having unacceptable outcomes and this will be a *false positive* finding. To account for this it is statistically appropriate to make a *multiple comparisons adjustment* (*i.e.*, to make the limits wider) and the amount of this adjustment will depend on the number of comparisons that need to be made, which in the case of United Kingdom cardiac surgical consultants is in excess of 260. If 95% control limits were used it would be almost certain that an outlier would be found due to chance alone, and the wider the confidence limits, the smaller the chance. There is however a balance to be struck here between protecting the patients and protecting the surgeons. The dynamic is complex, because imposing very tight limits on this type of analysis would almost certainly create the unintended negative consequence of encouraging surgeons to turn down higher-risk cases, to ensure they are not identified as *high-mortality* surgeons.

Outliers

As described above, any system for analysing surgeons' outcomes will inevitably, sooner or later, demonstrate a surgeon whose mortality outcomes fall outside pre-determined statistical limits and there will need to be clear processes in place to manage this when it arises. There will be responsibilities for local employers, specialist associations, Royal Colleges and the Regulator.

Local employers: the aim of all Trusts employing cardiac surgeons should be to continually monitor outcomes in the hospital as a whole and for its individual surgeons in particular, to improve overall quality and provide quality *assurance*. There should be mechanisms in place to pick up unsatisfactory outcomes at an early stage and to initiate processes to understand those outcomes and implement strategies to improve results. This process should be continuous, but should be thoroughly and systematically reviewed through the annual appraisal process. It must be recognised that high mortality outcomes do not necessarily imply poor surgical performance and when unsatisfactory outcomes are detected we would recommend a process that involves:

- careful scrutiny of the data,
- examination of the processes of care,
- consideration about issues about case-mix and
- finally this may lead to questions about the quality-of-care from the individual concerned.

Examples of what we believe is good practice in monitoring surgical outcomes are included on page 438. Re-certification will take place on a five-yearly cycle, and the outcomes of cardiac surgery for an individual who is about to be re-certified should come as no surprise to the individual concerned or their Trust. We would hope that if functional, supportive mechanisms are in place no surgeon should come to the point of re-certification without either satisfactory outcomes or a deep knowledge and justification about why seemingly unsatisfactory outcomes are not of any concern.

Specialist associations: Specialist Professional Associations such as the SCTS have a role in defining the standards required for re-certification and in the example of clinical outcomes for cardiac surgery, will need to support national data collection and analysis, define the appropriate risk model(s) to use, set thresholds for satisfactory outcomes and support surgeons and employing organisations in interpreting questionable outcomes or investigating concerns.

Royal Colleges of Surgery: There is a current dialogue between the GMC, the Academy of the medical royal colleges and the Royal College of Surgeons about the exact mechanism by which re-certification will be implemented. Due to differences in legislation there will be variation in these issues across the United Kingdom. These discussions and decisions are not complete at the time of going to press.

Ben Bridgewater, Steve Rooney, Steve Livesey and Tim Graham

Good practice examples

As described throughout this book, the SCTS has run a database project since 1994 and all cardiac surgical units in Great Britain and Ireland now collect data and submit to the national audit. There have been obvious developments associated with the *data initiative* including overall improvements in risk-adjusted mortality and the publication of hospital's and surgeon's results, but there have also been many more subtle changes that have been related to the necessity to collect comprehensive clinical information. The SCTS has taken an overall leadership role in defining a dataset and working with other organisations to collate, analyse and disseminate surgical activity trends and results, but actual data collection, validation and local use has evolved in the individual hospitals, and has done so in different ways. It is often surprising to visit cardiac surgical units to see quite how different they are. Whilst the fundamental outcome of risk-adjusted mortality remains very consistent across units as shown in the data in the appendices, the culture, processes and management systems vary significantly. The structures for collecting, validating and using cardiac surgical audit data have developed differently in the hospitals and we thought it would be of interest to collect a number of examples of what we regard as *good practice,* which may be useful to cardiac surgical units, and we believe the principles contained in these examples may easily be applied to other areas of medicine and surgery that may not have been driven down the route of data collection, governance and accountability to the same extent as cardiac surgery. These initiatives sit within the framework of quality, as defined by patient-safety, patient-experience and effectiveness-of-care.

Data collection is undertaken in the units in different ways. All hospitals now have an IT system, which may be commercially supplied or developed *in-house.* The actual process by which data finds its way onto the IT system varies; some hospitals collect data at the point of treatment directly onto the IT system by keyboard input, whilst others use a paper-based approach with the data being transcribed onto the IT system at a later date. Absolutely key to the quality of any analysis about surgical activity and outcomes is the quality of the data on which that analysis is based, and some degree of data validation is essential in the process. The SCTS ran a series of data validation visits between 2004 and 2006 where it was accepted that external validation of individual hospital patient-records against the data submitted to the database was a task outside the scope of existing resource, but it was felt that by examining a number of audit processes within the hospital you could gain some reassurance about the quality of the data. These data validation visits looked at a number of criteria including:

- ensuring there was an overt, documented institutional process for collecting and validating audit data with clearly-defined individual responsibilities
- checking the audit database for completeness against the theatre log
- checking the audit database activity against information on the hospital's administration system
- cross-checking mortality records within the database against mortuary records, ward information and externally tracked data from the Office of National statistics
- ensuring that there was regular feedback of data to clinical teams to ensure local validation

A number of visits have been conducted and the reports are published at www.scts.org.

The overall summary of these visits is that the majority of the units were displaying what we would regard as good practice against these criteria but there are a number of examples of processes that have evolved, which provide more robust systems. For example, at the Liverpool Heart and Chest Hospital all data fields on all patients are validated independently of the clinical team. This would have to be regarded as the *gold standard* and obviously has significant resource implications, but we would encourage units to move towards this type of system where possible. This is described in example 1.

An important part of the data validation process is feedback to clinical teams. There has been a long debate within the clinical community about the usefulness or otherwise of administrative data from hospital systems for any purpose other than determining financial flows. Historically these data have been inaccurate (National Adult Cardiac Surgical Database Report 2003, Society for Cardiothoracic Surgery of Great Britain & Ireland) and one of the possible reasons for this is that they have not been routinely fed back to clinicians in a timely fashion for local validation. Learning from this, many units have developed sophisticated systems for feedback to clinical teams and an example of this is the practice at the University Hospital of South Manchester. They feedback a pdf extract of information on a monthly basis to all consultants that contains activity, predicted risk and patient outcomes, including mortality along with some process and morbidity measures, for each consultant and the unit. The download also contains specific information on individual patients to allow more detailed validation; for example, all patients who have died, been re-explored for bleeding or not received the left internal mammary artery as a graft to the left anterior descending coronary artery are listed. This is described in example 2. The system ensures that all surgeons are informed at regular intervals how their outcomes compare to their peers and each consultant checks their own data and feeds back, at that stage, any issues that require resolution.

The South Manchester system focuses on activity and mortality, but it is accepted that other measures are important. The University Hospital in Birmingham has gone further & developed a *quality bundle* that is returned to each surgical team, as described in example 3. In addition to mortality data, they collect and feedback information on a number of specific outcomes including length of critical care and hospital stay, stroke rate, re-exploration for bleeding and new renal failure. It is the stated position of the SCTS that we should be moving from using risk-adjusted mortality data as a sole measure of quality to collecting and benchmarking validated *quality bundle* data, and we believe that doing so will drive improvements in care for patients still further. This initiative should be seen in the context of the plan for all hospitals to publish *quality accounts* as described on page 448. In addition to the *quality bundles* feeding back to clinical teams, they also have an electronic download of the activity that has been undertaken to their clinical coding department to help ensure that all patients undergoing surgery are correctly categorised within the Patient Administration System. This ensures that their organisation will be fairly represented in any analyses based on administrative data (such as those undertaken by Dr Foster or the Department of Health), and has also been responsible for making sure that the hospital's income under *payment by results* is appropriate for the activity they have undertaken; instigating this system increased the department's income by over £100,000 during the first financial year it was operative.

One of the outcomes of care collected by both Birmingham and South Manchester and now collected more widely in cardiac surgery are those of re-exploration for bleeding (see page 143) and usage of blood & blood products. Bleeding after cardiac surgery is a significant risk factor for a bad outcome, and unnecessary transfusion of blood and blood products is both a potential risk for patients and expensive for health care services. Some units have focussed on this area in detail, and linked up the cardiac surgical clinical data with data on transfusion practices from blood bank records; one such example comes from Guy's and St Thomas's Hospital (example 4). They have developed a system to *upload* data on the use of blood and blood products for each patient into individual patient's clinical records, and they monitor usage both by the unit and by each clinical team. This process is supported by an institutional transfusion guideline, and by implementing the guideline & feedback system the hospital has decreased its usage of blood products and the subsequent exposure of patient to the associated risk significantly as well as achieving significant cost savings.

All of the examples given so far focus on how data are used internally within cardiac surgical teams to assure and improve quality, both of the data and of patient-care. Individual teams and the cardiac surgery *directorate* have a responsibility for maintaining and improving care, but the ultimate responsibility for outcomes within the hospital lies with the Trust Board and, specifically, with the Chief Executive Officer. Experience suggests that when there are problems with outcomes within a hospital it is as likely to be a result of problems with the systems and structures of care as it is to be due to a poorly performing team or individual. Lord Darzi's report *High Quality Care for All* has the theme of clinical quality as its core ingredient and stresses the point that quality-of-care and the demonstration of quality should be at the heart of all in healthcare, from central political organisations with a proposed National Quality Board in England, right down through Regions with quality observatories, to Trust Boards, that are now advised to have quality as the priority item on each Board agenda. Cardiac surgical quality is clearly *on the radar* of all organisations providing this type of care, but one excellent example of linking together initiatives within the surgical department with activity at the Trust Board comes from the Liverpool Heart and Chest Hospital. They have developed a protocol for monitoring performance of care within their organisation, both for the hospital as a whole and for the individual teams, which is agreed and shared by all within the Trust. Rather than using the *wide* confidence intervals that have been adopted for the Healthcare Commission website, they have agreed to use an *early warning* system based on rigorous 90% control limits. Using this type of tight limit means that divergent outcomes, if detected, are quite likely to be due to chance alone, but as an organisation they have decided they would rather know about this early in order to trigger a prompt and appropriately supportive analysis, rather that waiting and possibly picking up things when it is too late. They have defined different types of divergent outcomes that would lead to the appropriate managerial interventions, and the underlying principles that place quality of patient care at the very heart of the organisation's business are excellent. This is described in more detail in example 5.

Overall scrutiny on cardiac surgical outcomes has driven all units in the country to improve their quality-of-care, and most observers agree that excellent results stem from good surgery taking place in excellent systems of care. Most units have implemented system-based approaches to quality improvement, which have been underpinned by data collection and subsequent benchmarking, and may be supported by the use of an integrated care pathway by the wider muliti-disciplinary team. A number of units have gone further and made more radical changes to their systems to help to ensure optimum outcomes. One example of this comes from Papworth Hospital, where they have recognised that cardiac surgical outcomes in newly appointed surgeons improve over the first few years of independent practice. They have responded to this by introducing a structured system for introducing newly appointed consultants to their unit that is supportive both of patient care and of the newly appointed surgeon, as described in example 6.

One of the concerns about the cardiac surgical data initiative is that it may have created unintended negative consequences. These issues have been explored in detail in the earlier section *public disclosure or public exposure*. In a *nutshell* the concern is that some patients may have been denied surgery because the surgeon is concerned about the quality of their outcomes data, rather than surgery being absolutely not in that patient's best interests. There is some debate about whether this is a real phenomenon and, if so, whether it is an important effect, but to mitigate against this possibility and to optimise potential outcomes for the highest risk patients, Papworth hospital have configured a *Surgical Council* approach for decision-making and delivery-of-care in this group. They have developed a structured approach that is described in more detail in example 7. Preliminary results from their group suggest that some patients, who would otherwise have been denied surgery, are being offered operations with satisfactory short-term outcomes, and other very-high-risk patients are also getting through surgery with reasonable results. Anecdotal reports suggest that other surgical units around the country are now following this lead.

The whole point of collecting and using cardiac surgery data is to demonstrate satisfactory outcomes for patients and to help to improve those outcomes. The risk-adjusted mortality for each hospital and about 70% of the surgeons in the United Kingdom are now published for patients on the Healthcare Commission (now Care Quality Commission) website. These data are supplemented by useful information about the local hospital including data on contact details, car parking, *etc* and general information about the problems that lead to people needing heart surgery and in-depth details about the types of operation performed. Some units have gone further and supplemented the data on the Healthcare Commission website with their own local audit data, which are sometimes presented in much more detail through their own websites. For example, St George's Hospital presents data on complication rates after surgery including use of the intra-aortic balloon pump, re-exploration for bleeding and post-operative stroke rates for the organisation. Manchester Royal Infirmary and Liverpool Heart and Chest Hospital have presented data on individual surgeon's outcomes using CUSUM curve methodology, and the University Hospital of South Manchester supplement data on overall outcomes of surgery with in-depth patient-focussed information about having heart surgery including *Matron's top tips*. In Liverpool they have also gone further by presenting data on patient-reported quality-of-life for a series of patients undergoing coronary artery bypass surgery (http://www.ctc.nhs.uk/Library/Our_Services/Qualityoflife.pdf), which is very much in line with the initiatives described in *High Quality Care for All*. James Cook University Hospital in Middlesbrough have used an innovative way of presenting data to patients using funnel plots with named surgeons on each of the *dots* within the funnel that shows patients clearly that they are in safe hands within a safe hospital when they come in for their surgery. This is described in more detail in example 8. This section would not be complete without mention of the annual audit report produced from Bristol Royal Infirmary. This comprehensive report contains data on risk factors, outcomes and complication rates for all the different operative groups, along with detail descriptions about methodologies of risk adjustment and graphical displays of named surgeon outcomes (http://www.uhbristol.nhs.uk).

Quality in healthcare has been elusive in the past: Lord Darzi's review has stressed that quality-of-care must be defined from the patient's perspective and should include the aspects of patient safety, patient experience and the effectiveness of care. There are a huge amount of data given in this report about the effectiveness of care, including both short- and longer-term outcomes for patients, and it is clear that you cannot achieve excellent clinical outcomes unless the patients remain safe throughout their treatment. Within the speciality of cardiac surgery there has also been increasing thought given to issues about improving patient experience. One such example comes from Derriford Hospital, Plymouth, where they have been concerned about the inconvenience, cosmetic issues and potential for complications that can occur from the conventional techniques used to remove the long saphenous vein from the leg for use as coronary artery bypass grafts. They have integrated, routinely, into their systems of care, techniques for removing the vein by a less invasive, endoscopic approach, which they believe improves the patient experience, both in the short- and longer-term. This is associated with increased costs of care, but their department is prepared to meet those cost to improve the care they give. This initiative is described in more detail in example 9.

A number of the *external* influences on cardiac surgery in recent years have been described in earlier sections and referred to again here, but a major change which is working its way through all hospitals in Great Britain and Ireland is that of the European legislation on maximum working hours; the European Working Time Directive (EWTD). This has led to the necessity to change the current model of delivering care in hospitals, which has relied heavily on junior doctors working long hours. All hospitals have been struggling with these issues, which are not easy to resolve, and the SCTS has done some work to describe possible *new ways of working* and to describe the staffing issues which underpin these (http://www.scts.org/documents/PDF/StaffingCardiothoracicUnitsFin.pdf). The new legislation will become active this year and one example about the way these changes may be made is described in example 10 from the Northern General Hospital in Sheffield. It is interesting that the need to comply with the EWTD has driven the hospital to implement tight protocol-driven management throughout the patient journey and they have agreed on a series of protocols by consensus across all the surgical teams. It is hoped that these consistent tight pathways will be associated with less variation in care, better compliance with *best practice* and associated improved outcomes for patients.

All of the examples we have given so far are related to initiatives taken within individual hospitals and have been related to the necessity for data collection and the associated concentration on clinical quality. Within the SCTS we have recognised that we have a role in providing training to help drive quality, and not just for trainees. We have also recognised that training is not just about clinical training, but should also include other aspects of professional development. We have included two examples of these initiatives. Example 11 describes a professional development workshop configured to teach senior trainees and young consultants about aspects of the internal NHS environment and the external factors that they must understand to develop their practice and effectively care for their patients. Example 12 describes a course that has been run to develop clinical directors' effectiveness; all developments in quality-of-care require change within organisations, and both the medical profession and NHS hospitals have a history of being resistant to change. The SCTS executive has recognised this and understands that change at a local level to bring about benefits for patients requires surgeons to work with their teams to bring about improvements, and that there is a portfolio of personal behaviours and available skills that can help in their efforts to achieve the intended aims. To help our members to develop we have worked with a commercial organisation, Rothwell Douglas, which has great expertise in these areas within the NHS, to run an *SCTS clinical leadership development workshop.* In this workshop current or aspiring clinical directors worked with expert facilitators from Rothwell Douglas to understand their own behaviours and styles, and explore how these can contribute to leading successful clinical teams, as well as concentrating on developing a number of techniques that are thought to contribute to creating successful change in the NHS workplace. These themes are also included in *High Quality Care for All; Fostering Leadership for Quality.*

Finally we would like to describe an initiative that sits a little outside of the usual NHS and Professional Society structures. Several years ago the Department of Health initiated a National Cardiothoracic Benchmarking Collaborative (NCBC), which it supported to allow hospitals providing interventional cardiac care to compare themselves with one another on the basis of various aspects of process, outcome and infrastructure data provided by the units. This initiative provided an opportunity for managers and clinicians from the hospitals, including surgeons, cardiologists and anaesthetists, to get together to discuss issues in detail. This is an important development as it accepts fundamentally that for the quality-of-care to be excellent and for delivery-of-care to be efficient, doctors and managers must work together, and that they should take the opportunity to benchmark themselves and learn from best practice. It is also recognised that for this approach to be successful it needs to be supported with appropriate time, finance and expertise. After *pump priming* from the Department of Health, the HCBC is now supported by subscription from the majority of Trusts and has had very successful workshops in which there have been structured discussions about many of the issues related to the delivery of care as described in more detail in example 13. We hope that there will be increasing liaison between the SCTS, the other professional societies and the NCBC as we see the joint clinical / managerial forum as fundamental in providing opportunities to improve services for patients.

Example 1

Title: **Cardiac Database Validation Process at the Liverpool Heart & Chest Hospital.**

Contributors: Andrew Ward, Brian Fabri and Mark Jackson. Liverpool Heart and Chest Hospital.

Benefits: The quality of data in cardiac surgical audit databases is of the utmost importance to ensure that it accurately reflects activity, consultant attribution, risk and outcomes within the unit, and to allow a department's performance to be benchmarked fairly against others in comparative analyses. We have developed a comprehensive record validation system to ensure that all data are completely accurate.

Description: The hospital has a clinical quality department and, in association with the clinical leads, we have put together a comprehensive validation process underpinned by the following principles:

- each firm is responsible for entering complete data prior to the casenotes arriving in the Clinical Quality Department.
- surgical Registrars attend the Clinical Quality Department once per week to undertake validation work and respond to any queries raised.
- protected Validation Time is enforced: during the working week a responsible individual involved in the validation process secures an adequate amount of time to complete a preset number of casenotes to ensure CCAD submission deadlines are achieved. This is monitored on a weekly basis. Consultants receive a completeness check of their data on a monthly basis along with a graphical breakdown of their current status of completeness and validation.

The activity record within the cardiac database is checked against the Patient Administrative Systems and any discrepancies are resolved. Every set of casenotes is identified and retrieved from the Health Records Department. The record is validated using one of three distinct validation processes. If the data are correct, the record is *locked* on the Cardiac Database and the casenote returned to Health Records. If the data is incorrect, the casenote is referred for action during the next visit by a surgical registrar who checks and amends the record prior to it being locked. The three validation processes used are:

Process A: All casenotes are validated for completeness and each variable on the database is checked for a value, but not its validity. All ***EuroSCORE*** and SCTS minimum dataset variables are validated in 100% of cases.

Process B: 15% of all casenotes are completely validated. This process consists of identifying a random sample of each consultant's activity. Each set of casenotes is then subject to complete validation, which includes checking all variables on the Cardiac Database for both completeness and quality.

Process C: The casenotes of all deceased patients are completely validated for all variables, both for completeness and for data quality.

Overall data quality is monitored on a monthly basis and the number of incomplete variables is reported at each surgical audit meeting.

The support for cardiac surgery within the Clinical Quality Department consists of 1.5 whole-time equivalent audit officers.

Further details available from: Mark Jackson at mark.jackson@lhch.nhs.uk

Example 2

Title: **Feedback of data to clinical teams to help data validation and drive ongoing quality improvement.**

Contributor: Mark Jones. Consultant Cardiac Surgeon and Clinical Audit Lead, Wythenshawe Hospital, Manchester.

Benefits: Regular, structured and timely feedback of data to clinical teams gives surgeons an opportunity to validate data whilst the cases are *fresh in the mind* and presenting benchmarked data gives an optimum opportunity to drive quality improvement.

Description: Data are collected at the time of surgery on all patients by the clinical teams on a commercially available software system. These data are pooled and presented back to each clinical team *via* an automated electronic download, which provides comparative information for each clinical team and pooled unit data. The process occurs monthly on cumulative data, which start at the beginning of April each year. The data presented have the number of cases, predicted mortality, actual mortality and a number of other outcomes including critical care and hospital post-operative stay along with various process measures and data on blood and blood product usage as shown in the figure. These data are supplemented by information about activity against each individual's job plan commitments. The automated download also contains information on specific patients to enable in-depth validation; for example, alongside the data on the proportion of patients who have the Left Internal Mammary Artery (LIMA) anatomosed to the Left Anterior Descending (LAD) coronary artery is a list of the patients who have had an LAD graft where the LIMA was not used. Similarly there is list of patients who have not come through surgery and those who have been re-explored for bleeding, to allow for optimum data validation. Each consultant surgeon is asked to review their own and the overall data each month to look for potential errors, and to inform them exactly where they stand against unit averages and their peers.

Cardiac Surgery Performance — Data extracted 30/12/2008 at 16:10:10 — Printed on 30/12/2008 at 16:10:10
For the period 01-Apr-2008 to 30-Nov-2008 inclusive

Consultant	Group	Num ops	Deaths	% mortality rate	Median POLOS	Mean logistic EuroSCORE	% LAD using LIMA	% Trainee operator	Cases no discharge	% non-elective CABG	Re-exploration for bleeding	Mean ICU stay	Mean HDU stay	% First-time CABG not using blood	% First-time CABG not using blood products	% scheduled operating against annual target
T HOOPER	(a) first time CABG alone	30	1	3.3	8.0	4.7					1			74.4	86.6	
	(b) All CABG alone (incl. redo)	31	1	3.2	8.0	4.85	90.3				1					
	(c) Valve + CABG	14			10.0	6.33					1					
	(d) Total CABG ops (b + c)	45	1	2.2	9.0	5.31				51.1	2					
	(e) Other	2			2.0	2.89										
	(f) Valve alone	55			9.0	8.44					1					
	(g) CABG or Valve + other ops	4	1	25.0	9.5	8.01										
	(h) Congenital	3			6.0	0.99										
	Total CABG / Valve ops	109	2	1.8	9.0	6.82		24.1			3	3.9	0.1			93
UNIT TOTAL	(a) first time CABG alone	376	5	1.3	6.0	3.96					5			81.8	90.8	
	(b) All CABG alone (incl. redo)	381	5	1.3	6.0	4.09	90.7				5					
	(c) Valve + CABG	89	3	3.4	10.0	9.35					3					
	(d) Total CABG ops (b + c)	470	8	1.7	7.0	5.09				33.8	8					
	(e) Other	35	4	11.4	9.0	7.84										
	(f) Valve alone	141	1	0.7	8.0	8.43					1					
	(g) CABG or Valve + other ops	23	1	4.3	10.0	11.77					2					
	(h) Congenital	3			6.0	0.99										
	Total CABG / Valve ops	672	14	2.1	7.0	6.14		14.7	0		11	4.9	0.2			

Further information available from: Mark Jones at mark.jones@uhsm.nhs.uk

Example 3

Title: **The development of *quality bundles* to improve care for patients undergoing cardiac surgery at Queen Elizabeth Hospital, Birmingham.**

Contributor: Domenico Pagano. Consultant Cardiac Surgeon and Director of the Quality and Outcomes Research Unit, University Hospital of Birmingham NHS Foundation Trust.

Benefits: As described in the Darzi review *High Quality Care for All* we believe that one of the features of high performing teams is that they are prepared to collect data on their processes and outcomes and to compare their performance with others to continuously improve the quality-of-care they give to patients. To help us do this we have developed a series of *quality bundles* that describe patient outcomes and compliance with a number of processes known to be associated with better outcomes. Each surgical team's performance on these *bundles* is feedback on a monthly basis to help support quality improvement.

Description: We have assembled a series of measures that we believe should be benchmarked to underpin optimum care for patients. These have been produced from our understanding of the available evidence base and are agreed with all consultant surgeons. The *quality bundles* contain a mixture of process and outcome measures, and they are different for the different operative groups. The table gives the coronary artery bypass surgery quality bundle, along with our performance between 2005 and 2008.

Peri-operative care	
Administration of β-blockers on the day of surgery	85.3%
Prescription of antiplatelet therapy at discharge	96.4%
Prescription of ACE inhibitors at discharge	90.1%
Prescription of anti-lipid therapy at discharge	96.4%
Operative care	
Use of at least 1 internal mammary artery	92%
Appropriate prescription of prophylactic antibiotics	100%
Post-operative outcomes	
Survival to hospital discharge	98.5%
Risk-adjusted predicted survival (***EuroSCORE***)	95.7-96.6%
Re-operation for bleeding / tamponade	3.6%
Re-operation for deep sternal wound infection	0.2%
Re-operation for any cause	5.8%
Post-operative ventilation for greater than 24 hours	20%
Permanent stroke (type 1 neurological deficit)	0.7%
New post-operative dialysis / haemofiltration	1.6%
Length of post-hospital stay (mean / median)	10.1 days / 7 days
Post-discharge hospital re-admission	7.7%

Further details available from: Domenico Pagano at domenico.pagano@btinternet.com

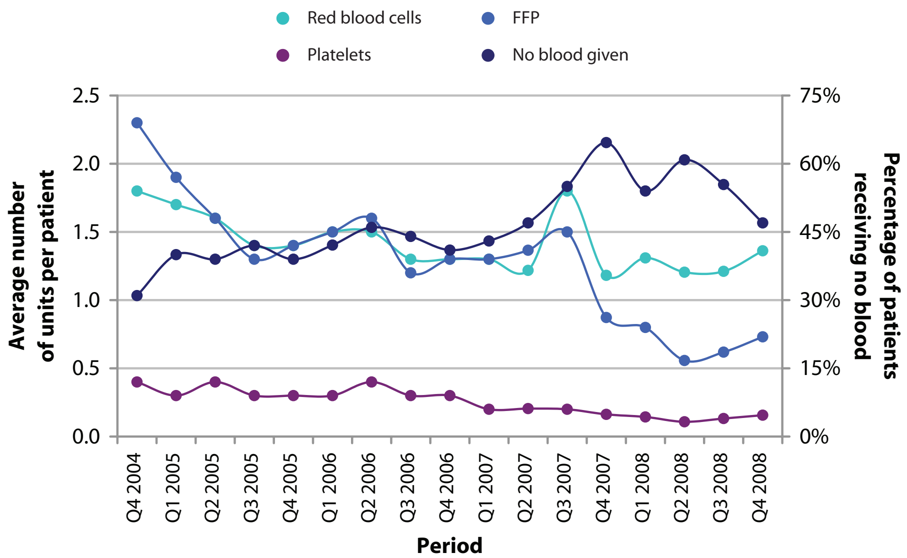
Example 4

Title: **Use of ongoing audit of blood and blood products to decrease transfusion rates at Guy's and St Thomas's Hospital.**

Contributor: Louise Meaney, transfusion practitioner; Su Ferrente, Laboratory Informatics; Claire Harrison, Haematology Consultant; and James Roxburgh, Consultant Cardiothoracic Surgeon.

Benefits: Blood transfusion has permitted many great advances in surgery and oncology; however, its role and safety have been increasingly questioned with the increasing number of pathogens that are potentially transfusion-transmissible, resulting in increasing costs and risks of blood shortages with more donor exclusions. Donor numbers are falling rapidly and overall the National Blood Service estimates it requires 0.25 million new donors annually. The latest data with regard to infection hazards in transfusion suggest that the risks for viral infections range from 1 in 0.64 million for hepatitis B to 1 in 43.6 million for hepatitis C; in addition there have now been 4 documented cases of transfusion transmission of new variant CJD. However, more significant are the risks of known complications *e.g.*, transfusion-related acute lung injury, or an error in the complex transfusion process resulting in an ABO incompatible transfusion (approximately 12 of these occur in the United Kingdom *per* annum) and since 1996 in the United Kingdom alone 491 deaths have occurred in which blood transfusion was at least probably causally implicated. Recent data have called into question more specific risks of transfusion in the cardiac surgery setting with suggestions of increased mortality, morbidity and costs for patients receiving a blood transfusion after cardiac surgery. At Guy's and St Thomas's Hospital we have initiated a structured audit combining data on transfusion rates for individual patients from the blood transfusion service with the SCTS clinical dataset. Structured data collection, supplemented by defined departmental policies and guidelines have led to a marked reduction in transfusion rates, making surgery safer for patients and contributing to major cost savings within the department.

Changes in transfusion rates over time (n=4,933)



Description: The cardiac surgery unit and blood transfusion departments at GSTFT recognised the need for a collaborative, comprehensive approach to reducing inappropriate blood transfusion in cardiac surgery, which was launched in 2005. Key components of our strategy were pre-operative screening and management of anaemia, agreeing a strategy for stopping anti-platelet agents where appropriate, abandonment of routine cross-match for elective cardiac surgery, agreement of a strategy to manage post-operative bleeding and a quarterly complex audit with results individually fedback to each clinician using data collected from TOMCAT (cardiac surgery database), which is merged with data from Blood Transfusion Laboratory Informatics. The surgical data are produced by means of a simple extract of the relevant SCTS database fields from TOMCAT (surgeon, anaesthetist, operation group, urgency, *etc*). The surgical data could easily be extracted from any software system that collects the SCTS dataset. The transfusion data are extracted from the Laboratory Information System (PATHNET). The surgical and transfusion data are then imported into a CT Blood Audit database. This database contains all the queries to manipulate the data to obtain figures for blood product usage for all cardiac patients.

The blood product usage is then presented not only as part of the quarterly trend, but at a more specific level examining usage by consultant, operation group and urgency. This has been very important as it has allowed a more targeted drive to reduce blood-product usage. The quarterly trends for mean blood use (and percentage of patients having no blood) are shown in the graph. During this time use has fallen and approximate reductions in blood use annually are as follows: red cells 800 units, fresh frozen plasma 2,560 units, and 400 pools of platelets. In financial terms alone this amounts to a recurrent saving of over £0.25 million *per* annum. The trend has been for continuing improvement despite a change in availability of aprotinin (unit policy had been to use tranexamic acid as first choice). Our current plan is to introduce use of ROTEM and other near patient whole blood / platelet function analysis to guide product use further.

Further details from: James Roxburgh at james.roxburgh@gstt.nhs.uk

Example 5

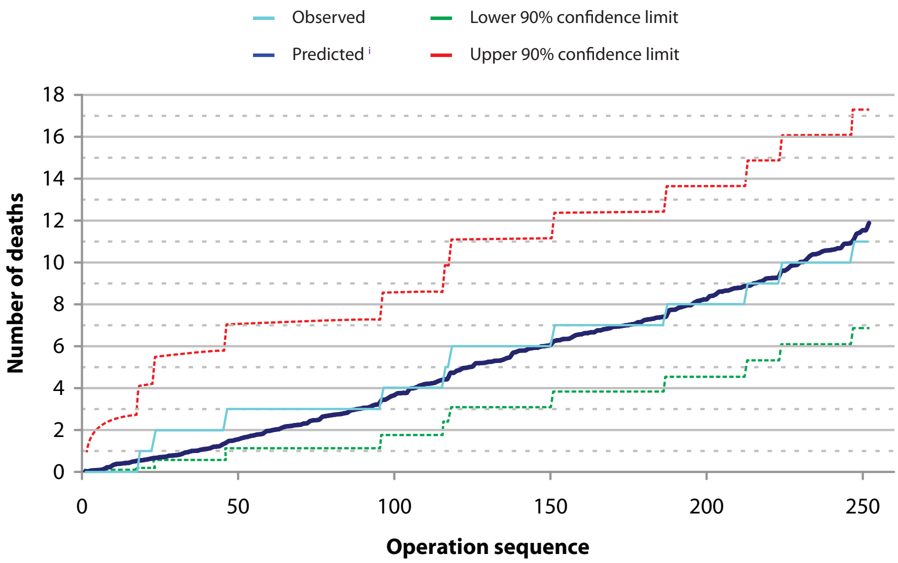
Title: **Policy for measuring and managing cardiac surgical performance; a system of integration of clinical quality data into organisational management structures.**

Contributor: Brian Fabri, Consultant Cardiac Surgeon and Audit Lead (primary contact) and Mark Jackson, Associate Director, Quality Improvement (in collaboration with all consultant cardiac surgeons) The Liverpool Heart & Chest Hospital.

Benefits: The Liverpool Heart and Chest Hospital has developed a measurement system and management process for the assessment of performance with respect to in-base hospital post-operative mortality, which applies to all cardiac surgeons who work at the hospital. The process and methodology are accepted by all in the organisation from Trust Board down to the individual surgical teams, and allows divergent performance to be detected early to allow appropriate intervention to take place to maintain optimum surgical outcomes for patients

Description: A clearly-defined written policy has been accepted by all cardiac surgeons and is ratified by the Trust Board. Individual consultants ensure data recorded about his / her practice are accurately and contemporaneously added to the bespoke cardiac surgery database. The Clinical Quality Department provides anonymised graphical and quantitative risk-adjusted cumulative summation mortality reports to each surgeon regarding their own performance and that of their peers every six months. Copies are made available to the Associate Medical Director (Surgery & Anaesthesia) every six months and to the Medical Director and the Chair of the Clinical Quality Committee every twelve months. These data are used both for consultant appraisal and performance management. The report shows the surgeon's last three years predicted mortality (derived from logistic ***EuroSCORE***) and their observed mortality, surrounded by 90% confidence limits. A hypothetical surgeon's example is shown below:

CUSUM plot over 252 operations showing acceptable performance



i Regional performance 2006-2008; 0.31 × Logistic ***EuroSCORE***

The *trigger* for a review of the acceptability of surgical performance occurs when predicted mortality, according to the operation-specific logistic ***EuroSCORE***, runs below (transgresses) the lower bound 90% confidence limit for observed mortality.

Four classes of transgression of the above standard are recognised:

- new (occurrence of a transgression, unrelated to a previous episode; monitoring continues for a further reporting cycle to determine if intervention is required)
- transient (a transgression that has occurred and been corrected within the reporting cycle)
- recovering (following review performance and intervention, risk-adjusted mortality is improving)
- persistent (following review performance and intervention, risk-adjusted mortality is not improving: re-training and other measures considered)

Each of the above classes has a specific management process in place that is peer supportive, but is led by medical management. On occasions when reviews are being undertaken, the Trust Board is kept informed *via* the Clinical Quality Committee.

The Liverpool Heart & Chest Hospital has developed policies based upon the same methodology for thoracic surgery and invasive cardiology.

Further details available from: Brian Fabri at brian.fabri@lhch.nhs.uk

Example 6

Title: **The structured management of casemix for new consultant appointments in cardiac surgery.**

Contributor: David Jenkins. Consultant Surgeon, Papworth Hospital, Cambridge.

Benefits: It has been described previously that there are quite marked improvements in risk-adjusted mortality rates in patients undergoing surgery under surgeons who are newly appointed to independent practice as those surgeons become more experienced. Case complexity and patient-risk have increased over recent years, and, to optimise patient outcomes, Papworth hospital has introduced a system to give structured development of newly appointed surgeon's casemix over time. As well as improving outcomes for patients it is hoped that this approach will support surgeons through the sometimes difficult transition from supervised to unsupervised practice.

Description: Surgeons taking on new consultant cardiac surgical appointments will have undergone extensive training and be signed off as having a *certificate of completion of training.* It is recognised that moving from unsupervised to independent practice is a difficult period, and that it is unusual for any trainee to gain extensive experience in the most complex and highest risk cardiac surgery. Papworth hospital have recognised this and introduced a structured development process designed to optimise patient outcomes and support new surgeons, which includes:

- during the first month newly appointed surgeons will have no on-call commitment, but are encouraged to make themselves available to double scrub with senior colleagues for emergency and transplant procedures. After the first month they will join the general on-call rota alongside a named senior colleague for support as necessary. By mutual consent, after a further month they may join the rota independently. The introduction for the transplant / VAD rota may be more extended.
- during the first 1-3 months, newly-appointed surgeons will operate only on selected elective cases, and for their first lists usually accept patients already reviewed and risk-stratified, from established consultants' waiting lists. Following a few months experience (usually in the region of >50 procedures) selected *in-house urgent* cases will be introduced if results are satisfactory.
- this process is supported by a *double scrubbing* culture (see surgical council example opposite) in which new consultants are encouraged to become involved in more complex operations (*e.g.*, dissections, ischaemic VSDs) to increase their experience in rarer procedures.

Further information from : David Jenkins at david.jenkins@papworth.nhs.uk

i Bridgewater B, Grayson AD, Au J, Hassan R, Dhimis W, Munsch C, Waterworth P, North-West Quality Improvement Programme in Cardiac Interventions. Improving mortality of coronary surgery over first four years of independent practice: retrospective examination of prospectively collected data from 15 surgeons. *BMJ.* 2004; **329:** 421.

Example 7

Title: **A surgical council to optimise decision-making and outcomes in high-risk patients referred for cardiac surgery.**

Contributor: Samer Nashef. Consultant Surgeon, Papworth Hospital, Cambridge.

Benefits: Patients who are at the highest risk for cardiac surgery are often those who potentially have the most to gain from successful surgery. Such patients may have complex multiple cardiac pathology and may benefit from a team approach both to the decision-making process and to the conduct of the operation and post-operative care. There is also concern that intense scrutiny on surgical outcomes may lead to reluctance to offer surgery to such patients. High-risk patients are becoming more complex and more frequent. Papworth Hospital has configured a *Surgical Council* approach to this group of patients. Their cardiac surgeons meet on a regular basis to discuss high-risk patients, and particularly whether surgery is in the patient's best interests, and if so they formulate a specific management plan for each patient designed to optimise outcomes.

Description: The Surgical Council meets every 2 weeks, and includes all of the cardiac surgeons at Papworth, co-opting other appropriate multi-disciplinary expertise as needed for discussion about specific patients. Patients referred to Council belong to one of 4 pre-determined categories:

- patients who have been referred for cardiac transplantation in whom there may be a possibility of conventional surgery
- patients with a logistic ***EuroSCORE*** of greater than 25
- patients who have been turned down for cardiac surgery at another hospital
- patients who do not fulfil the above criteria, but the responsible surgeon feels that the patient would benefit from the *Surgical Council* approach

Every patient is discussed in detail to ensure that the indication for surgery is assessed in a robust manner and, if a decision to offer surgery is made, to configure a detailed operative plan. Usually, patients will undergo surgery under the care of 2 consultant surgeons who will be chosen on the basis of sub-specialist expertise and experience, and may be different from the surgeon to whom the patient was initially referred.

A recent summary of the experience of the Surgical Council outcomes has been analysed. Of 66 patients assessed over 27 months, 30 were accepted and operated, surgery was not offered to 18 patients, 11 were inappropriate referrals and 4 patients subsequently declined surgery. The mean logistic ***EuroSCORE*** of those patients undergoing surgery was very high at 30 and actual in-hospital mortality was 6 of 30 (20%). Eight of the 66 patients had been refused surgery by their original hospitals; 6 of these were operated of whom 5 of survived.

In conclusion, the results of this approach so far are good, but no better than predicted by the logistic ***EuroSCORE***. The Surgical Council has succeeded in offering the benefits of surgery to patients who otherwise may not have had that opportunity

Reference: Allanah Barker and Samer Nashef. Submitted to SCTS annual meeting, November 2008

Further details available from: Samer Nashef at sam.nashef@papworth.nhs.uk

Example 8

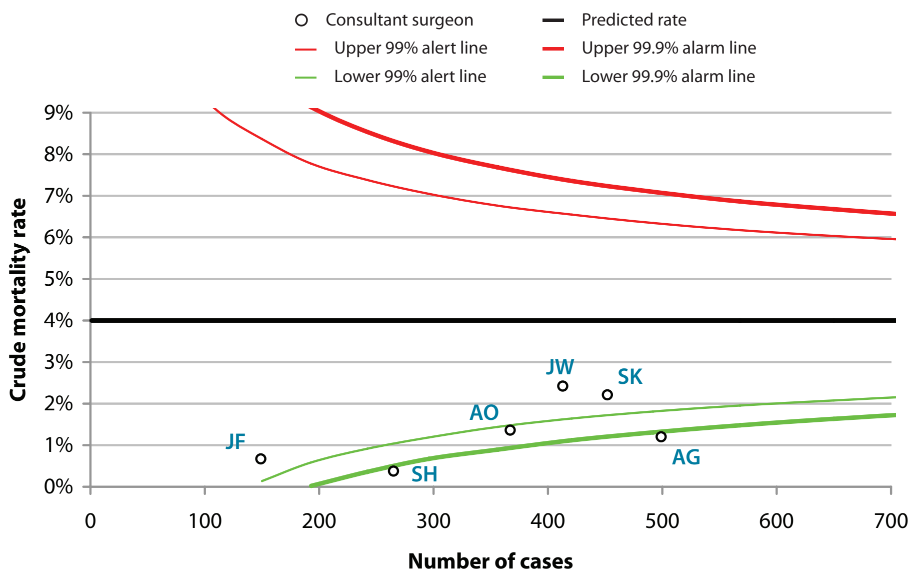
Title: **Publication of named-surgeon outcomes on funnel plots at James Cook University Hospital, Middlesbrough.**

Contributor: Andrew Owens. Consultant Cardiothoracic Surgeon.

Benefits: One of the recommendations of the Public Inquiry into the events at Bristol Royal Infirmary was that outcomes of surgery by individual surgical teams should be made available to the public. This has now happened for United Kingdom cardiac surgery through the Healthcare Commission website as described elsewhere in this book. It is clear from the data on website visits given in the appendices that patients are really quite interested in this type of information. Mortality rates are only one sort of information that may be useful for patients and relatives, and many patients may wish to have specific details about individual hospitals and will often now look to do so through the internet. We have developed a website to communicate with our patients, including a graphical presentation of named-surgeon mortality outcomes.

Description: The cardiothoracic surgery section of the James Cook University Hospital website is available at http://www.southtees.nhs.uk/live/?a=2073. The website has a general description of the department and the services provided and other useful web links, including the Healthcare Commission site. It also provides a list of the consultant surgeons, along with their contact details, training history and specialist interests. There is a section on *clinical outcomes* that describes the performance monitoring policies and resources within the hospital, which are dedicated to ensuring patients are receiving good care. When developing the webpage, considerable care was taken to emphasise the issues associated with measuring and publishing risk-adjusted mortality data, and we attempt to explain the methodologies used in easily comprehensible language. We decided to give information on named surgeons on this website, and opted for a graphical display with separate displays for coronary artery surgery, aortic valve surgery and mitral valve surgery. We use funnel plots over a three-year rolling cycle, updated quarterly (synchronous with our internal monitoring programme) with data points and initials for each surgeon as shown in the figure. We believe that this type of presentation is reassuring for patients and provide useful and easily understood information about each surgeon's outcomes.

Isolated CABG: Funnel plot on mortality at the James Cook University Hospital by consultant (n=2,145)



Further details available from: andrew.owens@stees.nhs.uk.

Example 9

Title: **Endoscopic vein harvesting to improve patient satisfaction and outcome.**

Contributor: Malcolm Dalrymple-Hay. Consultant Cardiac Surgeon, Derriford Hospital, Plymouth.

Benefits: Endoscopic vein harvesting (EVH) to obtain conduits for coronary artery bypass grafting (CABG) has been developed to reduce leg wound complications and improve patient satisfaction. It has been widely accepted in some cardiac surgical communities and is now viewed as the standard of care in the United States of America. In Europe, however, it remains relatively under-utilised. There are numerous prospective randomised controlled trials supporting the use of EVH when compared to an open technique in reducing leg wound complications. Outcomes including requirement for antibiotics, wound dehiscence, haematoma, wound infection, skin necrosis and seroma / lymphocele formation have all been significantly reduced with the use of EVH. These findings are consistent in both low- and high-risk patients for leg wound complications. Patients also report decreased post-operative pain and analgesia requirement, as well as less sensory disturbance following EVH. Mobility is improved post-operatively when compared to an open technique. Patients report improved satisfaction with the cosmetic result following EVH. The economic benefits of EVH have been explored by Lord Darzi *et al*. who concluded that minimally invasive harvesting was the most cost-effective method of harvesting the great saphenous vein and significantly improved the patient's quality of life. NICE guidance on this procedure was issued in December 2007 suggesting it was safe and effective. EVH is now routine within the cardiac surgical practice at Plymouth Hospitals NHS Trust.

Description: EVH involves the location and subsequent dissection of the long saphenous vein using a fibre-optic scope and endoscopic instrumentation. The vein is mobilised endoscopically and subsequently the branches are divided using cautery under direct vision. The proximal and distal ends of the vein are then divided when the required length is achieved. The whole length of vein can thus be harvested from a one-inch incision in the region of the knee and two stab incisions: one in the groin and one at the ankle. The radial artery can also be harvested using an endoscopic technique with or without tourniquet control. The procedure was initially performed by consultant cardiac surgeons who had received dedicated training in the harvest technique. Once the reported benefits described in the literature were confirmed in our practice, the decision was made that all patients should benefit from the technique and it has become the standard of care. The procedure now lies within the practice of the Surgical Care Practitioners (SCP), who independently harvest the conduit using an endoscopic technique. The learning curve for a SCP with no experience in endoscopic surgical techniques is approximately 20 cases.

Further details available from: Malcolm Dalrymple-Hay at Malcolm@dalrymple-hay.com

i Rao C, Aziz O, Deeba S, Chow A, Jones C, Ni Z, Papastavrou L, Rahman S, Darzi A and Athanasiou T. Is minimally invasive harvesting of the great saphenous vein for coronary artery bypass surgery a cost-effective technique? *J Thorac Cardiovasc Surg.* 2008; **135(4):** 809 - 815.

ii http://www.nice.org.uk/nicemedia/pdf/IPG248Guidance.pdf

Example 10

Title: **Introduction of protocols and systems to drive quality of care and configure a unit's manpower to comply with European legislation on maximal working hours.**

Contributor: David Hopkinson. Consultant Cardiothoracic Surgeon, Northern General Hospital, Sheffield.

Benefits: The European working time directive (EWTD) is legislation that prohibits a working week in excess of 48 hours. It also includes specified maximum time of any continuous working *shifts* and requirements for minimum rest periods. The historical model of providing care in British hospitals is not compatible with this new legislation. As the EWTD is being implemented there is also an increased focus on the quality of medical care, as described on page 26 (defining quality). We are in the process of introducing new systems for managing patients through the cardiac surgery *journey* to comply with these 2 initiatives. These include:

- ensuring that the service is consultant-led, particularly at the assessment and decision-making stages when patients are listed for surgery
- delivering care that is underpinned by a new group of Advanced Nurse Practitioners (ANPs)
- supporting care delivery with rigorous clinical protocols, which cover pre-operative, operative and post-operative care.

Implementing the system will achieve compliance with the EWTD, and it is hoped that protocol-based management & standardised care will result in minimised variation, improved compliance with *best practice* pathways, and thus better care for patients.

Description: The historical model of cardiac surgical care delivery for British hospitals relied heavily on junior doctors working long hours. This is now being *outlawed* by the EWTD. A requirement for doctors to work less and be *better* trained (see page 418; selection training and re-certification section), coupled with surgical consultant manpower projections that have led to a marked decrease in the overall number of trainees, has produced major challenges for cardiac surgery in particular, and British medicine in general. We are introducing a new system in which care will be predominantly delivered by consultants and those who work in the newly-created role of *Advance Nurse Practitioners*. Our calculations, based on an average working week of 37.5 hours, indicate that we require 14 such practitioners, who we have selected from experienced cardiac surgical nursing staff. They are currently being trained to undertake clinical assessments, prescribe medications and interpret relevant medical images. They are also trained to request haematological and biochemical investigations, and to interpret the results thereof. Training is being delivered by a one-to-one mentorship programme by each of the Consultant Surgeons, together with a well-established training programme provided by the School of Nursing within Sheffield Teaching Hospitals Trust, in conjunction with the University of Sheffield. The practitioners are continually assessed and formally examined by the School of Nursing. It takes, on average, two years for each ANP to complete all the modules, and having commenced a staged entry into the programme, the first fully-trained colleagues are now in post, with a roll-out over the next twelve months. In time, an ANP will be present around the clock on the cardiac surgery ward, and in the Pre-Assessment Clinic (PAC). Our five Surgical Care Practitioners (formerly known as Cardiac Surgeons' Assistants) are also being trained in clinical assessment to assist in the PAC. In addition they now provide the first level of out-of-hours cover for emergency surgery. Two more are in training.

Our previous model of care relied on a *firm-based* structure in which junior doctors were attached to a consultant for a period of training, and this was supported by documentation that described how each consultant liked to manage their patients, with significant differences in pathways between teams. This model is not workable with the new system. To facilitate this new personnel structure and way of working, we have developed consensus-based protocols for the pre-operative, peri-operative and post–operative care of all patients. These are actively maintained, contain appropriate *caveats* that will prompt discussion with the consultants, and are widely available (and displayed) throughout the unit. They represent the default line of management, and consultants are required to document clearly any requests for a deviation from them for a given patient. We consider these protocols essential to the new ways of working demanded by the EWTD. They standardise care and improve overall quality.

Further details available from: David Hopkinson at david.hopkinson@sth.nhs.uk

Example 11

Title: **A professional development course for young consultants and senior trainees.**

Contributor: Tim Graham, Domenico Pagano, Pala Rajesh and Steve Rooney.

Benefits: The historical model of training doctors has focussed on developing skills, knowledge and techniques to treat patients safely and effectively. It is becoming increasingly clear that doctors must also understand the environment in which they work in order to be truly effective, and that environment is complex and is changing all the time. We have accepted that we need to help senior trainees and junior consultants with these issues, as well as with the more conventional aspect of medical training, and have configured a development course along these lines.

Description: The Birmingham professional development workshop has been evolving over several years, and functions as a highly intensive, 2-day residential course. Senior trainees and junior consultants in cardiothoracic surgery are invited, and we have recently opened up the course to cardiology trainees, in line with the overall vision about multi-disciplinary care being essential to optimise outcomes for patients. The core faculty is comprised of cardiothoracic surgeons, but the wider teaching group includes surgeons, medical and non-medical managers, a coroner, representation from the Health Service Ombudsman, medico-legal and governance expertise and high level input from the Department of Health. The objectives of the course are to teach the participants about aspects of the internal hospital mechanisms and the external NHS and non-NHS environment that they will need to understand to develop their practice and deliver and improve services and care for their patients. The course includes sessions on the following topics:

- the NHS – the Department of Health view
- the NHS – a Trust's view
- the role of Her Majesty's coroner service
- the role of the NHS ombudsman
- clinical governance scenarios
- medico-legal scenarios
- starting off as a consultant
- managing poor performance

Whilst it is difficult to demonstrate that a course is definitively associated with the aims it is designed to deliver in the workplace, the workshop gets excellent participant and faculty feedback.

Further details from: Tim Graham at tim.graham@uhb.nhs.uk

The Birmingham professional development workshop is kindly supported by an educational grant from Medtronic.

Example 12

Title: **The SCTS clinical leadership development workshop.**

Contributor: The Executive Committee of the Society for Cardiothoracic surgery.

Benefits: Improving quality-of-care for patients requires changes to be made in the complex organisations that are NHS hospitals. The hospitals themselves, along with both the medical profession and the professions allied to medicine, are often resistant to change. We believe that the clinical directors are vitally important for assuring safe care and improving quality in the modern NHS and wished to provide some training for current or aspiring clinical directors to help them in what can often be a difficult role. The SCTS has worked with a commercial company, Rothwell Douglas, who have great expertise in this area within the NHS. It can be hard to evaluate whether such a course actually makes demonstrable differences in individual's ability to lead service development, but formal and informal feedback has suggested that the initial course was well-received by all participants who all found the things that they learnt were of use.

Description: We ran a 2-day, intensive, residential workshop for current or aspiring clinical directors in cardiothoracic surgery. The course was run by 2 highly qualified facilitators from Rothwell Douglas, who had produced extensive course material and case examples applicable to the speciality. They were supported by several members of the SCTS who had extensive clinical management experience. Teaching and exposure to techniques was achieved through a number of different modalities including small- and larger-group discussions, case-examples, role-play and theory-based presentations. The key themes of the workshop included describing the important personal attributes and behaviours for successful clinical leadership, techniques for difficult conversations, managing poor performance and theories of change management.

Further details available from: Ben Bridgewater at ben.bridgewater@uhsm.nhs.uk or Carol Rothwell at carol.rothwell@rothwelldouglas.com.

This initiative was kindly sponsored by St Jude Medical.

Example 13

Title: **The National Cardiothoracic Benchmarking Collaborative** (NCBC)**.**

Contributors: Rebecca Miles and Stephen Green. The National Cardiac Benchmarking Collaborative.

Benefits: The NCBC is an important development as it is fundamentally a *bottom up* programme with the Trusts themselves driving work on improving quality. It also firmly links the *managerial* and *clinical* agendas. At its core is the principle that for the quality-of-care to be excellent and for delivery-of-care to be efficient, doctors and managers must work together and use comparative data and benchmarking to improve services, and enable their organisations and teams to learn from best practice, and that this work should be supported with appropriate time and resource.

Description: The NCBC was initiated in 2006-2007 by a group of 26 specialist cardiac tertiary centres in England that wished to compare and benchmark their cardiac services across a range of different topics and indicators, including service structure, staffing, general management and organisation, financial and clinical management. Now entering its third year, this project has become an United Kingdom-wide initiative, with specialist cardiac centres participating from across all four countries of the UK. Formally coordinated by a multi-professional Steering Group from participating Trusts and chaired by a Trust Chief Executive (currently Stephen Bridge, the CEO of Papworth), it has broadened its remit to provide a cross-organisational forum for multi-professional discussions about wider strategic service planning and development issues, as well as clinical quality and outcomes. It has also built strong working links with the relevant professional societies who are also represented on the Steering Group. After initial support from the National Heart Team, the NCBC is now funded by subscription from participating Trusts. Each year, the benchmarking is followed up with successful workshops where there have been structured discussions about outcomes, financial flows, manpower issues, strategic service and clinical developments, commissioning, and many other issues related to the delivery-of-care.

Further details available from: Rebecca Miles at rebecca.miles1@btinternet.com

Quality accounts

Introduction

Lord Darzi's report *High Quality Care for All* describes the concept of putting *quality at the heart of everything we do* and to achieve this he describes a number of important factors, which include:

1. Bringing clarity to quality
2. Measuring quality
3. Publishing quality
4. Recognising and rewarding quality

The overall quality agenda in England will be overseen by a national quality board and local scrutiny is planned through regional quality observatories. A number of national clinical metrics of quality have been published and the ones applicable to adult cardiac surgery are in-hospital mortality after coronary artery bypass surgery, aortic valve surgery and all cardiac surgery, which are already published on the Healthcare Commission (now Care Quality Commission) website (see appendices).

Stated in Lord Darzi's report is the fact that national metrics of quality will need to be supplemented by further appropriate local measures, and it is acknowledged that one of the characteristics of high performing teams is their willingness to measure performance and to use those measurements in continuous quality improvements. To drive the process it is planned to publish *quality accounts* for hospitals in the same way that financial accounts are currently published, and this will be required by law from April 2010. These accounts are to focus on patient safety, experience and outcomes.

Recent guidance has been produced around *quality accounts,* which suggests that they should contain 4 sections:

- a statement on quality from the Chief executive.
- a description of priorities for quality improvement.
- a response to issues raised by the regulators or public representatives in the previous year.
- a quantitative description of the quality-of-care including indicators selected by the organisation covering patient safety, clinical effectiveness and patient experience as well as indicators covering the DH national priorities and compliance with core standards as declared to the Healthcare Commission / Care Quality Commission.

We have therefore generated an example *quality account* for cardiac surgery for a single NHS hospital using data from the SCTS database, supplemented by local data. We have included some measures that are hospital-wide and departmental measures for others. We also expect there will be significant variation in what is published between hospitals, certainly at first, depending on what each hospital feels is important and also what it is able to measure at present. We think that the example *quality account* that follows will be far more comprehensive and specifically detailed to cardiac surgery than most of those that will be published, but we make no apologies for this. We feel that is right to be ambitious – to drive quality locally we agree with Lord Darzi's view that a team that actively collects, benchmarks and uses this information will be well configured to deliver the best possible care for their patients.

We feel that internal and external scrutiny to this level on all aspects of quality, particularly including issues around patient experience in addition to the other domains, is essential as it creates a culture where patients are placed definitively at the centre of healthcare delivery. We strongly believe that if this approach is implemented across all organisations, the serious failings in clinical governance such as that recently exposed at Mid Staffordshire Hospitals Trust, will become eradicated.

Ben Bridgewater, Mark Jackson and Brian Fabri

i http://www.cqc.org.uk/_db/_documents/Investigation_into_Mid_Staffordshire_NHS_Foundation_Trust.pdf

An example of a quality account: Liverpool Heart and Chest Hospital

Current view of the Trust's position and status of quality

The Trust has in place a comprehensive clinical quality strategy that has been implemented throughout 2008 / 2009 by the Clinical Quality Committee. Major achievements for the year include:

- no hospital acquired MRSA bloodstream infections.
- a low number of hospital-acquired *Clostridium difficile* infections, placing our performance well under the target set by our local Primary Care Trust.
- low waiting times for treatment, reflected in 18 out of every 20 patients receiving their procedure within 18 weeks of being referred by their general practitioner.
- for procedures that have not been performed as an emergency, one death in every 10 has been prevented as a result of our safety work (a 10% reduction in an already low mortality rate, equivalent to 7 deaths this year).
- the right care, at the right time being given to the right patients, reflected in high rates of consistency in the application of treatment that has been proven to work (care bundles).
- some of the lowest lengths-of-stay in the country, ensuring the patient returns to their home surroundings as quickly as possible.
- almost nine of every ten patients reporting that the hospital is meeting their expectations all of the time.
- full compliance with all standards as specified by the independent health regulator, the Healthcare Commission.
- all minimum standards of care met as defined by the Department of Health.

Despite this excellent performance, we remain ambitious to improve. This report provides detail of what aspects of clinical care the Trust has prioritised for improvement in the following twelve months.

Overview of organisational effectiveness initiatives

The Trust has a series of ongoing initiatives to improve organisational effectiveness in quality. Examples include:

- since September 2008, the Trust has participated in the Patient Safety First Campaign, which has seen the Trust adopt patient safety as a top priority.
- between September 2008 and April 2009, the Trust participated in the leadership for improving patient safety (LIPS), which has equipped Executives and senior staff with the skills necessary to lead and implement quality improvement methodology.
- with effect from January 2009, the Trust Board have included *quality* as a major component of their agenda, which includes the report of a patient story, review of performance in quality and dedicated training.
- the Trust has a track record of using Patient Reported Outcome Measures (PROMS) routinely, which places it ahead of the national rollout planned from 2009 / 2010.
- the Trust has implemented an integrated approach to learning from the patients' experience, which includes the conduct of focus groups, monthly satisfaction surveys and regular matron's rounds, the results of which are reported to the Patients Experience Committee, a newly established sub-committee of the Trust Board.

Description of priorities for quality improvement

How have we prioritised our quality improvement initiatives?

Following Trust Board consultation, we have confirmed our top five quality priorities to be:

1. Death in-hospital (mortality).
2. Surgical site infections.
3. Improve the outcomes of care in heart attack, heart failure and bypass grafting patients (advancing quality).
4. Non-clinical cancellations.
5. Improve the experience of care for our patients.

These have been signed off by Mr Raj Jain, Chief Executive and Dr Glenn Russell, Medical Director.

These priorities were identified from a detailed discussion amongst the membership of the Clinical Quality Committee, which has representation from the Executive Directors and Directorate senior clinical leaders. These priorities were discussed further and agreed at the Trust Board.

Our selected priorities and proposed initiatives

Each of the priorities above, together with our proposed initiatives for 2009 / 2010, is described in detail below:

Priority one: reduce the number of deaths in-hospital

Description of issue and rationale for prioritising

We were successful this year in reducing the number of deaths in-hospital following an elective procedure by 10%, but we wish to go further.

We have very recently introduced a new service called primary angioplasty. This sees the admission of patients in the throes of a heart attack, which is a high-risk condition. As such, we predict that the number of deaths in-hospital will rise this year. We need to see how this new procedure affects the number of deaths, and then plan work to reduce it.

As a consequence of the amount of cardiac surgery we perform, death following coronary artery bypass grafting is the single biggest contributor to the total number of deaths in-hospital. This year we saw an increase that we are keen to reverse.

Aim

To reduce the number of deaths in-hospital by 10% by the end of 2009 / 2010.

Identified areas for improvement

1. Improve the consistency (reliability) of all elements of the sepsis care bundle.
2. Introduce a regular multi-disciplinary team (MDT) discussion for cardiac surgical cases where the benefit of the operation is questionable.
3. Evaluate the benefit of CT angiography for identification of poor blood supply to the bowel.
4. Improve the escalation of the Modified Early Warning Score (MEWS) for patients who are showing signs of clinical deterioration.

Board Sponsor	Dr Glenn Russell, Medical Director
Implementation Lead	Mr Brian Fabri, Clinical Lead (Cardiac Surgery)
Programme Manager	Dr Mark Jackson, Associate Director (Quality Improvement)

Priority two: reduce the number of surgical site infections

Description of issue and rationale for prioritising

An internal review of our compliance with recently issued guidance from the National Institute for Clinical Excellence entitled *Surgical site infection: prevention and treatment of surgical site infection* (2008) has revealed opportunities for improving our infection prevention practice.

Aim

To reduce our rate of surgical site infections by 20% by the end of 2009 / 2010.

Identified areas for improvement

1. Implement the surgical site infection care bundle.
2. Improve the discipline of staff working in the theatre areas in order to minimise unnecessary movement in and out of the theatre, ensure strict adherence to the theatre-clothing policy, and excellence in hand-hygiene practice.
3. Introduce a new pre-operative skin preparation proven to reduce infections (2% chlorhexidine).
4. Improve use of the non-touch technique for wound dressing and cleaning.

Board Sponsor	Mrs Hazel Holmes, Director of Nursing & Infection Prevention
Implementation Lead	Mr Richard Page, Associate Medical Director, Surgery, Anaesthesia and Critical Care
Programme Manager	Mrs Nicola Best, Infection Prevention Nurse

Priority three: improve the outcomes of care in heart attack, heart failure and bypass grafting patients

Description of issue and rationale for prioritising

Patients with heart attack, heart failure and those receiving coronary artery bypass grafting make up a substantial proportion of the number of patients we treat. Having good processes of care will ensure that the outcomes (that is the results of the care) are excellent.

We have begun a programme of deployment of care bundles, which are a number of processes (treatments) that have been proven to work *bundled* together. Individual bundle elements have been shown to interact, such that the benefit is greater than the sum of the parts. Our ambition is for every appropriate patient to receive all elements of the bundle when they are required. This work is part of the Advancing Quality programme, being led by the NHS North West Strategic Health Authority.

Aim

Ensure all appropriate patients receive all elements of the relevant care bundles by the end of 2009 / 2010.

Identified areas for improvement

1. Improve the provision of smoking cessation advice.
2. Ensure all patients with heart failure receive the necessary self-care and lifestyle advice, and receive an evaluation of their heart function.
3. Ensure all patients who have had a heart attack receive the appropriate medication.
4. Widen our programme of measuring the patients own reported assessment (PROM) of the benefits derived from their treatment, and act on the results.

Board Sponsor	Mr Raj Jain, Chief Executive
Implementation Lead	Dr Raphael Perry, Associate Medical Director (Cardiology & Chest Medicine)
Programme Manager	Dr Mark Jackson, Associate Director (Quality Improvement)

Priority four: reduce the number of non-clinical cancellations for elective procedures

Description of issue and rationale for prioritising

Following admission to hospital, the patient expects that the procedure they need will be undertaken on the date scheduled. However, on occasion, the procedure is cancelled for reasons of administration rather than clinical necessity. Cancellation is both inconvenient and distressing for patients.

Over the last few years, the Trust has only just managed to keep the number of non-clinical cancellations under control. We recognise the upset being cancelled so close to their operation causes to our patients, and wish to radically improve our performance.

Aim

Reduce the number of cancellations for non-clinical reasons by 30% by the end of 2009 / 2010.

Identified areas for improvement

1. Improve the planning and scheduling of pacemaker and bypass grafting procedures.
2. Ensure efficiency of practices on the day of the procedure.
3. Improve the delivery of care from procedure through to discharge.

Board Sponsor	Dr Glenn Russell, Medical Director
Implementation Lead	Mrs Ann Parker-Clements, General Manager Surgery, Anaesthesia and Critical Care
Programme Manager	Mrs Tracy Rawlings, Assistant General Manager (Surgery), Anaesthesia & Critical Care

Priority five: improve the experience of care for our patients

Description of issue and rationale for prioritising

The patients we treat are often facing life-threatening illness or illness that substantially reduces their quality-of-life. As care-givers, we want to deliver technically excellent care that either extends life or dramatically reduces the burden of symptoms. However, from talking to patients, we know this is not the be-all-and-end-all of care-delivery. Patients want to be treated with dignity and respect, have their views listened to and acted upon, not be harmed as a consequence of the healthcare delivery and receive care in a comfortable, clean and friendly environment in addition to many other things. Collectively, these issues make up the experience of the patient, which as a Trust we are keen to improve.

Aim

Develop and begin the implementation of a comprehensive patient experience strategy within 2009 / 2010.

Identified areas for improvement

The patient experience strategy will:

1. Introduce the Customer Service Excellence model (an unique improvement tool to help us put patients, carers and relatives at the core of what we do), to at least one major area of the Trusts activities.
2. Explore and develop a number of different methods of capturing feedback from the users of our services, and act on the results.
3. Implement the Nursing Assessment and Accreditation system, which assesses clinical standards that includes the delivery of person centred care.

Board Sponsor	Mrs Hazel Holmes, Director of Nursing & Infection Prevention
Implementation Lead	Mrs Jane Brooks, Deputy Director of Nursing
Programme Manager	Vacancy, Matron for Corporate Services

Response to issues raised by the regulators or public representatives

The Liverpool Heart & Chest Hospital NHS Trust has declared compliance with all core standards for better health for the year 2008 / 2009. This year, we have also:

- achieved level 2 of the prescribed risk management and patient safety standards published by the NHS Litigation Authority
- received a report from the Mersey Internal Audit Agency that provided significant assurance against our statement of compliance with core standards C3 (NICE Interventional Procedures), C12 (Research Governance) and C22a/c (Public Health Partnerships)

Additionally, we have taken the following action to respond to concerns raised by our external regulators:

1. In 2008 / 2009, we did not achieve compliance with the Healthcare Commission diagnostic waiting times target published as part of the annual health check. This was due to unclear accountability for this target and has resulted in major changes to our governance arrangements for performance management.
2. In November 2008, implementation of the hygiene code was inspected by the Healthcare Commission, which revealed deficiencies in compliance with duties 2d3, 4a and 4f. Since then, we have implemented a comprehensive action plan that includes improved cleaning and inspection regimes, improvements in policies for the environment and strengthened arrangements for the decontamination of endoscopes. These actions have satisfied the Healthcare Commission who has now awarded full compliance.

Response to LINks and to feedback from members and governors

Examples of feedback from patients and the public (considering comments from our LINks representative, Members and Governors) included:

- continued high rates of satisfaction reported from in-patients, out-patients, carers and families
- a drop in patient satisfaction with the quality of food compared to previous years
- scope for additional improvement in the elective admission and discharge process
- concerns over breakdowns in communication leading to delays or sub-optimum treatment
- frequent reports over being discharged too early

We will consider the appropriate initiatives to deal with these concerns, and continue to ask the necessary questions to identify the processes of care that require improvement.

Quantitative description of the quality of care

Waiting time measures

	2008 / 09	2007 / 08	Target
Maximum 2-week waiting time from urgent GP referral to first outpatient appointment for all urgent suspect cancer referrals	100%	100%	98%
Maximum 18-week waiting time for admitted patients from point of referral to treatment	91%	80%	85%
Maximum 18-week waiting time for non-admitted patients from point of referral to treatment	95%	95%	90%

Metrics against Department of Health national priorities and performance against Healthcare Commission national core standards.

Hospital-wide measures: the national metrics

	Procedures	Mortality	
		Count	Rate
In-hospital mortality following coronary artery surgery ❶	1,022	12	1.17%
In-hospital mortality following aortic valve replacement ❶	210	3	1.43%
In-hospital mortality following all cardiac surgery ❶	1,752	58	3.31%

Hospital-wide measures of safety

	LHCH		National	Peer
	2009	2008	most recent	most recent
In base hospital mortality ❺	1.2%	1.2%	Not useful	1.1%
Harm as measured by the Global Trigger Tool	63	NA	NA	NA

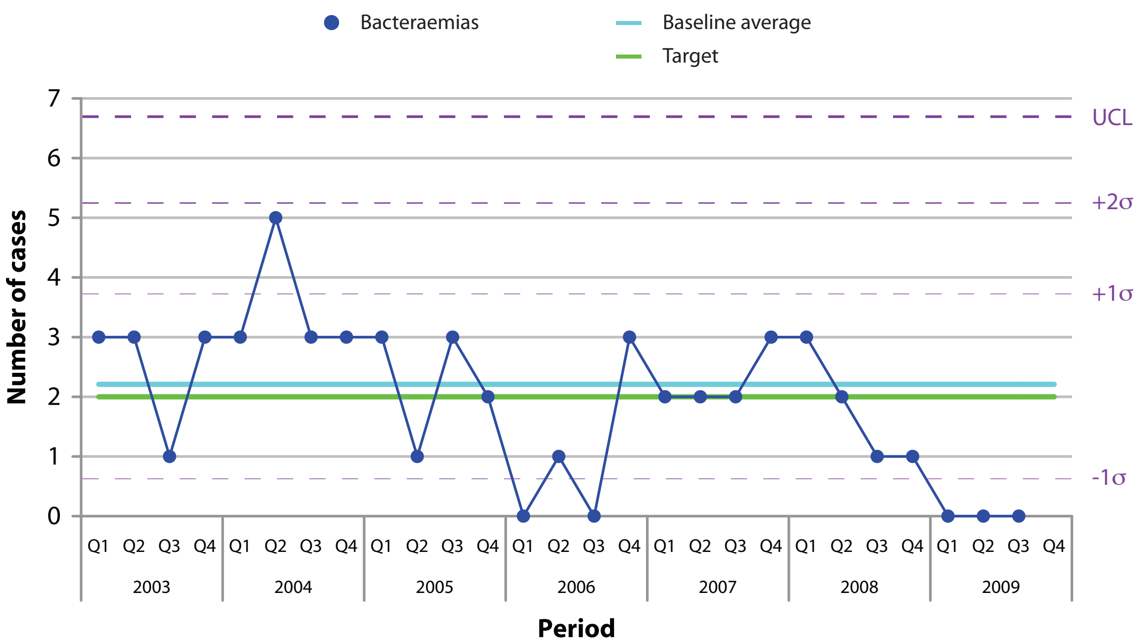
Other measures

The following charts are mostly statistical process control charts (SPCC). They are an easy-to-follow and methodologically robust way of displaying data. Each chart has a target value, which may be the historical benchmark or a nationally-defined target, and these are given in green and blue respectively. Actual performance for each measure is then given for the appropriate time-period on the chart, and the allowable degree of variability is represented by control limits (1- and 2-sigma, together with upper and lower control limits) that are supported by pre-defined rules for recognising when measures have changed significantly following an improvement intervention.

MRSA bacteraemia rate❷

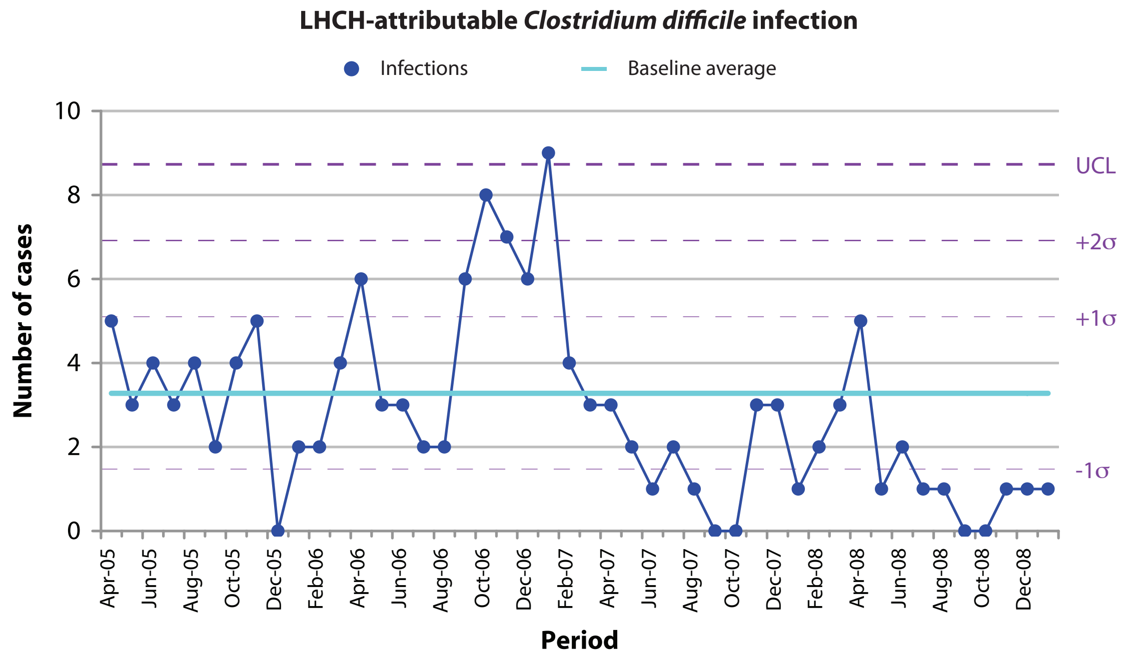
The Trust's target is for less than 8 cases per year *i.e.*, 2 *per* quarter. This target has been achieved since the second quarter of 2008.

MRSA bacteraemia; target = <8 cases per year



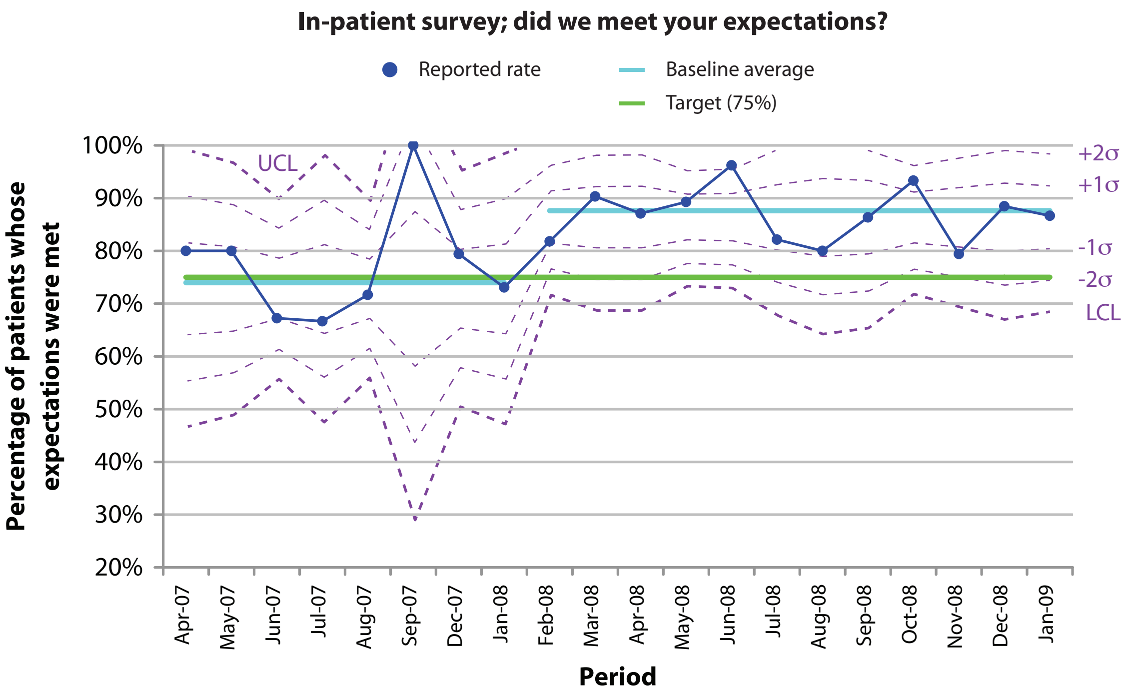
C. difficile infection rate ❷

The chart shows an improving rate of *C. difficile* infection within the Trust. Since April 2008 all time-periods have had infection rates lower than the historical benchmark.



Patient satisfaction survey ❻

Of the 189 cardiac surgery patients who completed the 2008 inpatient survey, 89% felt the care they had been given had met their expectations.



Data on complaints and claims

- 68 formal complaints received; 61 responded to within the 25-day timeframe,
- 2 complaints were accepted outside the 12-month time-frame set by the DH for Trusts accepting to investigate complaints
- 867 concerns / contacts received through PALS

Peri-operative care

We have selected a number of measures of peri-operative care. These data have been taken from an audit of 100 patients undergoing CABG surgery between August and October 2008.

Prescription of aspirin therapy at discharge ❹

N=100	Yes: 83% (83)	No: 7% (7)	Review: 0% (0)	Cont-Ind: 7% (7)

Prescription of Clopidogrel at discharge ❺

N=100	Yes: 80% (80)	No: 17% (17)	Review: 0.0.% (0)	Cont-Ind: 3% (3)

Prescription of β-blocker therapy at discharge ❺

N=100	Yes: 73% (73)	No: 17% (17)	Review: 0% (0)	Cont-Ind: 10% (10)

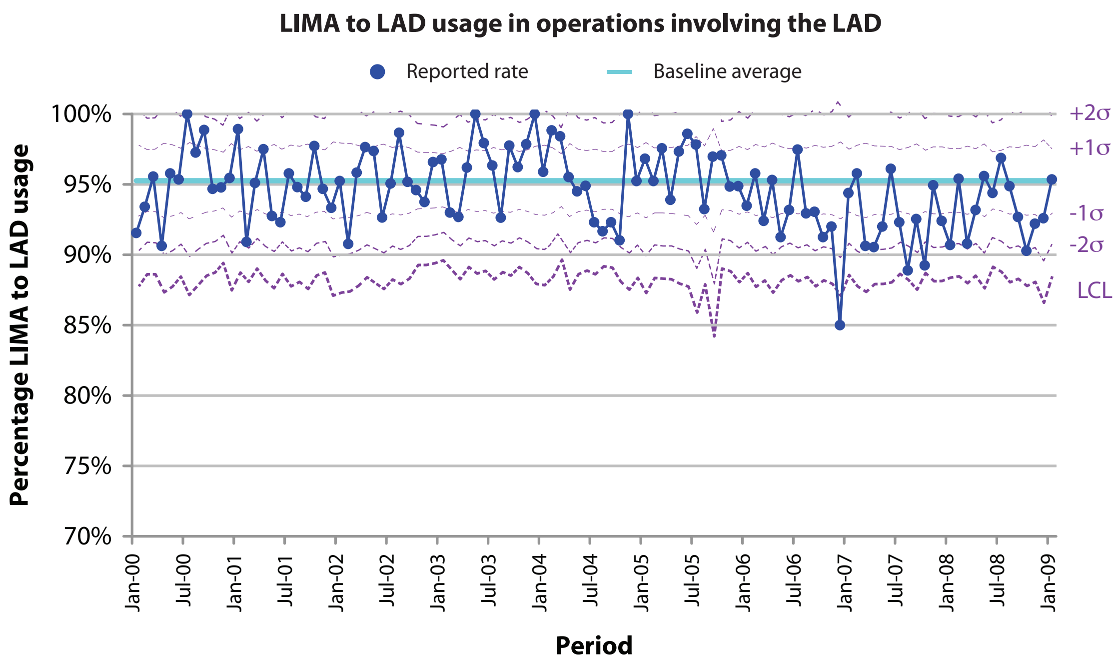
Prescription of statin therapy at discharge ❺

N=100	Yes: 91% (91)	No: 7% (7)	Review: 0% (0)	Cont-Ind: 2% (2)

Operative care

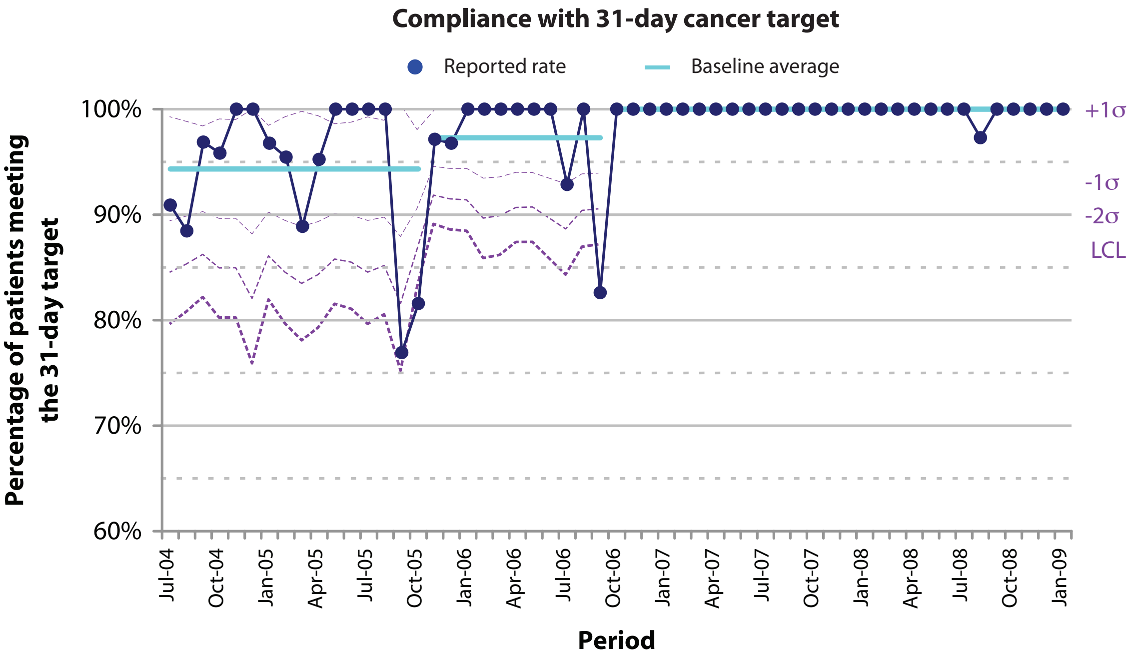
Use of at least 1 internal mammary artery ❸

LIMA usage: the left internal mammary artery is known to be associated with better patient outcomes in the short- and longer-term. Our LIMA usage rate for left anterior descending coronary artery grafts is consistently high.



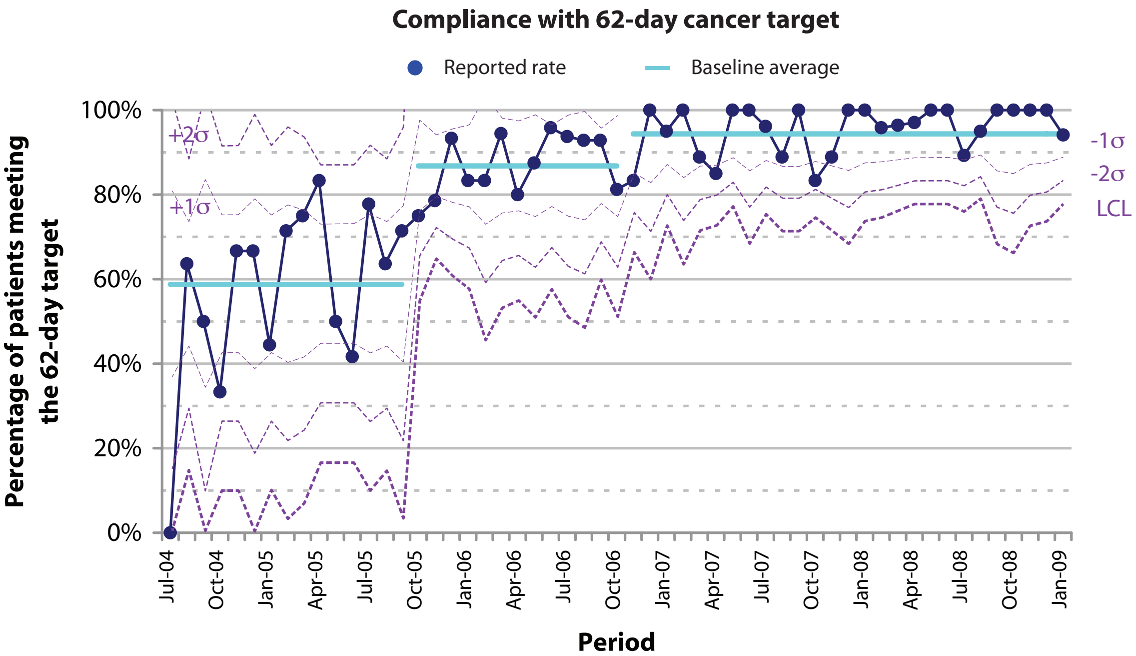
31-day cancer target ⑦

Since November 2006, we have consistently achieved 100% compliance with the 31-day cancer target for each month, with the exception of August 2008.



62-day cancer target ⑦

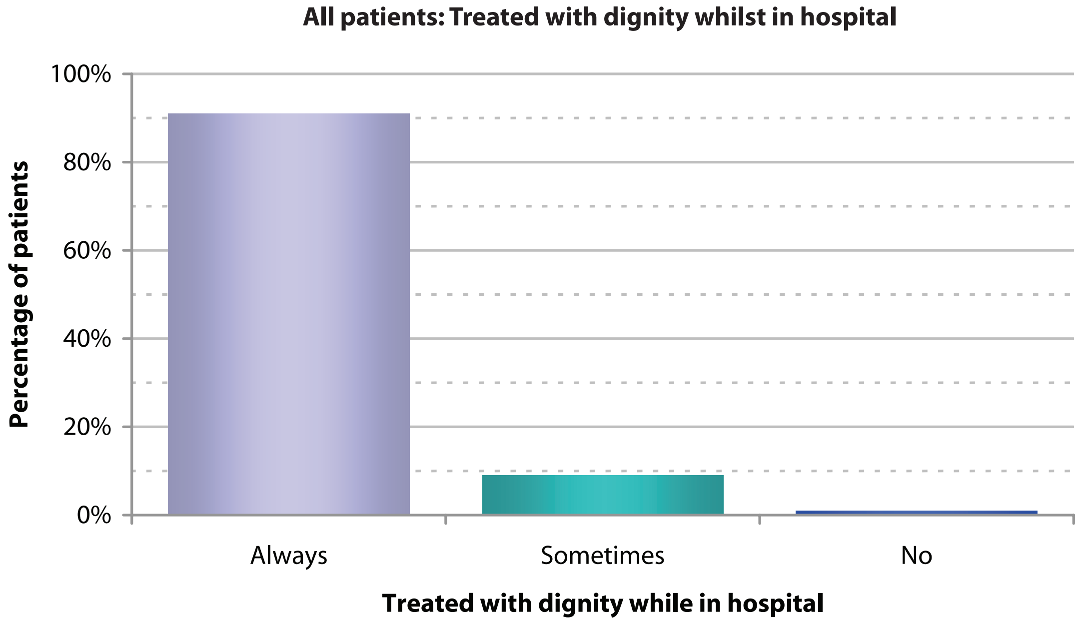
There has been a steady improvement in the compliance rates for the 62-day cancer target over time with a gradual increase in the baseline average to a current value of 94%.



i Whilst cancer targets are not relevant to cardiac surgery we have included them here for completeness as part of the organisation's compliance with important targets for patient's access to care.

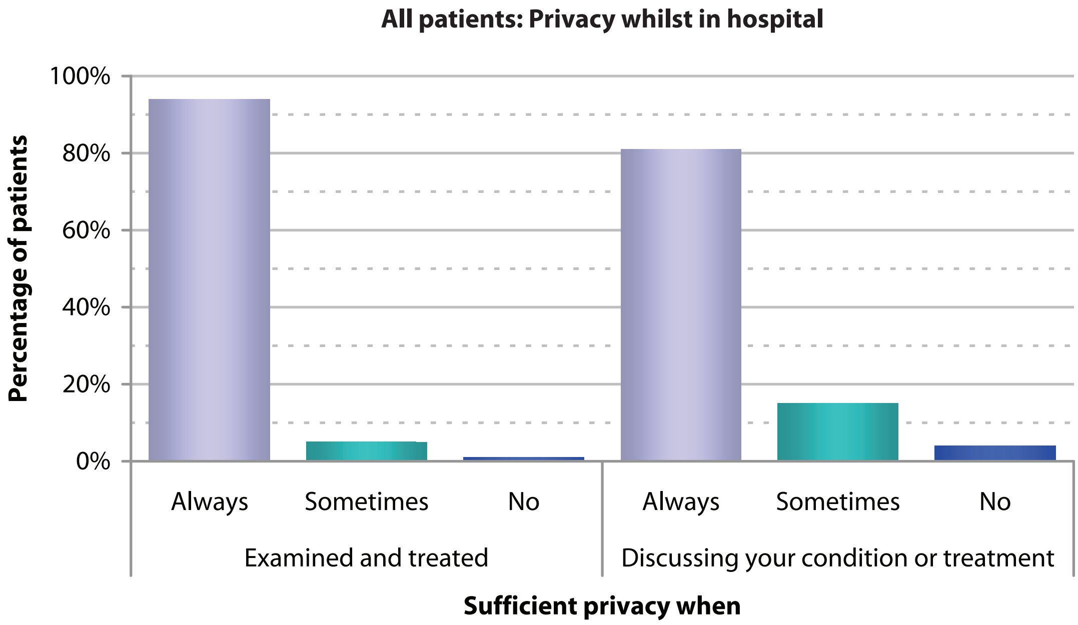
Dignity ❻

The hospital survey data show high levels of satisfaction with issues related to patient dignity.



Privacy ❻

The hospital survey data show high levels of satisfaction with respect to patient privacy.



Appropriate prescription of prophylactic antibiotics ❹

100% of all CABG operations in the period October 2008 to January 2009.

Other in-hospital, non-mortality measures

Stroke ❸

n = **1,161**	Transient: **0.4%** (8)	Permanent: **1.2%** (20)

New renal failure ❸

n = **1,689**	Failure: **2.7%** (46)	Haemo: **1.9%** (33)

Re-operation ❸

n = **1,689**	Reop: **4.4%** (74)

Prolonged post-operative length-of-stay (>10 days) ❸

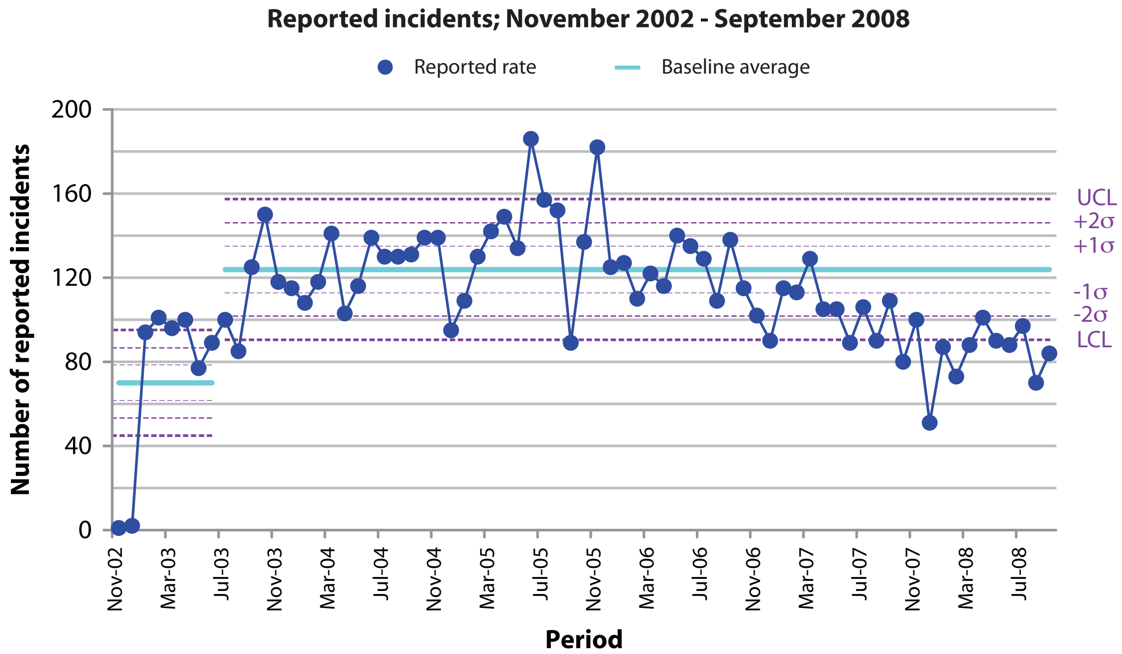
n = **1,689**	>10 days: **21.1%** (357)

Prolonged ventilation ❸

n = **1,684**	>24 hours: **5.3%** (89)

Reported clinical incidents ❺

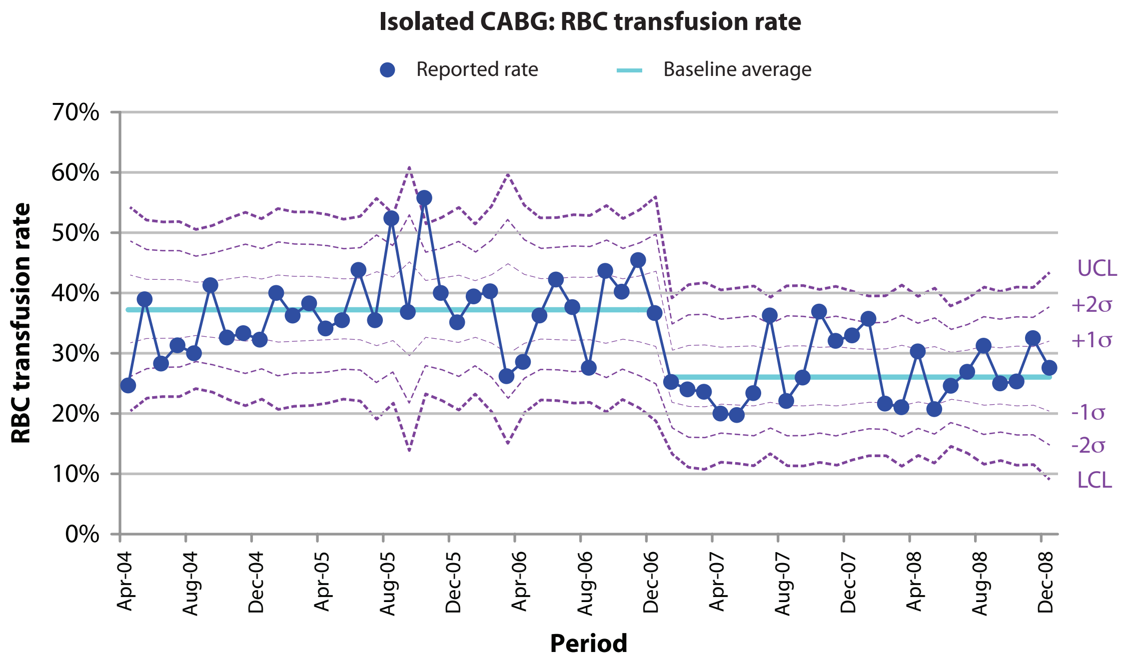
The reported clinical incident rates have fallen over the last 12 months.

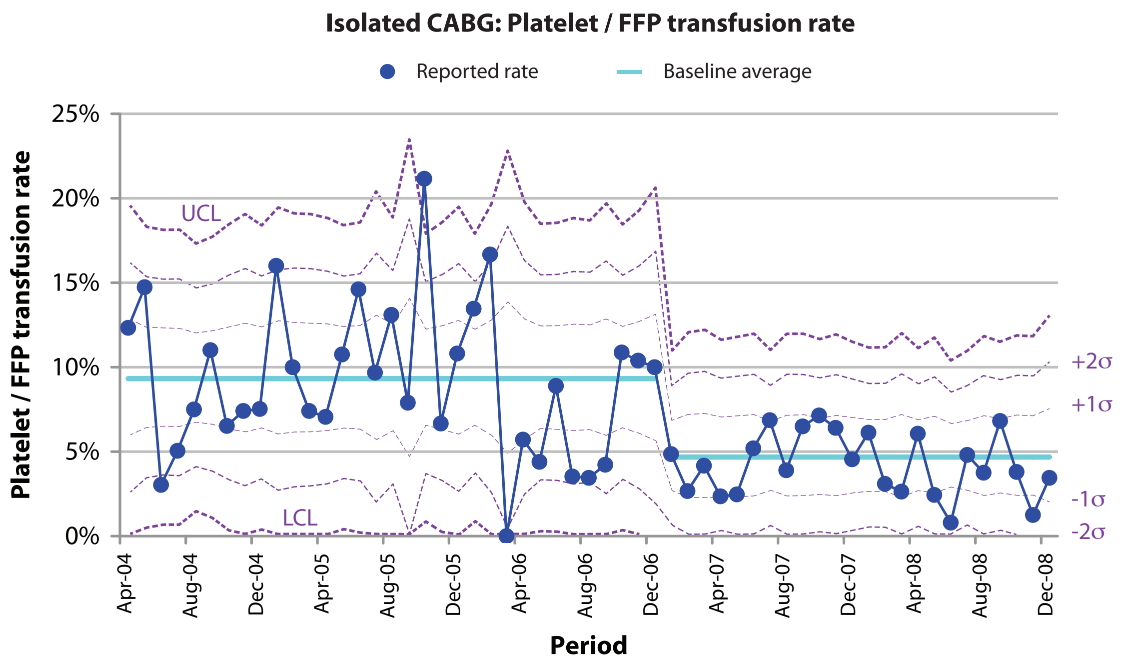


Patients undergoing a blood transfusion 5

The usage of red blood cell transfusion for patients undergoing isolated CABG has fallen over time. Because the transfusion rate has fallen we have *reset* our benchmark at just over 25%.

The usage of platelet transfusion for patients undergoing isolated CABG has fallen over time. Because the transfusion rate has fallen we have *reset* our benchmark at just under 5%.





Non-mortality outcomes following hospital discharge

Written medication and hospital stay summary received by GP within 72 hours of discharge [i]

	LHCH		National	Peer
	2009	2008	most recent	most recent
Percentage received	55%	NA	NA	NA

Operations cancelled for non-clinical reasons [i]

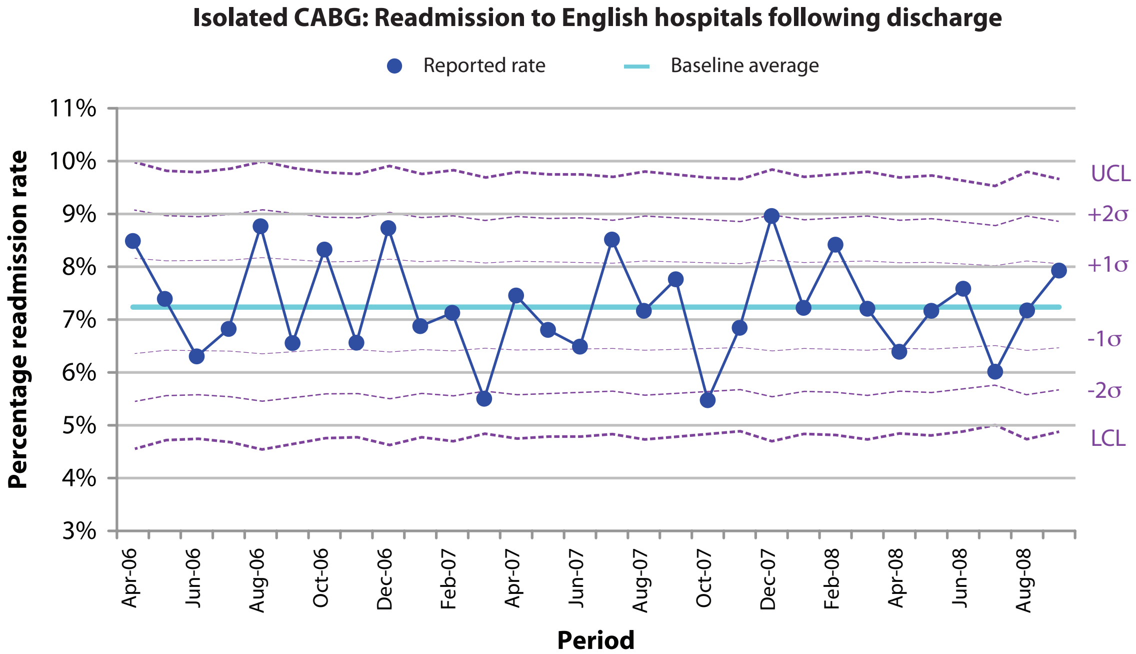
	2008 / 09	2007 / 08	Target
Percentage cancelled	1.3%	1.0%	1.5% [ii]

NHS staff satisfaction [i]

	2008 / 09	2007 / 08	Target
Staff satisfaction	3.32	3.18	3.53 [iii]

Readmission 5

We collect data on patients who have been re-admitted to hospitals in England. We also serve patients from Wales, some of whom may be re-admitted to Welsh hospitals after their cardiac surgery, and we accept this may be a small underestimate.



i Metrics against Department of Health national priorities and performance against Healthcare Commission national core standards.

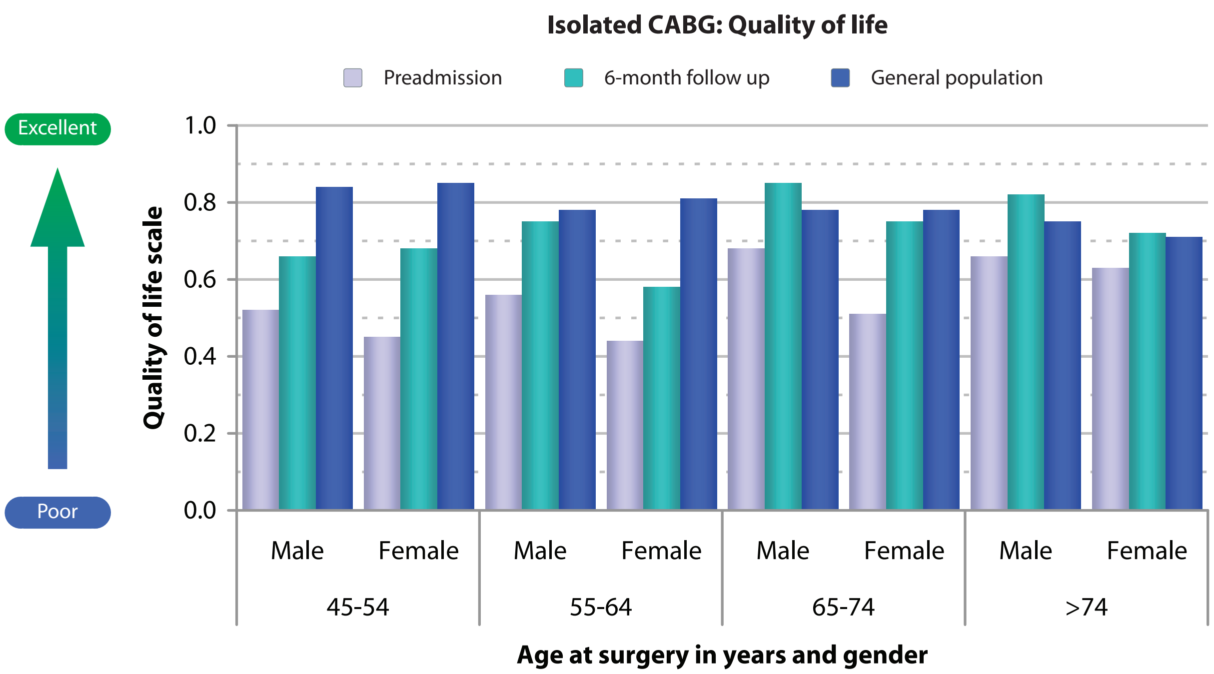
ii Scores of between 0.8% and 1.5% represent under-achievement.

iii This is not a target, but the average score for NHS Trusts.

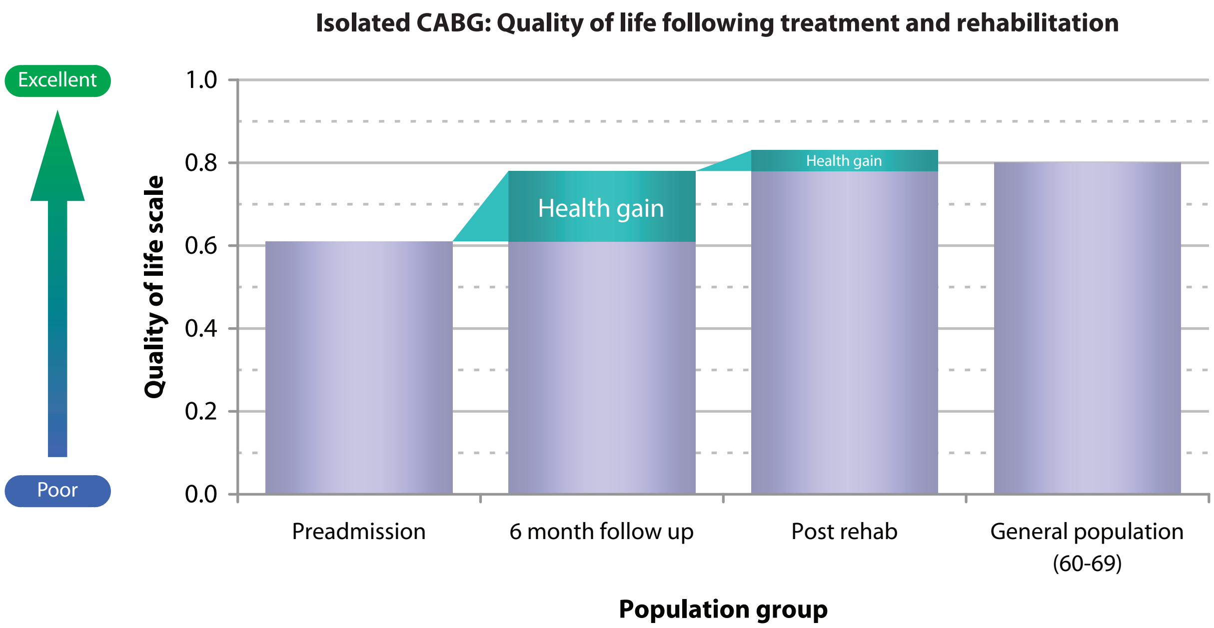
iv Please see http://www.cqc.org.uk/guidanceforprofessionals/healthcare/nhsstaff/annualhealthcheck2008/09/qualityofservices/exis/acuteandspecialisttrusts.cfm for an explanation of the above metrics.

Quality of life 5

The data show that isolated coronary artery bypass surgery improves quality-of-life for patients. In general, post-operative quality-of-life is similar to that of an age-matched healthy population.



Many of our patients undergo cardiac rehabilitation, which is known to be beneficial. These data show that cardiac rehabilitation provides an incremental health gain, above coronary artery surgery alone.



i Quality of life has been measured with the EQ-5D: www.euroqol.org

ii The above data are from a sample of 542 patients undergoing surgery. This study is ongoing and not all of these patients have yet reached 6 months of follow up.

Key to sources for quoted metrics

Data are collected from different sources, which are referred to as follows:

❶ indicates national clinical metrics

❷ indicates data fields in the current SCTS dataset

❸ indicates fields currently returned to the National Patient Safety Agency

❹ indicates fields in the NHS North-West advancing quality program

❺ indicates fields thought to be important locally

❻ indicates national patient survey data

❼ indicates national waiting-time targets

Notes on recommended metrics

1. Harm as measured by the Global Trigger Tool (events per 1,000 bed days). This measure is derived from a systematic review of a sample of patient casenotes, and is a key measure of the Patient Safety First Campaign.
2. In-base hospital mortality (% of all patients). The number of patients who die within our Trust following admission. Whilst our rates are comparable with our peer group, we anticipate an increase in deaths this year as a result of the new primary angioplasty service. We need to set a new baseline and then improve. National comparators are not useful as our casemix is very different from most other hospitals.
3. Perfect care score for patients receiving the Advancing Quality Care Bundles. Perfect care is deemed to have occurred when all elements of the care bundle have been used for appropriate patients. Missing one element of the bundle results in no score awarded, even if all other elements of care have been delivered to the patient. This result is the average of perfect care scores from the three bundles.
4. Medication and hospital stay summary received by the General Practitioner within 72 hours of discharge (% discharges). This result has been calculated from a small sample of patients drawn from general practice by Liverpool Primary Care Trust. Improving the timeliness of hospital summaries is a project we are taking forward with the local Primary Care Trust this year.

Appendices

Appendices

Healthcare Commission analysis including institutional mortality

Individual surgeons' operative mortality rates were published in the United Kingdom in 2005, initially by the Guardian Newspaper following a request under the newly introduced Freedom of Information Act. In response to this, following a collaboration between the Healthcare Commission and the SCTS, a more comprehensive analysis has been undertaken and presented on a website at www.healthcarecommssion.co.uk (now http://heartsurgery.cqc.org.uk). The methodology and style of presentation was agreed after extensive discussion between all interested parties including patient groups, surgeons, IT professionals and the Healthcare Commission. It has been updated annually since 2005, and the current version includes an analysis of operations between April 2004 and March 2007. All hospitals undertaking NHS surgery in England, Scotland, Wales and Northern Ireland are included. Each hospital was given the opportunity to have individual surgeon's mortality rates published if they should so wish, and currently about 70% of surgeons' data are available on the website. The format of presentation of results is based on a comparison of actual mortality to that predicted by a risk-prediction model. To compare hospitals' mortality rates the logistic ***EuroSCORE*** has been used, but because it is known to over-predict observed mortality for contemporary practice in the United Kingdom, the risk score has been re-calibrated to make it more accurate. This has been achieved by determining the actual and predicted mortality for each different operative group (CABG, AVR, mitral repair, *etc*) and using this to give a *re-calibration coefficient* for that group. These re-calibration coefficients have then been applied to the logistic ***EuroSCORE***. All cardiac surgical operations have been included with the exception of cardiopulmonary transplantation, ventricular assist devices and cardiac trauma. The re-calibration coefficients for the different operative groups are given in tables 1,2 and 3.

For each hospital, information is presented about the organisation. The results for isolated coronary artery bypass surgery, isolated AVR surgery and all cardiac surgery are then given for both the single year and the cumulative 3 years to March 2007. The interactive website gives the ability to compare mortality outcomes, either to a European standard (the original logistic ***EuroSCORE***) or the contemporary United Kingdom standard. For each hospital the number of cases is given along with the percentage survival rate and the predicted survival rate for that casemix. The predicted survival rate is given with appropriate confidence intervals and a comment is made as to whether the observed mortality is *as expected* or not.

For each hospital a list of the consultant surgeons is given. For those hospitals who wished to have individual surgical results displayed, there is a *practice profile* given for each surgeon, which enables the volume of surgery and the sub-specialist casemix to be seen. Finally the individual surgeon's mortality outcomes for all cardiac surgery and isolated coronary artery bypass surgery are displayed (in a similar graphical format to the unit results), again together with a comment about whether the results are as expected or not, for about 70% of the units.

This form of presentation has been well received. The website currently receives about 26,000 visits a month, and the format of analysis has been praised in the Chief Medical Officers report on professional re-certification *Good Doctors, Safer Patients* (2006).

Tables 4 a, b and c give a list of the hospitals whose data is currently available on the website, with their case volume, and the predicted mortality range for isolated coronary artery bypass surgery, aortic valve surgery and all cardiac surgery respectively.

Table 1. Number of cases, deaths, % mortality rate, average logistic ***EuroSCORE*** and observed to expected (O : E) mortality ratio for different operative groups

		Count	Deaths	Mortality rate	Logistic ***EuroSCORE***	O : E ratio
Operative group	CABG alone (1st time)	68,202	1,211	1.78%	4.00%	0.444
	CABG alone (redo)	1,506	109	7.24%	9.48%	0.764
	CABG + valve	11,589	802	6.92%	9.75%	0.710
	CABG + valve + other	1,208	187	15.48%	14.93%	1.037
	CABG + other	2,144	218	10.17%	13.94%	0.729
	Valve alone (1st time AVR)	10,191	223	2.19%	6.35%	0.344
	Valve alone (other)	9,039	501	5.54%	9.20%	0.603
	Valve + other	3,558	294	8.26%	11.32%	0.730

Table 2. Ratios for specific valve operations that were significantly different from the mean for valve operations

		Count	Observed mortality rate	Expected mortality rate	O : E ratio
Operation	Lower than predicted by average valve re-calibration factor				
	Redo AV repair	85	1.18%	7.20%	0.163
	Redo PVR	94	1.06%	5.36%	0.198
	Redo MV repair	2,213	1.63%	5.68%	0.286
	First-time AVR	9,837	2.18%	6.34%	0.343
	Redo AVR	1,513	6.81%	13.63%	0.500
	Higher than predicted by average valve re-calibration factor				
	Redo AVR and MVR	895	7.26%	10.39%	0.699
	Redo CABG + AVR	361	13.02%	17.23%	0.756
	First-time CABG +AVR + MV repair	104	9.62%	12.39%	0.776
	First-time CABG + MVR	851	9.17%	11.50%	0.797
	CABG + first-time MV repair	1,310	8.85%	10.42%	0.850
	Redo CABG + MVR	75	13.33%	15.53%	0.858
	First-time CABG + AVR + Other	545	14.86%	15.99%	0.929
	Redo AVR + MVR + TV repair	92	10.87%	11.39%	0.954
	Redo MVR + TV repair	247	12.55%	11.62%	1.080
	First-time CABG + MV repair + TV repair	90	15.56%	13.70%	1.136
	First-time CABG + AVR + MVR	235	11.06%	9.47%	1.168
	First-time CABG +MVR + Other	89	13.48%	11.25%	1.199
	Redo CABG + AVR + Other	59	35.59%	26.09%	1.364
	First-time MVR + TV repair	55	18.18%	13.05%	1.393
	Redo TVR	59	18.64%	8.20%	2.273

Table 3. O : E ratios for operations that were classified as *Other*

		Count	Observed mortality rate	Expected mortality rate	O : E ratio
Other operations	Epicardial pacemaker	73	1.37%	8.27%	0.166
	Atrial myxoma	241	2.49%	5.13%	0.486
	ASD closure	375	1.33%	2.73%	0.488
	CABG & LV aneurysmectomy	511	2.58%	10.35%	0.510
	Pericardiectomy	208	14.42%	5.31%	2.716

Table 4a. **All cardiac surgery**. Results of cardiac surgery displayed on the Healthcare Commission website; 3 years of data to the end of March 2007. Compared to the complex re-calibrated logistic ***EuroSCORE*** with 99% CIs

Centre	Counts	Deaths	Actual mortality	Predicted mortality	Upper CI	Lower CI
Aberdeen Royal Infirmary	1,665	69	4.1%	4.3%	5.9%	2.9%
Bart's & the London	4,927	168	3.4%	4.1%	5.0%	3.3%
Blackpool Victoria Hospital	2,938	82	2.8%	3.2%	4.2%	0.4%
Bristol Royal Infirmary	4,328	119	2.7%	3.2%	4.1%	2.4%
Castle Hill Hospital, Hull	2,809	110	3.9%	3.2%	4.3%	2.3%
Derriford Hospital, Plymouth	2,705	87	3.2%	3.3%	4.3%	2.3%
Edinburgh Royal Infirmary	2,713	113	4.2%	3.7%	4.8%	2.6%
Freeman Hospital, Newcastle	3,029	112	3.7%	4.1%	5.2%	3.1%
Glasgow Western Infirmary	2,584	82	3.2%	3.3%	4.5%	0.4%
Glenfield Hospital, Leicester	3,457	129	3.7%	4.5%	5.6%	3.5%
Guy's & St Thomas's Hospital, London	4,178	160	3.8%	4.0%	4.9%	1.6%
Hammersmith Hospital, London	1,619	44	2.7%	3.7%	5.2%	2.4%
Harley Street Clinic, London	629	11	1.7%	2.8%	5.1%	1.1%
James Cook Univ. Hospital, Middlesbrough	3,394	109	3.2%	3.7%	4.8%	0.9%
John Radcliffe Hospital, Oxford	2,668	113	4.2%	4.9%	6.2%	3.7%
King's College Hospital, London	1,856	93	5.0%	5.0%	6.6%	3.5%
Liverpool Heart & Chest Hospital	4,947	171	3.5%	3.7%	4.6%	3.0%
Leeds General Infirmary	3,565	93	2.6%	3.3%	4.3%	2.5%
London Bridge Hospital	822	16	1.9%	3.2%	5.2%	1.6%
Manchester Heart Centre	2,645	104	3.9%	3.3%	4.4%	2.3%
Morriston Hospital, Swansea	2,280	57	2.5%	4.8%	6.2%	3.5%
N Staffordshire RI, Stoke-on-Trent	2,760	87	3.2%	3.3%	4.4%	0.4%
New Cross Hospital, Wolverhampton	2,050	71	3.5%	3.7%	5.0%	2.5%
Northern General Hospital, Sheffield	3,139	127	4.0%	3.7%	4.8%	2.7%
Nottingham City Hospital	1,980	67	3.4%	3.6%	4.9%	2.4%
Papworth Hospital, Cambridge	5,212	180	3.5%	4.9%	5.8%	4.0%
Queen Elizabeth Hospital, Birmingham	2,726	117	4.3%	4.9%	6.2%	3.7%
Royal Brompton & Harefield, London	5,425	212	3.9%	3.8%	4.6%	3.0%
Royal Sussex County Hospital, Brighton	2,112	80	3.8%	3.6%	4.8%	2.4%
Royal Victoria Hospital, Belfast	2,360	90	3.8%	3.1%	4.2%	0.5%
Southampton General Hospital	2,137	34	1.6%	5.7%	7.3%	1.8%
St George's Hospital, London	3,046	80	2.6%	3.1%	4.1%	2.2%
St Mary's Hospital, London	455	23	5.1%	4.4%	7.5%	0.0%
The Heart Hospital, London	3,078	101	3.3%	3.4%	4.4%	0.7%
University Hospital of Wales, Cardiff	2,454	61	2.5%	4.5%	5.8%	0.9%
Walsgrave Hospital, Coventry	2,345	109	4.6%	3.8%	5.1%	0.7%
Wellington Hospital, London	970	25	2.6%	4.1%	6.1%	2.3%
Wythenshawe Hospital, Manchester	2,927	62	2.1%	3.4%	4.4%	0.4%

Table 4b. **Isolated, first-time CABG surgery**. Results of cardiac surgery displayed on the Healthcare Commission website; 3 years of data to the end of March 2007. Compared to the complex re-calibrated logistic ***EuroSCORE*** with 99% CIs

		Counts	Deaths	Actual mortality	Predicted mortality	Upper CI	Lower CI
Centre	Aberdeen Royal Infirmary	1,107	22	2.0%	2.5%	4.0%	1.2%
	Bart's & the London	3,090	50	1.6%	2.1%	2.9%	1.4%
	Blackpool Victoria Hospital	1,851	23	1.2%	1.4%	2.3%	0.6%
	Bristol Royal Infirmary	2,744	32	1.2%	1.6%	2.3%	0.9%
	Castle Hill Hospital, Hull	1,797	36	2.0%	1.5%	2.4%	0.7%
	Derriford Hospital, Plymouth	1,568	18	1.1%	1.5%	2.5%	0.7%
	Edinburgh Royal Infirmary	1,608	24	1.5%	1.7%	2.7%	0.8%
	Freeman Hospital, Newcastle	1,877	35	1.9%	1.9%	2.9%	1.0%
	Glasgow Western Infirmary	1,579	32	2.0%	1.6%	2.7%	0.8%
	Glenfield Hospital, Leicester	1,700	21	1.2%	1.8%	2.8%	0.9%
	Guy's & St Thomas's Hospital, London	2,534	59	2.3%	1.9%	2.7%	1.1%
	Hammersmith Hospital, London	1,046	22	2.1%	2.2%	3.7%	1.1%
	Harley Street Clinic, London	346	2	0.6%	1.4%	3.8%	0.0%
	James Cook Univ. Hospital, Middlesbrough	2,157	34	1.6%	1.9%	2.8%	1.1%
	John Radcliffe Hospital, Oxford	1,570	37	2.4%	1.9%	3.0%	1.0%
	King's College Hospital, London	1,038	21	2.0%	1.9%	3.2%	0.8%
	Liverpool Heart & Chest Hospital	3,000	63	2.1%	2.0%	2.8%	1.3%
	Leeds General Infirmary	2,293	33	1.4%	1.6%	2.5%	0.9%
	London Bridge Hospital	487	7	1.4%	1.4%	3.3%	0.2%
	Manchester Heart Centre	1,475	29	2.0%	1.5%	2.6%	0.7%
	Morriston Hospital, Swansea	1,460	19	1.3%	2.8%	4.2%	1.6%
	N Staffordshire RI, Stoke-on-Trent	1,853	25	1.3%	1.5%	2.5%	0.8%
	New Cross Hospital, Wolverhampton	1,416	22	1.6%	1.7%	2.8%	0.8%
	Northern General Hospital, Sheffield	1,881	47	2.5%	1.7%	2.7%	0.9%
	Nottingham City Hospital	1,134	17	1.5%	1.6%	2.8%	0.6%
	Papworth Hospital, Cambridge	2,648	49	1.9%	2.4%	3.4%	1.6%
	Queen Elizabeth Hospital, Birmingham	1,512	20	1.3%	1.7%	2.8%	0.8%
	Royal Brompton & Harefield, London	1,576	13	0.8%	1.5%	2.5%	0.6%
	Royal Sussex County Hospital, Brighton	1,204	17	1.4%	1.5%	2.7%	0.6%
	Royal Victoria Hospital, Belfast	1,527	35	2.3%	1.6%	2.6%	0.7%
	Southampton General Hospital	1,013	8	0.8%	2.7%	4.4%	1.4%
	St George's Hospital, London	1,768	24	1.4%	1.4%	2.3%	0.6%
	St Mary's Hospital, London	316	10	3.2%	2.4%	5.4%	0.3%
	The Heart Hospital, London	1,704	26	1.5%	1.6%	2.6%	0.8%
	University Hospital of Wales, Cardiff	1,299	12	0.9%	1.8%	3.1%	0.8%
	Walsgrave Hospital, Coventry	1,475	32	2.2%	1.9%	3.1%	0.9%
	Wellington Hospital, London	545	7	1.3%	1.6%	3.5%	0.4%
	Wythenshawe Hospital, Manchester	1,710	21	1.2%	1.6%	2.5%	0.8%

Table 4c. **Isolated, first-time AVR surgery.** Results of cardiac surgery displayed on the Healthcare Commission website; 3 years of data to the end of March 2007. Compared to the complex re-calibrated logistic ***EuroSCORE*** with 99% CIs

Centre	Counts	Deaths	Actual mortality	Predicted mortality	Upper CI	Lower CI
Aberdeen Royal Infirmary	125	3	2.4%	1.9%	6.4%	0.0%
Bart's & the London	420	14	3.3%	2.6%	5.2%	0.7%
Blackpool Victoria Hospital	227	3	1.3%	1.9%	5.3%	0.0%
Bristol Royal Infirmary	396	14	3.5%	2.2%	4.8%	0.3%
Castle Hill Hospital, Hull	200	2	1.0%	2.2%	6.0%	0.0%
Derriford Hospital, Plymouth	333	9	2.7%	1.9%	4.5%	0.0%
Edinburgh Royal Infirmary	221	7	3.2%	2.0%	5.4%	0.0%
Freeman Hospital, Newcastle	309	9	2.9%	2.2%	5.2%	0.3%
Glasgow Western Infirmary	285	6	2.1%	2.4%	5.6%	0.4%
Glenfield Hospital, Leicester	366	12	3.3%	2.4%	5.2%	0.3%
Guy's & St Thomas's Hospital, London	445	11	2.5%	2.5%	4.9%	0.7%
Hammersmith Hospital, London	159	3	1.9%	2.2%	6.3%	0.0%
Harley Street Clinic, London	85	0	0.0%	1.8%	7.1%	0.0%
James Cook Univ. Hospital, Middlesbrough	275	6	2.2%	1.9%	4.7%	0.0%
John Radcliffe Hospital, Oxford	350	9	2.6%	2.5%	5.4%	0.6%
King's College Hospital, London	197	6	3.0%	2.9%	7.1%	0.0%
Liverpool Heart & Chest Hospital	489	9	1.8%	2.4%	4.7%	0.6%
Leeds General Infirmary	376	8	2.1%	2.2%	4.8%	0.3%
London Bridge Hospital	84	1	1.2%	1.8%	7.1%	0.0%
Manchester Heart Centre	266	7	2.6%	2.1%	5.3%	0.0%
Morriston Hospital, Swansea	55	1	1.8%	3.4%	12.7%	0.0%
N Staffordshire RI, Stoke-on-Trent	126	0	0.0%	2.1%	7.1%	0.0%
New Cross Hospital, Wolverhampton	135	1	0.7%	2.1%	6.7%	0.0%
Northern General Hospital, Sheffield	277	4	1.4%	2.1%	5.1%	0.0%
Nottingham City Hospital	210	1	0.5%	1.7%	4.8%	0.0%
Papworth Hospital, Cambridge	632	14	2.2%	2.5%	4.6%	0.9%
Queen Elizabeth Hospital, Birmingham	268	5	1.9%	2.3%	5.6%	0.0%
Royal Brompton & Harefield, London	362	4	1.1%	2.1%	4.7%	0.3%
Royal Sussex County Hospital, Brighton	228	7	3.1%	2.1%	5.3%	0.0%
Royal Victoria Hospital, Belfast	221	2	0.9%	1.8%	5.0%	0.0%
Southampton General Hospital	242	2	0.8%	2.7%	6.2%	0.4%
St George's Hospital, London	279	3	1.1%	1.5%	4.3%	0.0%
St Mary's Hospital, London	30	1	3.3%	2.9%	16.7%	0.0%
The Heart Hospital, London	338	6	1.8%	2.2%	4.7%	0.3%
University Hospital of Wales, Cardiff	191	3	1.6%	1.9%	5.2%	0.0%
Walsgrave Hospital, Coventry	187	10	5.3%	2.5%	6.4%	0.0%
Wellington Hospital, London	96	0	0.0%	2.3%	8.3%	0.0%
Wythenshawe Hospital, Manchester	362	7	1.9%	2.0%	4.4%	0.3%

Primary Care Trust-related data

Deviation from predicted aortic valve replacement rates

Observed and predicted rates per million population of aortic valve replacement by Strategic Health Authority and Primary Care Trust; financial years 2004-2007; **significance at the 99.8% level**

			Observed			Predicted		
			Rate	LCL	UCL	Rate	Variance	
East Midlands SHA	**Overall**	Not signif.	**606**	**570**	**643**	**600**	**6**	**1%**
	Bassetlaw	Not signif.	649	434	928	632	17	3%
	Derby City	Signif. low at 99.0%	450	334	591	572	-122	-21%
	Derbyshire	Not signif.	629	540	728	638	-9	-1%
	Leicester City	Not signif.	500	384	638	474	26	6%
	Leics County & Rutland	Signif. high at 99.8 =%	723	624	834	609	114	19%
	Lincolnshire	Not signif.	689	595	792	705	-16	-2%
	Northamptonshire	Not signif.	588	499	687	549	39	7%
	Nottingham City	Not signif.	437	329	567	454	-17	-4%
	Nottinghamshire County	Not signif.	581	492	680	625	-44	-7%
East of England	**Overall**	Signif. high at 99.8 =%	**653**	**620**	**687**	**611**	**41**	**7%**
	Bedfordshire	Signif. high at 99.0%	666	548	800	557	109	19%
	Cambridgeshire	Signif. high at 99.8 =%	829	716	954	570	259	45%
	E & N Hertfordshire	Not signif.	588	492	697	562	26	5%
	Gt Yarmouth & Waveney	Not signif.	825	648	1,032	740	84	11%
	Luton	Not signif.	425	292	596	476	-51	-11%
	Mid Essex	Signif. low at 99.8%	451	348	573	577	-127	-22%
	Norfolk	Signif. high at 99.8 =%	852	749	964	724	128	18%
	North East Essex	Not signif.	645	513	798	689	-44	-6%
	Peterborough	Signif. high at 99.0%	682	492	917	517	165	32%
	South East Essex	Signif. low at 99.8%	507	394	640	656	-149	-23%
	South West Essex	Not signif.	647	529	782	557	89	16%
	Suffolk	Not signif.	650	551	760	660	-10	-2%
	W Hertfordshire	Not signif.	512	422	615	562	-50	-9%
	West Essex	Not signif.	604	466	769	591	13	2%
London	**Overall**	Not signif.	**466**	**442**	**491**	**448**	**18**	4%
	Barking & Dagenham	Not signif.	548	387	751	460	88	19%
	Barnet	Signif. high at 99.8 =%	699	565	853	504	194	39%
	Bexley	Signif. high at 99.0%	752	581	956	583	169	29%
	Brent	Signif. low at 99.8%	263	179	372	438	-175	-40%
	Bromley	Not signif.	663	527	820	594	68	12%
	Camden	Signif. high at 99.8 =%	535	398	701	363	171	47%
	City And Hackney	Not signif.	302	201	434	359	-57	-16%
	Croydon	Not signif.	494	383	625	481	12	3%
	Ealing	Signif. low at 99.8%	281	199	386	437	-155	-36%

Significance
- Signif. low at 99.8%
- Signif. low at 99.0%
- Not signif.
- Signif. high at 99.8 =%
- Signif. high at 99.0%

Observed and predicted rates per million population of aortic valve replacement by Strategic Health Authority and Primary Care Trust; financial years 2004-2007; **significance at the 99.8% level**

			Observed			Predicted		
		Significance	Rate	LCL	UCL	Rate	Variance	
London ...	Enfield	Signif. high at 99.8%	654	512	822	498	156	31%
London ...	Greenwich	Not signif.	465	338	621	438	27	6%
London ...	Hammersmith & Fulham	Not signif.	342	220	505	406	-64	-16%
London ...	Haringey	Not signif.	438	317	587	386	51	13%
London ...	Harrow	Not signif.	615	457	808	536	79	15%
London ...	Havering	Not signif.	657	506	837	630	27	4%
London ...	Hillingdon	Not signif.	533	399	696	508	25	5%
London ...	Hounslow	Not signif.	354	243	496	443	-89	-20%
London ...	Islington	Not signif.	486	343	667	384	103	27%
London ...	Kensington & Chelsea	Not signif.	487	345	665	467	20	4%
London ...	Kingston	Not signif.	478	330	665	468	10	2%
London ...	Lambeth	Not signif.	323	230	441	360	-36	-10%
London ...	Lewisham	Not signif.	380	272	515	397	-18	-4%
London ...	Newham	Not signif.	351	247	482	343	8	2%
London ...	Redbridge	Not signif.	514	382	675	490	25	5%
London ...	Richmond & Twickenham	Not signif.	505	354	695	483	21	4%
London ...	Southwark	Not signif.	344	241	474	377	-32	-9%
London ...	Sutton & Merton	Not signif.	485	381	606	478	7	2%
London ...	Tower Hamlets	Not signif.	391	272	543	331	61	18%
London ...	Waltham Forest	Not signif.	422	301	573	421	1	0%
London ...	Wandsworth	Not signif.	328	232	449	375	-47	-13%
London ...	Westminster	Not signif.	383	270	526	421	-38	-9%
North East	**Overall**	Not signif.	**620**	**573**	**670**	**611**	**9**	**1%**
North East	County Durham	Not signif.	570	472	681	621	-51	-8%
North East	Darlington	Not signif.	666	440	963	614	52	8%
North East	Gateshead	Not signif.	695	525	901	627	69	11%
North East	Hartlepool	Not signif.	495	298	768	591	-96	-16%
North East	Middlesbrough	Not signif.	695	500	938	555	140	25%
North East	Newcastle upon Tyne	Not signif.	619	479	786	541	78	14%
North East	North Tees	Not signif.	550	397	738	563	-13	-2%
North East	North Tyneside	Not signif.	527	383	704	632	-106	-17%
North East	Northumberland	Not signif.	603	476	752	676	-74	-11%
North East	Redcar & Cleveland	Not signif.	805	586	1,076	642	163	25%
North East	South Tyneside	Not signif.	749	550	993	636	113	18%
North East	Sunderland	Not signif.	620	483	781	598	22	4%

Significance
- Signif. low at 99.8%
- Signif. low at 99.0%
- Not signif.
- Signif. high at 99.8 =%
- Signif. high at 99.0%

Observed and predicted rates per million population of aortic valve replacement by Strategic Health Authority and Primary Care Trust; financial years 2004-2007; **significance at the 99.8% level**

			Observed			Predicted		
			Rate	LCL	UCL	Rate	Variance	
North West	**Overall**	Not signif.	**605**	**576**	**635**	**588**	**17**	**3%**
North West	Ashton Leigh & Wigan	Not signif.	511	393	651	576	-65	-11%
North West	Blackburn / Darwen	Not signif.	423	278	613	501	-78	-15%
North West	Blackpool	Signif. high at 99.8%	1,033	788	1,326	658	375	57%
North West	Bolton	Not signif.	590	455	752	562	29	5%
North West	Bury	Not signif.	601	438	800	561	39	7%
North West	C & E Cheshire	Signif. low at 99.0%	518	419	633	626	-107	-17%
North West	Central Lancs	Not signif.	573	467	693	583	-10	-2%
North West	Cumbria	Not signif.	743	629	870	684	59	9%
North West	East Lancs	Not signif.	508	402	632	576	-68	-12%
North West	Halton & St Helens	Not signif.	579	453	727	577	1	0%
North West	Heywood/Middleton/Rochdale	Not signif.	578	427	762	538	40	7%
North West	Knowsley	Not signif.	589	415	808	555	34	6%
North West	Liverpool	Signif. high at 99.8%	666	552	794	547	118	22%
North West	Manchester	Not signif.	450	361	553	449	1	0%
North West	North Lancs	Signif. high at 99.8%	859	709	1,030	700	159	23%
North West	Oldham	Signif. low at 99.0%	400	282	550	529	-129	-24%
North West	Salford	Not signif.	657	502	843	551	107	19%
North West	Sefton	Not signif.	733	583	909	675	59	9%
North West	Stockport	Not signif.	541	415	690	607	-66	-11%
North West	Tameside & Glossop	Signif. low at 99.0%	426	304	578	553	-127	-23%
North West	Trafford	Not signif.	616	462	802	578	37	6%
North West	Warrington	Not signif.	553	402	740	564	-10	-2%
North West	Western Cheshire	Not signif.	723	567	908	643	80	12%
North West	Wirral	Not signif.	727	587	889	649	78	12%
South Central	**Overall**	Not signif.	**537**	**502**	**574**	**564**	**-27**	**-5%**
South Central	Berkshire East	Signif. high at 99.8%	640	521	777	497	143	29%
South Central	Berkshire West	Not signif.	480	386	590	511	-31	-6%
South Central	Buckinghamshire	Not signif.	630	525	748	571	59	10%
South Central	Hampshire	Not signif.	572	508	642	630	-57	-9%
South Central	Isle Of Wight	Not signif.	700	500	951	767	-67	-9%
South Central	Milton Keynes	Not signif.	374	262	516	440	-66	-15%
South Central	Oxfordshire	Not signif.	491	408	586	552	-61	-11%
South Central	Portsmouth City	Signif. low at 99.8%	333	220	480	518	-185	-36%
South Central	Southampton City	Not signif.	465	341	616	499	-34	-7%
SE Coast	**Overall**	Signif. high at 99.0%	**668**	**630**	**708**	**631**	**37**	**6%**
SE Coast	Brighton & Hove	Not signif.	591	454	755	527	64	12%
SE Coast	E Sussex Downs & Weald	Signif. high at 99.8%	928	772	1,105	746	182	24%
SE Coast	Eastern & Coastal Kent	Not signif.	683	591	785	649	34	5%

Significance:
- Signif. low at 99.8%
- Signif. low at 99.0%
- Not signif.
- Signif. high at 99.8 =%
- Signif. high at 99.0%

Observed and predicted rates per million population of aortic valve replacement by Strategic Health Authority and Primary Care Trust; financial years 2004-2007; **significance at the 99.8% level**

			Observed			Predicted		
			Rate	LCL	UCL	Rate	Variance	
SE Coast...	Hastings & Rother	Not signif.	832	633	1,071	760	72	9%
SE Coast...	Medway	Not signif.	461	343	605	518	-57	-11%
SE Coast...	Surrey	Not signif.	594	524	671	598	-4	-1%
SE Coast...	West Kent	Signif. high at 99.8%	702	605	809	593	109	18%
SE Coast...	West Sussex	Not signif.	679	591	776	690	-11	-2%
South West	**Overall**	Not signif.	**679**	**644**	**715**	**665**	**14**	**2%**
South West	Bath & Ne Somerset	Signif. low at 99.8%	453	315	628	614	-162	-26%
South West	Bournemouth & Poole	Signif. low at 99.8%	390	291	511	687	-297	-43%
South West	Bristol	Not signif.	506	406	623	502	5	1%
South West	Cornwall & Isle Of Scilly	Signif. high at 99.8%	930	805	1,068	722	208	29%
South West	Devon	Signif. high at 99.8%	969	859	1,087	729	240	33%
South West	Dorset	Signif. low at 99.8%	575	462	706	810	-234	-29%
South West	Gloucestershire	Not signif.	590	496	695	639	-49	-8%
South West	North Somerset	Not signif.	746	570	955	682	63	9%
South West	Plymouth	Signif. high at 99.0%	727	571	910	584	143	24%
South West	Somerset	Not signif.	735	623	860	704	31	4%
South West	South Gloucs	Not signif.	508	378	667	569	-61	-11%
South West	Swindon	Not signif.	549	397	736	531	18	3%
South West	Torbay	Not signif.	658	466	901	761	-102	-13%
South West	Wiltshire	Not signif.	613	503	739	640	-27	-4%
West Midlands	**Overall**	Signif. low at 99.8%	**540**	**510**	**572**	**594**	**-54**	**-9%**
West Midlands	Birmingham E & N	Signif. low at 99.8%	404	312	512	562	-158	-28%
West Midlands	Coventry	Not signif.	471	362	602	540	-69	-13%
West Midlands	Dudley	Not signif.	557	434	703	631	-74	-12%
West Midlands	Heart of Birmingham	Signif. low at 99.8%	252	169	358	381	-129	-34%
West Midlands	Herefordshire	Not signif.	648	476	859	721	-73	-10%
West Midlands	North Staffordshire	Not signif.	658	496	853	648	10	1%
West Midlands	Sandwell	Signif. low at 99.0%	469	356	604	584	-115	-20%
West Midlands	Shropshire County	Not signif.	571	442	724	694	-123	-18%
West Midlands	Solihull	Not signif.	551	404	730	627	-76	-12%
West Midlands	South Birmingham	Not signif.	473	367	599	531	-58	-11%
West Midlands	South Staffordshire	Not signif.	553	462	655	609	-56	-9%
West Midlands	Stoke-On-Trent	Not signif.	565	431	725	596	-31	-5%
West Midlands	Telford & Wrekin	Not signif.	509	353	708	526	-17	-3%
West Midlands	Walsall	Not signif.	617	474	786	595	22	4%
West Midlands	Warwickshire	Not signif.	582	483	694	620	-38	-6%
West Midlands	Wolverhampton City	Not signif.	748	587	938	600	149	25%
West Midlands	Worcestershire	Signif. low at 99.8%	622	523	734	639	-17	-3%

Significance
- Signif. low at 99.8%
- Signif. low at 99.0%
- Not signif.
- Signif. high at 99.8 =%
- Signif. high at 99.0%

Observed and predicted rates per million population of aortic valve replacement by Strategic Health Authority and Primary Care Trust; financial years 2004-2007; **significance at the 99.8% level**

			Observed			Predicted		
			Rate	LCL	UCL	Rate	Variance	
Yorkshire & Humber	**Overall**	Signif. low at 99.8%	**516**	**485**	**547**	**585**	**-69**	**-12%**
	Barnsley	Not signif.	573	431	744	597	-24	-4%
	Bradford & Airedale	Signif. low at 99.8%	306	235	391	511	-204	-40%
	Calderdale	Signif. low at 99.0%	422	294	585	565	-143	-25%
	Doncaster	Not signif.	567	441	717	612	-45	-7%
	E Riding Of Yorkshire	Signif. high at 99.0%	842	689	1,018	694	148	21%
	Hull	Not signif.	520	396	667	544	-25	-5%
	Kirklees	Signif. low at 99.8%	380	291	487	543	-162	-30%
	Leeds	Signif. low at 99.8%	397	330	473	532	-135	-25%
	N Yorkshire & York	Not signif.	678	590	776	661	18	3%
	North East Lincs	Not signif.	475	326	666	614	-139	-23%
	North Lincs	Not signif.	621	445	840	639	-18	-3%
	Rotherham	Not signif.	636	490	810	595	41	7%
	Sheffield	Not signif.	536	443	642	568	-32	-6%
	Wakefield	Signif. low at 99.8%	400	301	519	585	-185	-32%

Significance
- Signif. low at 99.8%
- Signif. low at 99.0%
- Not signif.
- Signif. high at 99.8 =%
- Signif. high at 99.0%

Missing data

Cases in which the PCT code data are not recorded; all cardiac surgical centres in England; financial years 2004-2007

		PCT data			
		Coded	Blank	**All**	Percent missing
Hospital	Barts & the London	1,470	2	**1,472**	0.1%
	Bristol Royal Infirmary	1,315	0	**1,315**	0.0%
	Castle Hill Hospital, Hull	618	1	**619**	0.2%
	Derriford Hospital, Plymouth	1,203	8	**1,211**	0.7%
	Essex Cardiothoracic Centre, Basildon	0	19	**19**	100.0%
	Freeeman Hospital, Newcastle	980	1	**981**	0.1%
	Glenfield Hospital, Leicester	1,321	0	**1,321**	0.0%
	Guy's & St Thomas's Hospital, London	1,514	14	**1,528**	0.9%
	Hammersmith Hospital, London [i]	301	33	**334**	9.9%
	Harefield Hospital, Middlesex	777	0	**777**	0.0%
	James Cook University Hospital, Middlesbrough	971	1	**972**	0.1%
	John Radcliffe Hospital, Oxford	980	1	**981**	0.1%
	King's College Hospital, London	634	4	**638**	0.6%
	Leeds General Infirmary	966	6	**972**	0.6%
	Liverpool Heart & Chest Hospital [ii]	1,639	5	**1,644**	0.3%
	Manchester Heart Centre [ii]	936	0	**936**	0.0%
	N Staffordshire Royal Infirmary, Stoke-on-Trent	663	10	**673**	1.5%
	New Cross Hospital, Wolverhampton	601	1	**602**	0.2%
	Northern General Hospital, Sheffield	1,005	0	**1,005**	0.0%
	Nottingham City Hospital	657	0	**657**	0.0%
	Papworth Hospital, Cambridge	2,145	1	**2,146**	0.0%
	Queen Elizabeth Hospital, Birmingham	999	0	**999**	0.0%
	Royal Brompton Hospital, London	1,080	1	**1,081**	0.1%
	Royal Sussex County Hospital, Brighton	823	1	**824**	0.1%
	Southampton General Hospital	1,077	0	**1,077**	0.0%
	St George's Hospital, London	907	30	**937**	3.2%
	St Mary's Hospital, London [iii]	146	19	**165**	11.5%
	The Heart Hospital, London	1,046	0	**1,046**	0.0%
	Victoria Hospital Blackpool	892	5	**897**	0.6%
	Walsgrave Hospital, Coventry	618	1	**619**	0.2%
	Wythenshawe Hospital, Manchester	958	0	**958**	0.0%
	All	**29,477**	**163**	**29,640**	**0.5%**

i Missing data 2007

ii Probably represents Welsh patients

iii Missing data 2004 & 2005

Outcomes at the Prince of Wales Hospital at the Chinese University of Hong Kong

An example of international benchmarking against the SCTS national standard

Key findings

Patients undergoing cardiac surgery in the Prince of Wales Hospital (PoWH), Hong Kong are different from those in the United Kingdom with a smaller proportion of patients undergoing coronary artery bypass surgery, but more patients undergoing isolated valve surgery.

Patients undergoing isolated coronary artery bypass surgery in Hong Kong are younger and more likely to have diabetes than those in the United Kingdom. They are less likely to have impaired left ventricular ejection fraction or to undergo non-elective surgery. However, the overall predicted mortality of these patients (using the logistic ***EuroSCORE***) is similar.

The mortality for all cardiac surgery at the Prince of Wales Hospital was 15 out of 743 patients (2.1%; a further 17 patients did not have their post-operative status recorded), which was lower than, but not significantly different from the United Kingdom mortality of 3.4%. The mortality for isolated CABG was 4 of 404 patients (1.0%; another single CABG entry had no post-operative status data), which again is not significantly different from the United Kingdom mortality. These similarities remain after adjusting for predicted operative risk.

These analyses suggest that cardiac surgical outcomes at the Prince of Wales Hospital are similar to those in the United Kingdom and should provide reassurance to patients, clinicians, managers and commissioners of cardiac surgery in Hong Kong.

Introduction

The Cardiac Surgery unit at the Prince of Wales Hospital at the Chinese University of Hong Kong started a quality assurance program in November 2005. The aims were to collect data to optimise local quality improvement and provide information about clinical quality compared to other organisations, both nationally and internationally. The unit now collects high-quality, validated data *via* a computerised database. The dataset is identical with that of the SCTS in Great Britain and Ireland.

There have been two annual reports about cardiac surgery at the Prince of Wales Hospital, which are available at www.surgery.cuhk,edu.hk/cardiothoracic/default.htm. We recognise that there will be many organisations across the world that will be collecting data on their cardiac surgical programs, but few countries have a national cardiac surgery audit program and fewer still have complete coverage from all units and surgeons. To understand the quality of care and perform true *audit* it is necessary to compare outcome and processes against an accepted standard. Here we have compared cardiac surgery outcomes at the Prince of Wales Hospital with those in the SCTS national database.

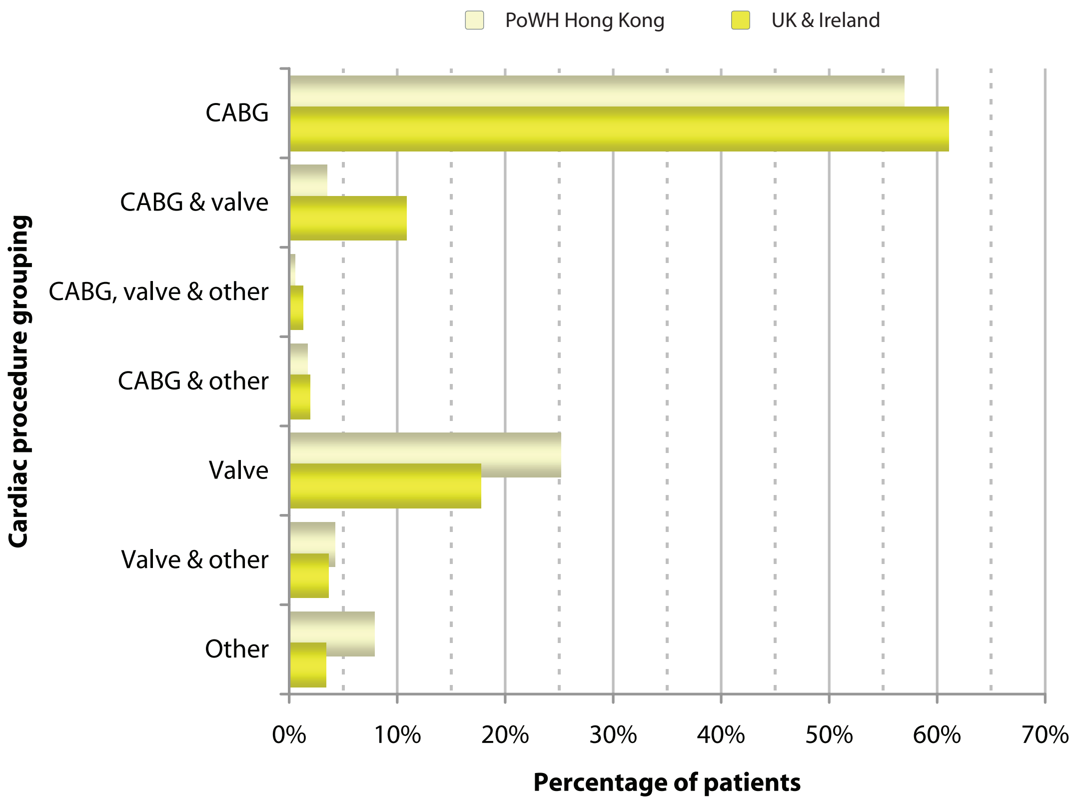
Comparison of casemix

Patients undergoing surgery in Hong Kong are different from those in the United Kingdom and Ireland. There is a higher proportion of isolated valve disease and a smaller proportion of coronary artery bypass surgery (affecting both the proportion of isolated CABG and combined valve & CABG surgery). There is also a markedly higher proportion of *other* surgery undertaken in Hong Kong.

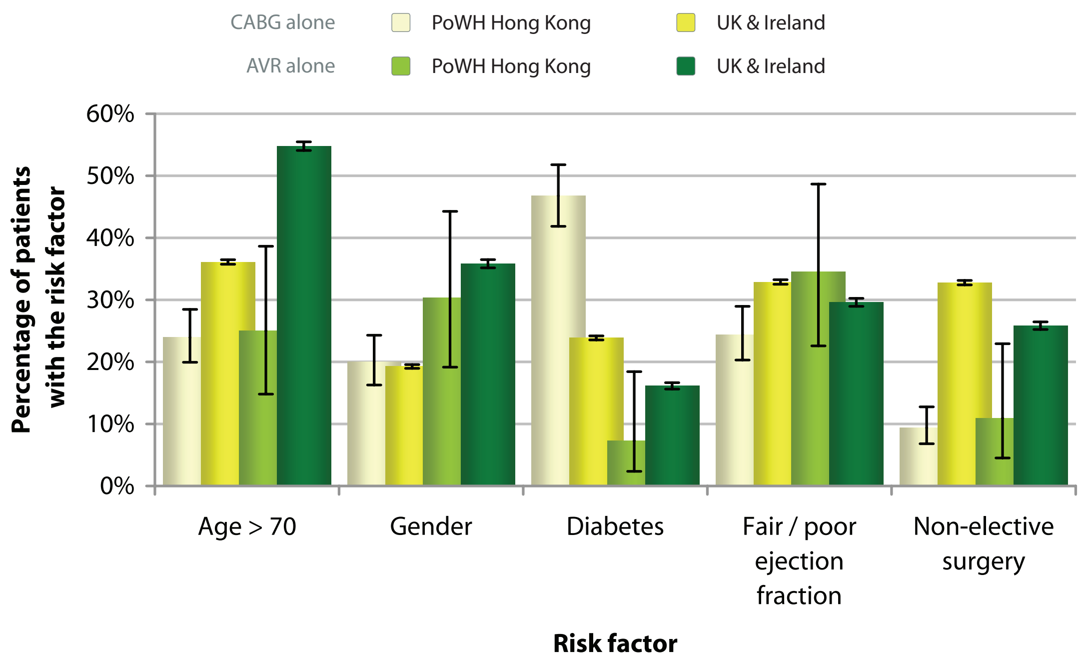
Comparison of risk factors

As well as undertaking different types of surgery, the incidence of risk factors within different operative groups is different in Hong Kong; patients undergoing coronary artery bypass surgery are likely to be younger, more likely to have diabetes and less likely to have impaired left ventricular function or to undergo non-elective surgery.

A comparison of casemix in Hong Kong and the UK & Ireland financial years 2006-2008 (n=726 & n=111,397 respectively)



A comparison of risk factors in Hong Kong and the UK & Ireland; financial years 2006-2008



Mortality

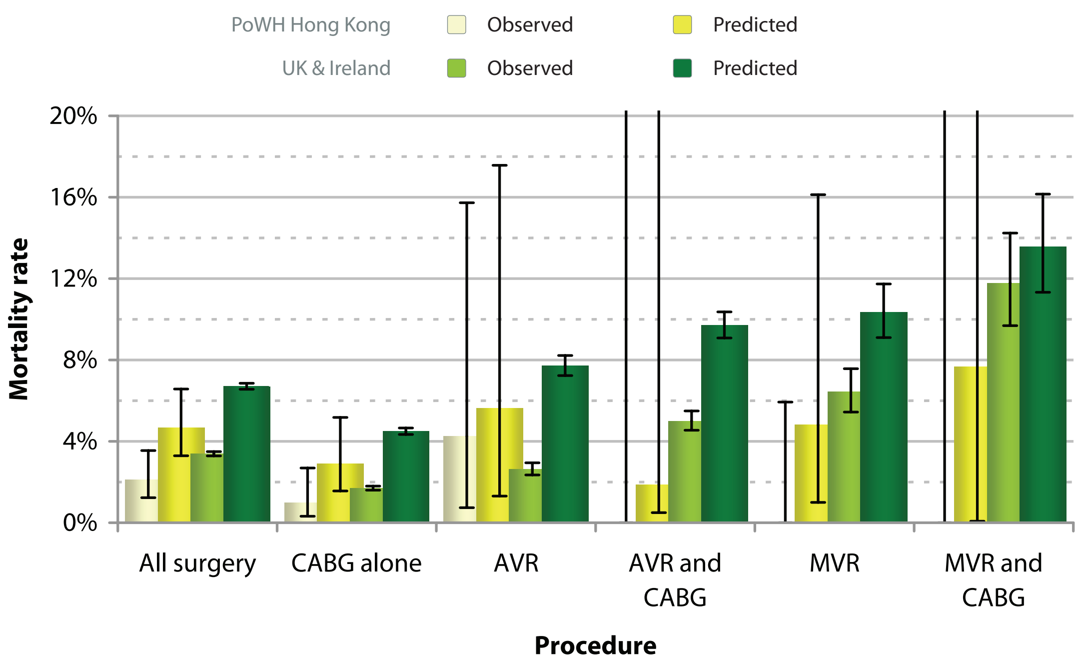
There are no significant differences in either observed or predicted (according to the logistic ***EuroSCORE***) mortality between practice in Hong Kong and that in Great Britain and Ireland, for any operative group.

Mortality and procedure for the financial years 2006-2008

		Mortality data					
		Hong Kong			United Kingdom		
		Count	Observed rate	Predicted rate [i]	Count	Observed rate	Predicted rate [i]
Procedure group	CABG alone	404	1.0%	2.9%	65,396	1.7%	4.5.%
	AVR	47	4.3%	5.6%	11,439	2.6%	7.7%
	AVR and CABG	8	0.0%	1.9%	8,381	5.0%	9.7%
	MVR	49	0.0%	4.8%	2,132	6.4%	10.3%
	MVR and CABG	5	0.0%	7.7%	815	11.8%	13.6%
	All surgery	**709**	**2.1%**	**4.7%**	**110,987**	**3.4%**	**6.7%**

i Predicted as per the logistic ***EuroSCORE***

A comparison of observed and predicted procedure-specific mortality rates in Hong Kong and the UK & Ireland; financial years 2006-2008

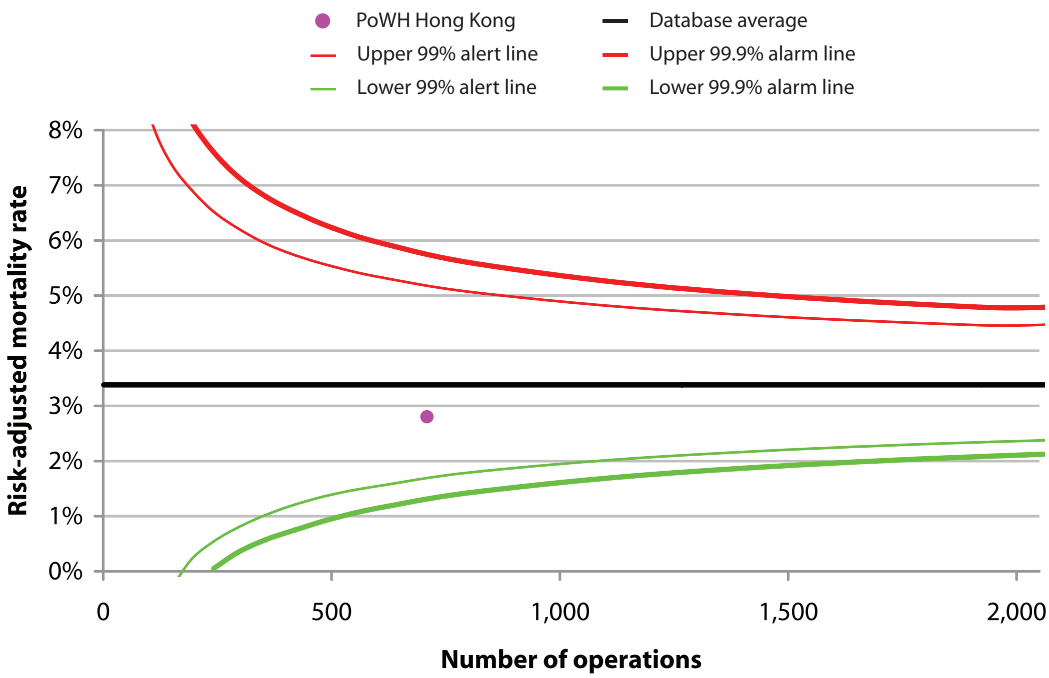


Funnel plots

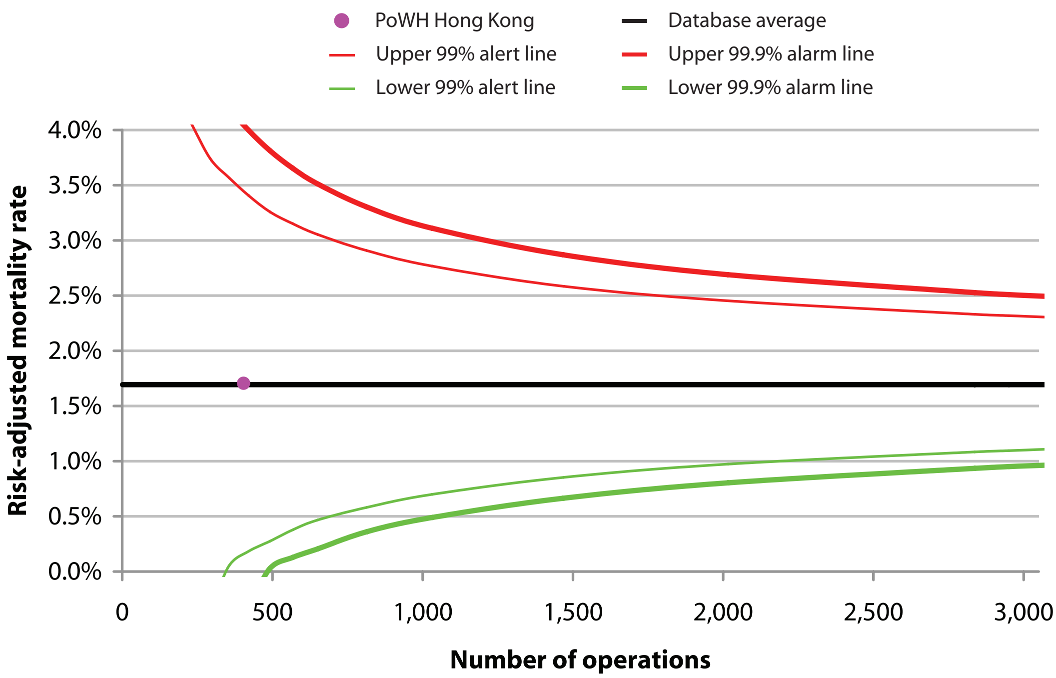
We have benchmarked outcomes for all surgery, isolated CABG and isolated AVR surgery against the contemporary re-calibrated logistic ***EuroSCORE***, as described in elsewhere in these appendices. For simplicity we have simply used 0.5 of the logistic ***EuroSCORE*** for the *all surgery* comparison. We have used the exact calibration factors of 0.44 and 0.34 respectively for isolated AVR surgery and isolated CABG.

Outcomes at the Prince of Wales Hospital fall comfortably within the control limits for all operative groups, showing satisfactory quality.

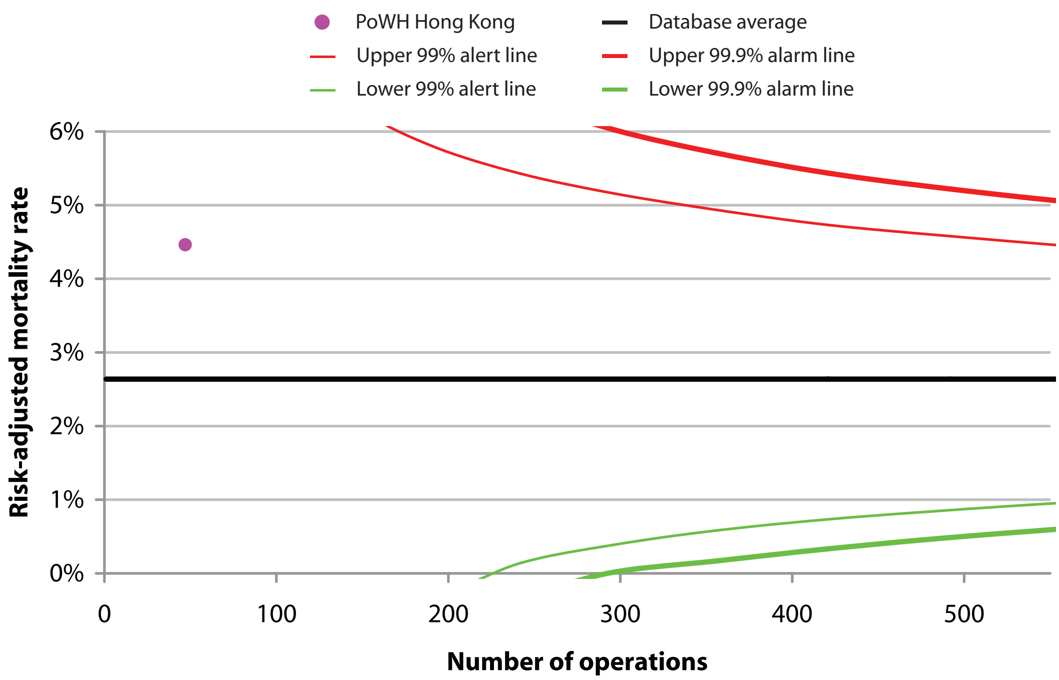
All operations: Risk-adjusted funnel plot on mortality by hospital; risk defined as 50% logistic *EuroSCORE*; financial years 2006-2008



Isolated CABG: Risk-adjusted funnel plot on mortality by hospital; risk defined as 34% logistic *EuroSCORE*; financial years 2006-2008



Isolated AVR: Risk-adjusted funnel plot on mortality by hospital; risk defined as 44% logistic *EuroSCORE*; financial years 2006-2008



Other post-operative outcomes

In general the other post-operative outcomes seen at the Prince of Wales Hospital are excellent, with a lower incidence of all complications than in the remainder of the SCTS database.

Other post-operative outcomes; the upper numbers represent the crude percentage mortality rate and the lower numbers the count within the sub-group ; financial years 2006-2008

		Outcome					
		Re-operation for bleeding		New post-operative stroke		New post-operative HF / dialysis	
		PoWH HK	UK & I	PoWH HK	UK & I	PoWH HK	UK & I
Operation group	CABG alone	1.5% 402	3.3% 56,057	1.0% 396	1.1% 57,632	0.3% 400	2.6% 56,683
	AVR alone	0.0% 47	5.5% 9,683	2.1% 47	1.7% 10,234	0.0% 47	3.1% 9,970
	AVR & CABG	0.0% 8	6.9% 7,101	0.0% 8	2.7% 7,405	0.0% 8	5.8% 7,187
	MV repair alone	0.0% 9	3.8% 1,905	0.0% 9	1.3% 1,942	0.0% 9	2.1% 1,866
	MVR repair & CABG	33.3% 3	6.0% 1,141	0.0% 2	2.5% 1,190	0.0% 3	9.0% 1,135
	MVR alone	4.2% 48	5.3% 1,786	0.0% 46	2.8% 1,875	0.0% 49	6.5% 1,827
	MVR & CABG	0.0% 5	8.5% 692	20.0% 5	3.7% 721	0.0% 5	12.2% 711
	All	**1.9%** **700**	**4.7%** **94,636**	**1.5%** **688**	**1.7%** **97,170**	**0.4%** **690**	**3.9%** **95,153**

Summary

This analysis describes a methodology that will enable any organisation or group of organisations, in the world to compare their outcomes against a comprehensive national dataset derived from complete coverage of all operations in NHS hospitals in the United Kingdom. There are systematic differences in case-mix between the Prince of Wales Hospital in Hong Kong and the pooled United Kingdom data, but in terms of both crude and risk-adjusted mortality the outcomes are in line with United Kingdom standards, as are the complication rates. These data should provide reassurance for patients, clinicians, managers and commissioners of services at the Prince of Wales Hospital that the cardiac surgery programme is safe, and that the unit is actively looking to monitor and improve its standards.

Malcolm Underwood and Ben Bridgewater

The EACTS Guideline for resuscitation in cardiac arrest after cardiac surgery

Joel Dunning on behalf of the clinical guidelines committee of EACTS

James Cook University Hospital, Middlesbrough, United Kingdom

Every year, over 250,000 patients have cardiac surgery in some 450 centres in Europe. The incidence of cardiac arrest after cardiac surgery is around 0.7% to 2.9% and has reduced in recent years. The most remarkable statistic regarding these patients is the relatively good outcome with 17%-79% of patients suffering a cardiac arrest surviving to hospital discharge, a far higher proportion than can be hoped for when cardiac arrest occurs in other settings. The reason for this superior survival is the high incidence of reversible causes for the arrest. Ventricular fibrillation (VF) accounts for the rhythm in 25-50% of cases and, in the intensive care unit (ICU) setting, this is immediately identified and treated. In addition, tamponade and major bleeding account for many arrests and both conditions may be quickly relieved by prompt resuscitation and emergency resternotomy where appropriate.

Because many patients may potentially be saved by prompt treatment, ICU staff must be well-versed in managing cardiac arrests. Practising protocol-based arrest management has been shown to halve the time to chest re-opening and reduce complications in the conduct of the resternotomy after cardiac surgery.

Historically, there have been two major issues in the resuscitation of patients who arrest after cardiac surgery. Firstly, the 2005 European Resuscitation Council guidelines did not provide a comprehensive protocol tailored to our particular needs and therefore issues remained unanswered such as the conduct of emergency resternotomy, pacing and ventilator issues. Also there were anomalies such as recommending 1 mg of adrenaline in non-VF / VT immediately on identification of arrest, and a single DC shock followed by 2 minutes of external cardiac massage prior to checking for success if a patient went into VF. Secondly our survey of 349 surgeons internationally found that only 32% followed these guidelines & 25% had never read the guidelines for resuscitation that applied to their patients. In addition only 7% of cardiac intensive care units regularly practise for their greatest emergency.

The European Association for Cardio-Thoracic Surgery has undertaken a project to provide a view on resuscitation in cardiac arrest after cardiac surgery by using a multi-modal methodology for evidence generation including the extrapolation of existing guidelines from the International Liaison Committee On Resuscitation (ILCOR) where possible, structured literature reviews on issues particular to cardiac surgery published in the Interactive Journal of Cardiovascular and Thoracic Surgery (ICVTS), an international survey on resuscitation hosted by CTSNet and manikin simulations of potential protocols. This has been published in the European Journal of Cardiothoracic Surgery and is now the recommended protocol for resuscitation of all patients who arrest after cardiac surgery in an intensive care unit environment across Europe [i]. This guideline has addressed many issues, but at the heart of the protocol is the realisation that rapid resternotomy, once simple reversible causes for the arrest have been excluded, is the key to achieving the best outcome for the patient. A good outcome can only be achieved if the arrest is managed as a multi-practitioner activity and EACTS have defined several key roles that should be allocated and their functions should be practised regularly. A summary of the algorithm is given opposite.

Some of the additional recommendations are as follows:

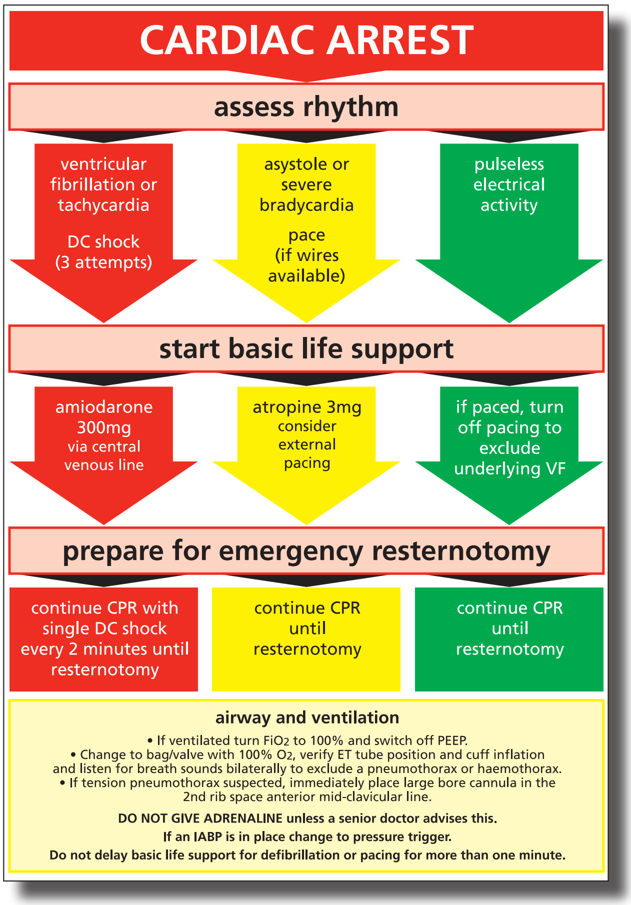
1. A delay to external cardiac massage for up to 1 minute for defibrillation in VF or to maximise pacing for asystole or extreme bradycardia, to avoid unnecessary massage in these potentially reversible situations.
2. Oxygen should be turned to 100% and the PEEP turned off, the ventilator disconnected and a bag / valve used. ET tube patency and position should be checked and a stethoscope should be used to look for a tension pneumothorax.
3. 1 mg of adrenaline should not be given during the arrest, and adrenaline should only be given by senior clinicians.
4. In VF, three sequential attempts should be made to cardiovert the patient. If this fails amiodarone should be given and resternotomy performed.
5. In asystole or extreme bradycardia, if pacing and atropine fail to return spontaneous output, then resternotomy should be performed.
6. In established pulseless electrical activity, any pacing should be turned off to exclude underlying VF but if there is no pneumothorax then resternotomy should be performed immediately.

7. Two people should be donning a gown and gloves preparing for resternotomy as soon as the arrest is identified and not waiting for the call to perform the resternotomy.
8. Units should have a tailor-made emergency resternotomy set containing only 5 pieces of equipment: a scalpel, a heavy needle holder, a wire cutter, a retractor and suction. In addition a single windowed *all-in-one* drape should be used. Betadine to the chest is unnecessary and washing hands prior to donning gown and gloves is not required.

This protocol has been developed in conjunction with the Cardiothoracic Advanced Life Support course (www.csu-als.com). The EACTS protocol was developed after many iterations and has been shown to halve the time to emergency resternotomy and to greatly increase staff confidence and knowledge. A specifically manufactured emergency resternotomy manikin containing a sternotomy incision, 6 wires for removal and a heart / lungs is now available to assist training.

This protocol is published by the Clinical Guidelines committee of EACTS and it is endorsed as the preferred method for conducting an arrest in a patient who suffer cardiac arrest in United Kingdom cardiac intensive care units by the Society for Cardiothoracic Surgery in Great Britain and Ireland.

Further details from: joeldunning@doctors.org.uk



i Dunning J, Fabbri A, Kolh P, Levine A, Lockowandt U, Mackay J, Pavie A, Strang T, Versteegh M, Nashef SA. On behalf of the EACTS clinical guidelines committee. European Journal of Cardiothoracic Surgery, 2009, In Press.

Predictive scoring systems

The *EuroSCORE*

The ***EuroSCORE*** is a system that generates a pre-operative prediction of mortality risk for cardiac surgery patients. It was assembled using data provided by a large number of hospitals from across Europe, employing logistic regression techniques; it is, therefore, particularly pertinent to the European cardiac surgery patient and the European cardio-thoracic surgeon. The table shows the risk factors used and their weightings as defined in the additive ***EuroSCORE***; the appropriate scores are simply added together to give a patient-specific approximation of the risk of death following cardiac surgery.

	Factor	Definition	Score
Patient-related factors	Age	Per 5 years or part thereof over 60 years	1
	Gender	Female	1
	Chronic pulmonary disease	Long term use of bronchodilators or steroids for lung disease	1
	Extra-cardiac arteriopathy	Any one or more of the following: claudication, carotid occlusion or >50% stenosis, previous or planned intervention on the abdominal aorta, limb arteries or carotids	2
	Neurological dysfunction	Severely affecting ambulation or day-to-day functioning	2
	Previous cardiac surgery	Requiring opening of the pericardium	3
	Serum creatinine	>200 µmol l^{-1} pre-operatively	2
	Active endocarditis	Patient still under antibiotic treatment for endocarditis at the time of surgery	3
	Critical pre-operative state	Any one or more of the following: ventricular tachycardia or fibrillation or aborted sudden death, pre-operative cardiac massage, pre-operative ventilation before arrival in the anaesthetic room, pre-operative inotropic support, intra-aortic balloon counterpulsation or pre-operative acute renal failure (anuria or oliguria <10 ml hr^{-1})	3
Cardiac-related factors	Unstable angina	Rest angina requiring iv nitrates until arrival in the anaesthetic room	2
	LV dysfunction	Moderate or LVEF 30-50%	1
		Poor or LVEF <30	3
	Recent myocardial infarction	Within 90 days of surgery	2
	Pulmonary hypertension	Systolic PA pressure>60 mmHg	2
Operation-related factors	Emergency	Carried out on referral before the beginning of the next working day	2
	Other than isolated CABG	Major cardiac procedure other than or in addition to CABG	2
	Surgery on the thoracic aorta	For disorder of the ascending, arch or descending aorta	3
	Post-infarct septal rupture		4

Another version, the logistic ***EuroSCORE***, is detailed on the ***EuroSCORE*** website: www.euroscore.org. This model uses the same suite of risk factors, but assigns quite different weightings to each factor, and the final risk prediction is derived from these weightings using a more complex formula:

$$\text{Logistic } \textbf{\textit{EuroSCORE}} \text{ predicted mortality} = \frac{e^{(\beta_o + \sum b_i X_i)}}{1 + e^{(\beta_o + \sum b_i X_i)}}$$

where:

e — is the base for natural logarithms and is approximately 2.7182 …

β_o — is the constant of the logistic regression equation: -4.789594

β_i — is the coefficient of the variable X_i in the logistic regression equation provided in the table below.

X_i — is set to 1 if a categorical risk factor is present and 0 if it is absent. For the age risk factor, $X_i = 1$ if patient age <60 year old and X_i increases by one point per year thereafter: for age 59 year or less $X_i = 1$, age 60 $X_i = 2$, age 61 $X_i = 3$, and so on.

There is some evidence that this logistic model can provide slightly more accurate results, especially for the high-risk patient.

Datasets

The SCTS National Adult Cardiac Surgical Database

Society for Cardiothoracic Surgery in Great Britain and Ireland
National Adult Cardiac Surgical Database
Version 3.8; page 1

Patient identification & demographics

Local patient identifier		Date of birth	dd / mm / yyyy
NHS number		Date & time of operation	dd / mm / yyyy hh:mm
Patient name (surname)		Postcode of usual address	
Patient name (forename)		Patient gender	O 1. Male O 2. Female

Admission details

Admission date	dd / mm / yyyy	Administrative category	O 1. NHS O 2. Private

Angina status pre-surgery
- O 0. No angina
- O 1. No limitation of physical activity
- O 2. Slight limitation of ordinary activity
- O 3. Marked limitation of ordinary physical activity
- O 4. Symptoms at rest or minimal activity

Dyspnoea status pre-surgery
- O 1. No limitation of physical activity
- O 2. Slight limitation of ordinary activity
- O 3. Marked limitation of ordinary physical activity
- O 4. Symptoms at rest or minimal activity

Number of previous MIs
- O 0. None
- O 1. One
- O 2. Two or more
- O 9. Unknown

Interval between surgery and last MI
- O 0. No previous MI
- O 1. MI <6 hours
- O 2. MI 6-24 hours
- O 3. MI 1-7 days
- O 4. MI 8-21 days
- O 5. MI 22-90 days
- O 6. MI >90 days

Previous interventions

Previous PCI
- O 0. No previous PCI
- O 1. PCI <24 hours before surgery
- O 2. PCI >24 hours before surgery; same admission
- O 3. PCI >24 hours before surgery; previous admission

Date of last PCI dd / mm / yyyy

Previous cardiac, vascular or thoracic surgical interventions
- O 0. No previous surgery
- ☐ 1. CABG
- ☐ 2. Valve
- ☐ 3. Congenital cardiac
- ☐ 4. Other cardiac
- ☐ 5. Aortic - ascending or arch
- ☐ 6. Aortic - descending or abdominal
- ☐ 7. Other thoracic
- ☐ 8. Carotid endarterectomy
- ☐ 9. Other peripheral vascular

Date of last cardiac operation dd / mm / yyyy

Risk factors for the acquisition of coronary disease

Diabetes management
- O 0. Not diabetic
- O 1. Diet
- O 2. Oral therapy
- O 3. Insulin

Cigarette smoking history
- O 0. Never smoked
- O 1. Ex-smoker
- O 2. Current smoker

History of hypertension
- O 0. No hypertension
- O 1. Treated or BP >140 / 90 >1 occasion prior to admission
- O 9. Unknown

This form is designed so that questions requiring a single response-option are identified with round radio-buttons next to the options, whereas questions where more than one response option may be selected are identified by square tick boxes next to the options

Society for Cardiothoracic Surgery in Great Britain and Ireland
National Adult Cardiac Surgical Database
Version 3.8; page 2

Local patient identifier ☐☐☐☐☐☐☐☐☐☐ Date of operation dd / mm / yyyy

Additional medical history and risk factors

Renal disease at the time of surgery
- ○ 0. No renal disease
- ○ 1. Functioning transplant
- ○ 2. Creatinine >200 μmol l^{-1}
- ○ 3. Dialysis: acute renal failure; onset within 6 weeks of cardiac surgery
- ○ 4. Dialysis: chronic renal failure; more than 6 weeks prior to cardiac surgery
- ○ 9. Unknown

History of pulmonary disease
- ○ 0. No pulmonary disease
- ○ 1. COAD / emphysema
- ○ 2. Asthma

History of neurological disease
- ○ 0. No history of neurological disease
- ☐ 1. TIA or RIND
- ☐ 2. CVA with full recovery
- ☐ 3. CVA with residual deficit

Neurological dysfunction ○ 0. No ○ 1. Yes

Extra-cardiac arteriopathy ○ 0. No ○ 1. Yes

Carotid bruits ○ 0. No ○ 1. Yes

Pre-operative heart rhythm
- ○ 0. Sinus rhythm
- ○ 1. Atrial fibrillation / flutter
- ○ 2. Complete heart block / pacing
- ○ 3. VF or VT
- ○ 4. Other abnormal rhythm

Cardiac investigations

Left- or right-heart catheterisation
- ○ 0. Never
- ☐ 1. This admission
- ☐ 2. Previous admission

Date of last catheterisation dd / mm / yyyy

Extent of coronary vessel disease
- ○ 0. No vessel with >50% diameter stenosis
- ○ 1. One vessel with >50% diameter stenosis
- ○ 2. Two vessels with >50% diameter stenosis
- ○ 3. Three vessels with >50% diameter stenosis
- ○ 9. Not investigated

Left main stem disease
- ○ 0. No LMS disease or LMS disease <50% diameter stenosis
- ○ 1. LMS disease >50% diameter stenosis
- ○ 9. Not investigated

PA systolic mmHg; value if known **LVEDP** mmHg; value if known

Aortic valve gradient mmHg; value if known **Mean PAWP / LA pressure** mmHg; value if known

Ejection fraction category
- ○ 1. Good (≥50%)
- ○ 2. Fair (30-49%)
- ○ 3. Poor (<30%)
- ○ 9 Not measured

Ejection fraction value value if known

Pre-operative status and support

Intravenous nitrates or any heparin
- ○ 0. No
- ○ 1. Until operation
- ○ 2. Within one week of operation

Cardiogenic shock pre-op ○ 0. No ○ 1. Yes

iv inotropes prior to anaesthesia ○ 0. No ○ 1. Yes

Ventilated pre-operatively ○ 0. No ○ 1. Yes

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Society for Cardiothoracic Surgery in Great Britain and Ireland
National Adult Cardiac Surgical Database

Version 3.8; page 3

Local patient identifier		Date of operation	dd / mm / yyyy

Operation

Operative urgency
- ○ 1. Elective
- ○ 2. Urgent
- ○ 3. Emergency
- ○ 4. Salvage

Previous heart operations — number

Responsible consultant surgeon — GMC number

Responsible consultant anaesthetist — GMC number

First operator — GMC number

First operator grade
- ○ 1. Consultant
- ○ 2. Staff grade / Clinical assistant
- ○ 3. SpR
- ○ 5. SHO
- ○ 6. Associate specialist
- ○ 9. Other

First operator - Calman year of trainee
- ○ 8. Not applicable
- ○ 1. Year 1
- ○ 2. Year 2
- ○ 3. Year 3
- ○ 4. Year 4
- ○ 5. Year 5
- ○ 6. Year 6

First assistant — GMC number

First assistant grade
- ○ 1. Consultant
- ○ 2. Staff grade / Clinical assistant
- ○ 3. SpR
- ○ 5. SHO
- ○ 6. Associate specialist
- ○ 7. Surgeon's assistant
- ○ 9. Other

First assistant - Calman year of trainee
- ○ 8. Not applicable
- ○ 1. Year 1
- ○ 2. Year 2
- ○ 3. Year 3
- ○ 4. Year 4
- ○ 5. Year 5
- ○ 6. Year 6

Procedures classified by group

Cardiac procedures
- ○ 1. CABG alone
- ○ 2. CABG & valve
- ○ 3. CABG, valve & other
- ○ 4. CABG & other
- ○ 5. Valve alone
- ○ 6. Valve & other
- ○ 8. Other

Other cardiac procedures
- ○ 0. No other cardiac procedures
- ☐ 1. LV aneurysmectomy
- ☐ 2. Acquired VSD
- ☐ 3. Atrial myxoma
- ☐ 4. Pulmonary embolectomy
- ☐ 5. Cardiac transplant
- ☐ 6. Pulmonary transplant
- ☐ 7. Cardiac trauma
- ☐ 8. Epicardial pacemaker
- ☐ 9. Pericardiectomy
- ☐ 10. ASD closure
- ☐ 11. Other (for congenital condition)
- ☐ 19. Other (not listed above)

Other non-cardiac procedures
- ○ 0. No vascular / thoracic procedures
- ☐ 1. Aorta or peripheral vascular
- ☐ 2. Carotid endarterectomy
- ☐ 3. Other thoracic

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Society for Cardiothoracic Surgery in Great Britain and Ireland
National Adult Cardiac Surgical Database
Version 3.8; page 4

Local patient identifier | | Date of operation | dd / mm / yyyy

Graft procedure data

Number of DCAs[i] | number

	Graft 1	Graft 2	Graft 3	Graft 4	Graft 5	Graft 6	
Graft site	code	code	code	code	code	code	see below for codes
Graft conduit	code	code	code	code	code	code	see below for codes
Anastomosis	code	code	code	code	code	code	see below for codes

CABG: Graft sites
- 1 → 1. Prox RCA
- 2 → 2. Mid RCA
- 3 → 3. Distal RCA
- 4 → 4. RCA-PDA
- 5 → 5. RCA-LV
- 6 → 6. LMS
- 7 → 7. Prox LAD
- 8 → 8. Mid LAD
- 9 → 9. Distal LAD
- 10 → 10. Diag 1
- 11 → 11. Diag 2
- 12 → 12. Prox Cx
- 13 → 13. Int
- 14 → 14. OM1
- 15 → 15. OM2
- 16 → 16. Distal Cx
- 15 → 17. Cx-PDA

CABG: Graft conduits
- 1 → 1. Pedicle LIMA
- 2 → 2. Pedicle RIMA
- 3 → 3. Pedicle RGEA
- 4 → 4. Free LIMA
- 5 → 5. Free RIMA
- 6 → 6. Free RGEA
- 7 → 7. Radial artery
- 8 → 8. Long SV
- 9 → 9. Short SV
- 10 → 10. Cephalic vein
- 11 → 11. Other artery
- 12 → 12. Othe

CABG: Graft anastomosis
- 2 → 2. End-to-side
- 3 → 3. Side-to-side

Aorta procedure data

Number of aorta segments operated on | number

	Root	Ascending	Arch	Descending	Abdominal	
Aortic pathology	code	code	code	code	code	see below for codes
Aortic procedure	code	code	code	code	code	see below for codes

Aorta: Pathology
- 1 → 1. Aneurysm
- 2 → 2. Syphilis
- 3 → 3. Dissection
- 4 → 4. Transection
- 5 → 5. Coarctation
- 6 → 6. Atheromatous
- 7 → 7. Marfans
- 9 → 9. Mycotic
- 10 → 10. Other connective tissue disorder
- 11 → 11. Congenital
- 12 → 12. Infection - native
- 13 → 13. Infection - graft
- 99 → 99. Unknown

Aorta: procedure
- 1 → 1. Interposition tube graft
- 2 → 2. Tube graft plus separate AVR
- 3 → 3. Root replacement with composite valve graft & coronary reimplantation
- 4 → 4. Root replacement with preservation of native valve & coronary reimplantation
- 5 → 5. Homograft root replacement
- 6 → 6. Autograft root replacement (Ross procedure)
- 7 → 7. Aortic patch graft
- 8 → 8. Sinus of valsalva repair
- 9 → 9. Reduction aortoplasty

i. Distal coronary anastomosis

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Appendices

Society for Cardiothoracic Surgery in Great Britain and Ireland
National Adult Cardiac Surgical Database
Version 3.8; page 5

Local patient identifier | | Date of operation | dd / mm / yyyy

Valve procedure data

Number of valves replaced / repaired: number

	Aortic valve	Mitral valve	Tricuspid valve	Pulmonary valve
Haemodynamic pathology	1. Stenosis 2. Regurgitation 3. Mixed	1. Stenosis 2. Regurgitation 3. Mixed	1. Stenosis 2. Regurgitation 3. Mixed	1. Stenosis 2. Regurgitation 3. Mixed
Explant type	1. Native valve 2. Mechanical 3. Biological 4. Homograft 5. Autograft 6. Ring	1. Native valve 2. Mechanical 3. Biological 4. Homograft 5. Autograft 6. Ring	1. Native valve 2. Mechanical 3. Biological 4. Homograft 5. Autograft 6. Ring	1. Native valve 2. Mechanical 3. Biological 4. Homograft 5. Autograft 6. Ring
Native valve pathology	code	code	code	code
Other native valve pathology	enter as text	enter as text	enter as text	enter as text
Reason for repeat valve replacement	1. Thrombosis 2. Dehiscence 3. Embolism 4. Infection 5. Intrinsic valve failure 6. Haemolysis 19. Other reason	1. Thrombosis 2. Dehiscence 3. Embolism 4. Infection 5. Intrinsic valve failure 6. Haemolysis 19. Other reason	1. Thrombosis 2. Dehiscence 3. Embolism 4. Infection 5. Intrinsic valve failure 6. Haemolysis 19. Other reason	1. Thrombosis 2. Dehiscence 3. Embolism 4. Infection 5. Intrinsic valve failure 6. Haemolysis 19. Other reason
Other reason for repeat valve replacement	enter as text	enter as text	enter as text	enter as text
Valve procedure	1. Replacement 2. Repair	1. Replacement 2. Repair	1. Replacement 2. Repair	1. Replacement 2. Repair
Implant type	2. Mechanical 3. Biological 4. Homograft 5. Autograft	2. Mechanical 3. Biological 4. Homograft 5. Annuloplasty ring	2. Mechanical 3. Biological 4. Homograft 5. Annuloplasty ring	2. Mechanical 3. Biological 4. Homograft 5. Autograft
Implant prosthesis name	HVR prosthesis name	HVR prosthesis name	HVR prosthesis name	HVR prosthesis name
Valve prosthesis model				
Valve serial number				
Valve size	mm	mm	mm	mm

Native valve pathology

1 → 1. Congenital
2 → 2. Degenerative
3 → 3. Active infection endocarditis
4 → 4. Previous infective endocarditis
5 → 5. Rheumatic
6 → 6. Annuloaortic ectasia
7 → 7. Calcific degeneration
8 → 8. Ischaemic
9 → 9. Functional regurgitation
19 → 19. Other native valve pathology

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Society for Cardiothoracic Surgery in Great Britain and Ireland
National Adult Cardiac Surgical Database
Version 3.8; page 6

Local patient identifier		Date of operation	dd / mm / yyyy

Perfusion & myocardial protection

Cardiopulmonary bypass	○ 0. No	○ 1. Yes	
Predominant method of myocardial protection	○ 0. Non-cardioplegic	○ 1. Cardioplegia	
Cardioplegia - solution	○ 8. Not applicable	○ 1. Blood	○ 2. Crystalloid
Cardioplegia - temperature	○ 8. Not applicable	☐ 1. Cold	☐ 2. Warm
Cardioplegia - infusion mode	○ 8. Not applicable	☐ 1. Antegrade	☐ 2. Retrograde
Cardioplegia - timing	○ 8. Not applicable	○ 1. Intermittent	○ 2. Continuous
Non-cardioplegic myocardial protection	○ 8. Not applicable ○ 1. Aortic cross-clamping with fibrillation ○ 2. Fibrillation with perfusion ○ 3. Cross-clamp with direct coronary perfusion ○ 4. Cross-clamp and beating heart ○ 5. Beating heart without cross-clamp		
Intra-aortic balloon pump used	○ 0. Not used ☐ 1. Pre-operatively	☐ 2. Intra-operatively ☐ 3. Post-operatively	
Reason for IABP use	○ 0. Not used ○ 1. Haemodynamic instability ○ 2. Unstable angina ○ 3. CPB wean ○ 4. Prophylactic		
Height	cm	**Weight**	kg
Cumulative bypass time	min	**Cumulative cross-clamp time**	min
Total circulatory arrest time	min		

Post-operative course

Re-operation	○ 0. No re-operation required ☐ 1. Re-operation for bleeding or tamponade ☐ 2. Re-operation for valvular problems ☐ 3. Re-operation for graft problems ☐ 4. Re-operation for other cardiac problems ☐ 5. Sternum resuturing (sterile) ☐ 6. Surgery for deep sternal wound problem	
New post-operative stroke	○ 0. None ○ 1. Transient stroke	○ 2. Permanent stroke
New haemofiltration or dialysis	○ 0. No	○ 1. Yes
Discharge destination from cardiothoracic ward	○ 4. Not applicable - patient deceased ○ 1. Home	○ 2. Convalescence ○ 3. Other hospital
Patient status at discharge	○ 0. Alive	○ 1. Dead
Date of discharge / death	dd / mm / yyyy	

This form is designed so that questions requiring a single response-option are identified with round radio-buttons next to the options, whereas questions where more than one response option may be selected are identified by square tick boxes next to the options

SCTS / BCIS dataset for TAVI

BCIS

The British Cardiovascular Intervention Society & The Society for Cardiothoracic Surgery in Great Britain & Ireland
Transcatheter aortic valve dataset
Version 3.5; page 1

Patient identification & demographics

Local patient identifier		Date of birth	dd / mm / yyyy
NHS number		Date & time of operation	dd / mm / yyyy hh:mm
Patient name (surname)		Postcode of usual address	
Patient name (forename)		Patient gender	1. Male; 2. Female

Ethnic origin	1. Caucasian 2. Black	3. Asian 4. Oriental	8. Other 9. Unknown

MDT meeting

MDT meeting	0. No 1. Yes	9. Unknown
Date of MDT meeting	dd / mm / yyyy	
MDT decision	0. Conservative [1] 1. Transcatheter aortic valve implant'n	2. Surgical valve operation
Primary reason for TAVI	0. Formally turned down for surgery 1. Assessed as high risk for surgery	2. Patient refused surgery

Medical history and risk factors for coronary disease

Diabetes	0. Not diabetic 1. Diabetes (dietry control) 2. Diabetes (oral medicine)	3. Diabetes (insulin) 4. Newly-diagnosed diabetes 9. Unknown
Smoking status	0. Never smoked 1. Ex smoker	2. Current smoker 9. Unknown
Creatinine	mmol l^{-1}	
Renal function	0. Native renal function 1. Functioning renal transplant 2. Acute renal failure: dialysis	3. Chronic renal failure: dialysis 9. Unknown
Previous MI and interval between procedure and last MI	0. No previous MI 1. MI <6 hours 2. MI 6-24 hours	3. MI 1-30 days 4. MI 31-90 days 5. MI >90 days
History of pulmonary disease	0. No pulmonary disease 1. COAD / emphysema	2. Asthma 9. Unknown
History of neurological disease	0. No history of neurological disease 1. TIA or RIND 2. CVA with full recovery	3. CVA with residual deficit 4. Other history of neuro'l dysfunction 9. Unknown
Extra-cardiac arteriopathy	0. No 1. Yes	9. Unknown

1 Continued medical therapy

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BCIS

The British Cardiovascular Intervention Society &
The Society for Cardiothoracic Surgery in Great Britain & Ireland
Transcatheter aortic valve dataset
Version 3.5; page 2

Local patient identifier ________ Date of operation dd / mm / yyyy

Medical history and risk factors for coronary disease …

Extensive calcification of the ascending aorta
- ○ 0. No
- ○ 1. Yes
- ○ 9. Unknown

Pre-operative heart rhythm
- ○ 0. Sinus rhythm
- ☐ 1. Atrial fibrillation / flutter
- ☐ 2. First degree heart block
- ☐ 3. RBBB
- ☐ 4. LBBB
- ☐ 5. Complete heart block
- ☐ 6. Paced rhythm
- ☐ 7. VF / VT
- ☐ 8. Other abnormal rhythm
- ☐ 9. Other abnormal conduction
- ☐ 10. Unknown

Previous interventions

Previous cardiac surgery
- ○ 0. No
- ☐ 1. Previous CABG
- ☐ 2. Previous valve operation
- ☐ 3. Other operation [2]
- ☐ 9. Unknown

Previous aortic valve percutaneous procedure
- ○ 0. No
- ○ 1. Yes: aortic valvuloplasty, but **not** as part of a staged procedure
- ○ 2. Yes: staged aortic valvuloplasty as part of this procedure
- ○ 3. Yes: previous TAVI
- ○ 9. Unknown

Previous PCI
- ○ 0. No
- ○ 1. Yes, but **not** as part of a hybrid
- ○ 2. Yes, as part of a hybrid
- ○ 9. Unknown

Pre-procedure clinical status

Height ______ m

Weight ______ kg

Critical pre-operative status
- ○ 0. No
- ☐ 1. Unstable angina [3]
- ☐ 2. VT or VF [4]
- ☐ 3. Acute renal failure [5]
- ☐ 4. Ventilated
- ☐ 5. Cardiogenic shock [6]
- ☐ 6. IV inotropes

CCS angina status
pre-procedure; stable only
- ○ 0. No angina
- ○ 1. No limitation of physical activity
- ○ 2. Slight limitation of ordinary physical activity
- ○ 3. Marked limitation of ordinary physical activity
- ○ 4. Symptoms at rest or minimal activity
- ○ 9. Unknown

2 Requiring opening of the pericardium
3 On IV therapy at the time of the procedure
4 Ventricular tachycardia or ventricular fibrillation within this clinical episode in hospital prior to TAVI
5 Immediately prior to TAVI
6 Immediately pre-procedure

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BCIS

The British Cardiovascular Intervention Society &
The Society for Cardiothoracic Surgery in Great Britain & Ireland

Transcatheter aortic valve dataset

Version 3.5; page 3

Local patient identifier | Date of operation dd / mm / yyyy

Pre-procedure clinical status …

NYHA dyspnoea status
pre-procedure; stable only
- O 1. No limitation of physical activity
- O 2. Slight limitation of ordinary physical activity
- O 3. Marked limitation of ordinary physical activity
- O 4. Symptoms at rest or minimal activity
- O 9. Unknown

Admission date for procedure [7] dd / mm / yyyy

Results of cardiac investigations

PA systolic >60 mm Hg
- O 0. No
- O 1. Yes
- O 8. Not measured
- O 9. Unknown

Aortic valve peak gradient mm Hg

Aortic valve area cm^2

Aortic annular diameter mm

Aortic annular measurement method
- O 0. TTE
- O 1. TOE
- O 2. Angiographic
- O 3. CT
- O 4. MRI
- O 5. Other
- O 9. Unknown

Aortic valve pathology
- ☐ 1. Stenosis
- ☐ 2. Regurgitation
- ☐ 9. Unknown

Aortic valve aetiology
- O 0. Congenital
- O 1. Degenerative
- O 2. Rheumatic
- O 3. Bioprosthetic
- O 4. Previous infective endocarditis
- O 5. Other
- O 9. Unknown

LV function
- O 1. Good (≥50% diameter stenosis)
- O 2. Fair (30-49% diameter stenosis)
- O 3. Poor (<30% diameter stenosis)
- O 8. Not measured
- O 9. Unknown

Extent of coronary vessel disease [8]
- O 0. No vessels
- O 1. One vessel
- O 2. Two vessels
- O 3. Three vessels
- O 9. Not investigated

Left main stem disease
- O 0. No LMS disease or LMS disease ≤50% diameter stenosis
- O 1. LMS >50% diameter stenosis
- O 9. Not known

7 First hospital in the chain if one exists
8 Vessels with >50% diameter stenosis

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The British Cardiovascular Intervention Society &
The Society for Cardiothoracic Surgery in Great Britain & Ireland
Transcatheter aortic valve dataset
Version 3.5; page 4

Local patient identifier | Date of operation dd / mm / yyyy

Procedure data

Date & time of operation	dd / mm / yyyy hh:mm	
Surgeon operators	Initial. Surname	
Cardiology operators	Initial. Surname	
Proctored case	O 0. No O 1. Yes	O 9. Unknown
Per-procedural imaging	O 0. None O 1. TTE	O 2. TOE O 3. Other
Procedure urgency	O 1. Elective O 2. Urgent	O 3. Emergency O 4. Salvage
Anaesthesia	O 0. None O 1. Sedation	O 2. Regional O 3. General
Aortic balloon valvuloplasty	O 0. Not done O 1. Completed	O 2. Failed
Diameter of largest balloon	mm	
Delivery approach	O 1. Femoral - percutaneous O 2. Femoral - surgical O 3. Axillary	O 4. Subclavian O 5. Transapical O 6. Other
Sheath size	Fr	
Circulatory support	O 0. No O 1. Yes - elective	O 2. Yes - emergency O 9. Unknown
Valve manufacturer		
Valve model		
Valve serial number		
Valve size	mm	
Device failure	O 0. No failure O 1. Probably iatrogenic	O 2. Probably intrinsic O 9. Unknown
Vascular closure technique	O 0. Manual pressure O 1. Surgical closure	O 2. Device closure

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BCIS

The British Cardiovascular Intervention Society &
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Transcatheter aortic valve dataset
Version 3.5; page 5

Local patient identifier ______ Date of operation dd / mm / yyyy

Immediate procedural outcomes and complications (in the catheter laboratory)

Valve successfully deployed	0. No 1. Yes	9. Unknown
Aortic regurgitation by echo	0. None 1. Mild 2. Moderate	3. Severe 9. Unknown
Aortic regurgitation by angio	0. None 1. 1 2. 2	3. 3 4. 4 9. Unknown
Death	0. No 1. Yes	9. Unknown
Myocardial infarction [9]	0. No 1. Yes	9. Unknown
Tamponade	0. No 1. Yes - requiring surgical intervention	2. Yes - requiring percutaneous int'n
Major vascular injury	0. No 1. Yes	9. Unknown
Major apical cannulation complications	0. No 1. Yes	9. Unknown
Bailout PCI	0. No 1. Yes	9. Unknown
New conduction abnormality requiring pacing	0. No 1. Yes	9. Unknown
Conversion to valve surgery	0. No 1. Yes	9. Unknown
CVA	0. No 1. Yes	9. Unknown
Emergency valve in valve	0. No 1. Yes	9. Unknown
Cardiogenic shock	0. No 1. Yes	9. Unknown
Device emobilsation	0. No 1. Yes	9. Unknown

9 Intended to record clinical myocardial infarction, not simply peri-procedural cardiac marker release. For the purpoes of this audit we will use the Universal Definition of MI type 5 (that used to diagnose MI at the time of CABG).

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The British Cardiovascular Intervention Society & The Society for Cardiothoracic Surgery in Great Britain & Ireland

Transcatheter aortic valve dataset

Version 3.5; page 6

Local patient identifier | Date of operation dd / mm / yyyy

Post-procedural complications (after leaving the cath. laboratory; up to discharge)

Death	0. No 1. Yes	9. Unknown
Myocardial infarction [9]	0. No 1. Yes	9. Unknown
CVA	0. No 1. Yes	9. Unknown
TIA / RIND	0. No 1. Yes	9. Unknown
Valve in valve implant	0. No 1. Yes	9. Unknown
Surgical AVR	0. No 1. Yes	9. Unknown
Permanent pacing	0. No 1. Yes - pre-procedure therapeutic [10] 2. Yes - pre-procedure prophylactic	3. Yes - per-procedure 4. Yes - post-procedure 9. Unknown
Device migration	0. No 1. Yes	9. Unknown
GI haemorrhage	0. No 1. Yes	9. Unknown
Tamponade	0. No 1. Yes	9. Unknown
Platelet transfusion	0. No 1. Yes	9. Unknown
Blood transfusion	0. No 1. Yes	9. Unknown
New haemofiltration / dialysis post-operatively	0. No 1. Yes	9. Unknown
Late vascular complications requiring surgery	0. No 1. Yes	9. Unknown
Infective endocarditis	0. No 1. Yes	9. Unknown

9 Intended to record clinical myocardial infarction, not simply peri-procedural cardiac marker release. For the purpoes of this audit we will use the Universal Definition of MI type 5 (that used to diagnose MI at the time of CABG).

10 Including distant past.

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BCIS

The British Cardiovascular Intervention Society &
The Society for Cardiothoracic Surgery in Great Britain & Ireland

Transcatheter aortic valve dataset

Version 3.5; page 7

Local patient identifier | Date of operation dd / mm / yyyy

Discharge

Date of discharge / death	dd / mm / yyyy
Discharge destination from cardiothoracic ward	○ 1. Home ○ 2. Convalescence ○ 3. Other hospital ○ 4. Not applicable - patient deceased

One-year follow up

Life status	○ 1. Alive ○ 2. Dead ○ 9. Unknown
CCS angina status *if alive*	○ 0. No angina ○ 1. No limitation of physical activity ○ 2. Slight limitation of ordinary physical activity ○ 3. Marked limitation of ordinary physical activity ○ 4. Symptoms at rest or minimal activity ○ 9. Unknown
NYHA dyspnoea status *if alive*	○ 1. No limitation of physical activity ○ 2. Slight limitation of ordinary physical activity ○ 3. Marked limitation of ordinary physical activity ○ 4. Symptoms at rest or minimal activity ○ 9. Unknown

Two-year follow up

Life status	○ 1. Alive ○ 2. Dead ○ 9. Unknown
CCS angina status *if alive*	○ 0. No angina ○ 1. No limitation of physical activity ○ 2. Slight limitation of ordinary physical activity ○ 3. Marked limitation of ordinary physical activity ○ 4. Symptoms at rest or minimal activity ○ 9. Unknown
NYHA dyspnoea status *if alive*	○ 1. No limitation of physical activity ○ 2. Slight limitation of ordinary physical activity ○ 3. Marked limitation of ordinary physical activity ○ 4. Symptoms at rest or minimal activity ○ 9. Unknown

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SCTS eLogBook

The Society for Cardiothoracic Surgery in Great Britain and Ireland
eLogbook
Version 1.0; page 1

Patient identification & demographics

Local patient identifier		Date of birth	dd / mm / yyyy
NHS number		Date & time of operation	dd / mm / yyyy hh:mm
Patient name (surname)		Hospital identifier	
Patient name (forename)		Patient gender	O 1. Male O 2. Female

Operation data

Operative urgency	O 1. Elective O 2. Urgent	O 3. Emergency O 4. Salvage
Number of previous heart ops		
Responsible consultant surgeon		GMC number
First operator		GMC number
First operator grade	O 1. Consultant O 2. Staff grade / clinical assistant O 3. SpR	O 4. SHO O 5. Associate specialist O 9. Other
First operator Calman year of trainee	O 1. Year 1 O 2. Year 2 O 3. Year 3	O 4. Year 4 O 5. Year 5 O 6. Year 6 O 8. Not applicable
First assistant		GMC number
First assistant grade	O 1. Consultant O 2. Staff grade / clinical assistant O 3. SpR	O 4. SHO O 5. Associate specialist O 9. Other
First assistant Calman year of trainee	O 1. Year 1 O 2. Year 2 O 3. Year 3	O 4. Year 4 O 5. Year 5 O 6. Year 6 O 8. Not applicable

Risk score

Parsonnet score	
Additive *EuroSCORE*	
Logistic *EuroSCORE*	

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The Society for Cardiothoracic Surgery in Great Britain and Ireland
eLogbook
Version 1.0; page 2

Local patient identifier [ ] Date of operation dd / mm / yyyy

Procedure

Cardiac procedures

- ○ 1. CABG alone
- ○ 2. CABG and valve
- ○ 3. CABG, valve and other
- ○ 4. CABG and other
- ○ 5. Valve alone
- ○ 6. Valve and other
- ○ 8. Other

Other cardiac procedures

- ○ 0. No other cardiac procedures
- ☐ 1. LV anerysmectomy
- ☐ 2. Acquired VSD
- ☐ 3. Atrial myxoma
- ☐ 4. Pulmonary embolectomy
- ☐ 5. Cardiac transplant
- ☐ 6. Pulmonary transplant
- ☐ 7. Cardiac trauma
- ☐ 8. Epicardial pacemaker
- ☐ 9. Pericardiectomy
- ☐ 10. ASD closure
- ☐ 11. Other (for congenital condition)
- ☐ 19. Other (not listed above)

Other thoracic and vascular procedures

- ○ 0. No thoracic & vascular procedures
- ☐ 1. Aortic or peripheral vascular
- ☐ 2. Carotid endarterectomy
- ☐ 3. Other thoracic

Graft procedure data

Number of grafts [ ]

	Graft 1	Graft 2	Graft 3	Graft 4	Graft 5
Graft site					
Graft conduit					
Graft anastamosis					

Graft site

1. Prox RCA
2. Mid RCA
3. Distal RCA
4. RCA-PDA
5. RCA-LV
6. LMS
7. Prox LAD
8. Mid LAD
9. Distal LAD
10. Diag 1
11. Diag 2
12. Prox circumflex
13. Intermediate
14. OM1
15. OM2
16. Distal circumflex
17. Circumflex-PDA

Graft conduit

1. Pedicle LIMA
2. Pedicle RIMA
3. Pedicle RGEA
4. Free LIMA
5. Free RIMA
6. Free RGEA
7. Radial artery
8. Long saphenous vein
9. Short saphenous vein
10. Cephalic vein
11. Other artery
12. Other

Graft anastomosis

2. End to side
3. Side to side

Conduit harvest - enter the trainee's GMC number

LIMA		**Radial artery**	
RIMA		**Cephalic vein**	
Long saphenous vein		**RGEA**	
Short saphenous vein		**Other**	

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The Society for Cardiothoracic Surgery in Great Britain and Ireland

eLogbook

Version 1.0; page 3

Local patient identifier | Date of operation dd / mm / yyyy

Valve procedure data

Number of valves

Enter the trainee's GMC number

Aortic valve	Mitral valve
Aortotomy	Bi-caval cannulation
Decalcification of annulus	Access to mitral valve
Excision of valve	Assessment and repair
Implantation of valve	Excision of valve [1]
Closure of aortotomy	Repair of valve
De-airing of heart	Ring
	Implantation of valve
	Atrial closure
	De-airing of heart

Preparation for bypass

Sternotomy	Weaning
Thoracotomy	Sternal closure
Cannulation	Thoracotomoy closure

Post-operative complications

Re-operation
- ○ 0. None necessary
- ☐ 1. For bleeding or tamponade
- ☐ 2. For valvular problems
- ☐ 3. For graft problems
- ☐ 4. For other cardiac problems
- ☐ 5. Sternal resuturing (sterile)
- ☐ 6. Surgery for deep wound problem

New post-operative stroke
- ○ 0. None
- ○ 1. Transient
- ○ 2. Permanent

New post-operative haemofiltration / dialysis
- ○ 0. No
- ○ 1. Yes

Patient status at discharge
- ○ 0. Alive
- ○ 1. Dead

1 And annular debridement

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Atrial fibrillation surgery dataset

The European Association for Cardio-Thoracic Surgery
International atrial fibrillation database form
Page 1; Version 1.0

Demographics and other identifiers

Unique patient-identifier	
Date of birth	dd / mm / yyyy
Gender	○ Male ○ Female ○ Unknown

Atrial fibrillation history

Type of atrial fibrillation	○ Paroxysmal (self-terminating episodes) ○ Persistent (with episodes that require any intervention to cardiovert) ○ Permanent (established rhythm of at least one month's duration)
Duration of atrial fibrillation	○ Less than 1 year ○ 1-5 years ○ 6-10 years ○ More than 10 years
Etiology	☐ Lone atrial fibrillation ☐ Rheumatic ☐ Ischaemic ☐ Dilated ☐ Degenerative ☐ Congenital ☐ Other
Details of other etiology	
Atrial fibrillation therapy	☐ Digoxin ☐ Beta-blockers ☐ Cardioversion ☐ Calcium antagonist ☐ Anti-platelets ☐ Anti-coagulants ☐ Amiodarone ☐ Prev. percutaneous ablation ☐ Pacemaker ☐ Flecainde ☐ Other
Details of other atrial fibrillation therapy	
Size of left atrium [i]	mm
Previous thrombo-embolic event	○ No ○ Yes

Primary disease

Primary disease	☐ Mitral ☐ Aortic ☐ Tricuspid ☐ Lone atrial fibrillation ☐ Coronary ☐ Other
Details of other primary disease	

Surgery information

Date of procedure	dd / mm / yyyy
Access	○ Minimal access ○ Sternotomy
Aortic cross-clamp time	min
Cardiopulmonary bypass time	min [ii]

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i. Using TEE maximum transverse diameter.
ii. Enter 0 if off-pump

The European Association for Cardio-Thoracic Surgery
International atrial fibrillation database form
Page 2; Version 1.0

Unique patient-identifier		
Date of procedure	dd / mm / yyyy	
	Atrial fibrillation procedure details	
Type of atrial fibrillation surgery	O Incisions with a knife (e.g., Maze operation) O Ablation procedure (heating or cooling technologies)	
Incisional lesion set	O Right-sided lines only O Left-sided lines only	O Maze III O Other
Details of other incisional lesion set		
Type of surgical ablation	☐ Dry uni-polar RF ☐ Irrigated uni-polar RF ☐ Dry bi-polar RF ☐ Irrigated uni-polar RF ☐ Microwave	☐ Cryo ☐ Laser ☐ Ultrasound ☐ Bi-polar thermocautery ☐ Other
Details of other surgical ablation		
Dry uni-polar RF instrument used	O Thermaline [iii]	O Cobra [iii]
Irrigated uni-polar RF instrument used	O Isolator [iv] O Isolator long [iv]	O Cobra bi-polor [iii]
Dry bi-polar RF instrument used	O Isolator [iv] O Isolator long [iv]	O Cobra bi-polor [iii] O Isthmus
Irrigated bi-polar RF instrument used	O Cardioblate bi-polar [v]	
Type of microwave antenna used	O Flex 2 [iii] O Flex 4 [iii]	O Flex 10 [iii]
Cryo-ablation instrument used	O Surgifrost [vi]	O Nitrous oxide
Type of laser instrument used	O Optimaze 5cm	O Optiwave 980 [viii]
Ultrasound system used	O Epicore Ultracinch [vii]	O Epicore Ultrawand [vii]

iii. Boston Scientific
iv. Atricure
v. Medtronic; BP device
vi. Cryocath
vii. St. Jude
viii. Edwards Lifesciences

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The European Association for Cardio-Thoracic Surgery
International atrial fibrillation database form
Page 3; Version 1.0

Unique patient-identifier	
Date of procedure	dd / mm / yyyy

Left atrial lesions

Bi-lateral exclusion of PV	○ None ☐ Epicardial	☐ Endocardial
PV isolation (box lesion)	○ None ☐ Epicardial	☐ Endocardial
Connection bi-lateral exclusion of PV	○ None ☐ Epicardial	☐ Endocardial
Connection LPV to LA appendage	○ None ☐ Epicardial	☐ Endocardial
Connection of LPV to mitral annulus	○ None ☐ Epicardial	☐ Endocardial
Connection of RPV to mitral annulus	○ None ☐ Epicardial	☐ Endocardial
Appendage to MV annulus	○ None ☐ Epicardial	☐ Endocardial
LA appendage (excision or closure)	○ None ☐ Epicardial	☐ Endocardial
Other left atrial connection	○ None ☐ Epicardial	☐ Endocardial
Details of other left atrial connection		

Right atrial lesions

Right-sided Maze III	○ No	○ Yes
Posterior IVC to SVC connection	○ None ☐ Epicardial	☐ Endocardial
Anterior IVC to SVC connection	○ None ☐ Epicardial	☐ Endocardial
Isthmus (IVC to tricuspid annulus)	○ No	○ Yes
Other right atrial connection	○ None ☐ Epicardial	☐ Endocardial
Details of other right atrial connection		

Other type of surgical ablation

Other type of surgical ablation	

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The European Association for Cardio-Thoracic Surgery
International atrial fibrillation database form
Page 4; Version 1.0

Unique patient-identifier	
Date of procedure	dd / mm / yyyy

Concomitant surgery

Mitral valve operation	○ Repair ○ Mechanical prosthetic replacement ○ Biological prosthetic replacement	
Aortic valve operation	○ Repair ○ Mechanical prosthetic replacement ○ Biological prosthetic replacement	
Tricuspid valve operation	○ Repair ○ Mechanical prosthetic replacement ○ Biological prosthetic replacement	
Coronary artery bypass	☐ Arterial	☐ Venous
Number of arterial grafts		
Number of venous grafts		
Other disease description		

Operative status leaving the operating theatre

Ablation-related complication(s)	○ No	○ Yes
Details of ablation-related complication(s)		
Heart rhythm	○ Normal sinus ☐ Sick sinus ☐ Atrial ☐ Nodal ☐ Atrial fibrillation	☐ Atrial flutter ☐ Asystole ☐ Heart block ☐ Other
Details of other heart rhythm		
Degree of heart block	○ First degree ○ Second degree	○ Third degree
Heart rate	○ Normal (60-80 bpm) ○ Tachycardic (>80 bpm) ○ Bradycardic (<60 bpm)	○ Paced AV ○ Paced atrially
Atrial fibrillation therapy post-ablation	☐ Digoxin ☐ Beta-blockers ☐ Cardioversion ☐ Amiodarone ☐ Calcium antagonists	☐ Anti-platelets ☐ Anti-coagulants ☐ Flecainide ☐ Other
Details of other AF therapy post-ablation		

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The European Association for Cardio-Thoracic Surgery
International atrial fibrillation database form
Page 5; Version 1.0

Unique patient-identifier	
Date of procedure	dd / mm / yyyy

Discharge details

Date of discharge	dd / mm / yyyy	
Post-ablation complications	○ No	○ Yes
Details of post-ablation complications		
Heart rhythm at discharge	○ Normal sinus ☐ Sick sinus ☐ Atrial ☐ Nodal ☐ Atrial fibrillation	 ☐ Atrial flutter ☐ Asystole ☐ Heart block ☐ Other
Details of heart rhythm at discharge		
Heart rhythm was based on	○ 12-lead ECG ○ 24-hour tape	 ○ Other
Details of other rhythm determination		
Patient heart rate	○ Normal (60-80 bpm) ○ Tachycardic (>80 bpm)	 ○ Bradycardic (<60 bpm)
Atrial transport function	○ No ○ Normal	○ Abnormal ○ Unknown
Status at discharge	○ Alive ○ Cardiac death	○ Non-cardiac death ○ Unrelated death

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The European Association for Cardio-Thoracic Surgery
International atrial fibrillation database form
Page 6; Version 1.0

Unique patient-identifier		
Date of follow up	dd / mm / yyyy	
	Follow up details	
Complications	○ No	○ Yes ○ Unknown
Details of complications		
Heart rhythm at follow up	○ Normal sinus ☐ Sick sinus ☐ Atrial ☐ Nodal ☐ Atrial fibrillation	☐ Atrial flutter ☐ Pacing ☐ Asystole ☐ Heart block ☐ Other
Details of heart rhythm at follow up		
Was rhythm based on ECG	○ Surface ECG ○ Intra-cavitary recordings	○ Other
Atrial transport function	○ None ○ Normal	○ Abnormal ○ Not measured
Atrial fibrillation therapy	○ None ○ Digoxin ○ Beta-blockers	○ Cardioversion ○ Amiodarone ○ Prev percutaneous ablation ○ Other
Details of other atrial fibrillation therapy		
Heart rate	○ Normal (60-80 bpm) ○ Tachycardic (>80 bpm)	○ Bradycardic (<60 bpm)
Additional drug therapy	○ None ☐ Anti-coagulants ☐ Anti-platelets	☐ Calcium antagonists ☐ Other
Details of other additional drug therapy		
Status at discharge	○ Alive ○ Cardiac death	○ Non-cardiac death ○ Unrelated death ○ Lost to follow up

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Notes

The bright light of transparency: demonstrating quality in cardiac surgery

Over recent years in the United Kingdom there have been a number of high-profile cases where patient safety has been compromised. These failures have led to important inquiries, which have produced a series of reports and recommendations. Cardiac surgery has been at the centre of some of these events and the Society for Cardiothoracic Surgery in Great Britain and Ireland has responded by driving a number of initiatives to improve both outcomes of care for patients and quality assurance processes. This book analyses and demonstrates the current quality of contemporary adult cardiac surgery in Great Britain and Ireland. It is based on an analysis of over 400,000 patient-records collected since 1994. The book subjects the specialty of cardiac surgery to an unrivalled degree of scrutiny and demonstrates a culture that is determined to put patients and their outcomes at the centre of healthcare delivery.

Previous similar analyses have studied mortality as a primary measure of quality, but this report has been developed to include a comprehensive spectrum of measures that demonstrate patient-safety, patient-experience and clinical effectiveness.

The book contains analyses that show:

- Significant improvements in survival for most cardiac surgical procedures, despite increasing complexity of casemix and an increasing proportion of elderly patients undergoing heart surgery.
- Variation in the types of surgery undertaken for various disorders between hospitals, marked differences in volumes, and significant variations in equity of access to potentially life-saving treatments by geographical region.

In addition to the detailed surgical analyses, this report also contains the perspective of patient representatives on the Society for Cardiothoracic Surgeons' audit, descriptions of developments to optimise training, discussions on new initiatives to implement professional regulation of cardiac surgeons and *Good practice examples,* which will be of benefit both within cardiac surgery and across other areas of medicine and surgery.

> *This pioneering audit is an exemplar to other specialities in both medicine and surgery. It is crucial evidence that is driving the quality agenda, and its long-term benefit to patients and their families is overwhelming.*
>
> **David H Geldard MBE**
> **Immediate Past President, Heart Care Partnership (UK)**

> *For me the significance of this book lies in the commitment of British and Irish heart surgeons to be as sure as they possibly can be, and to show everyone, openly, that their patients' trust in them is well-founded. That's an achievement of which they should be justly proud.*
>
> **Lady Irvine MBE**

The Society for Cardiothoracic Surgery
Mr Ben Bridgewater
Consultant Cardiac Surgeon
University Hospital of South Manchester &
Co-director and Honorary Senior Lecturer
National Institute for Clinical Outcomes Research
University College London

Phone +44 (0) 20 7869 6893
Fax +44 (0) 20 7869 6890
email sctsadmin@scts.org

www.scts.org

Dendrite Clinical Systems
Dr Peter K H Walton
Managing Director
59A Bell Street
Henley-on-Thames
Oxfordshire RG9 2BA
United Kingdom

Phone +44 (0) 1491 411 288
Fax +44 (0) 1491 411 377
email publishing@e-dendrite.com

www.e-dendrite.com