Appendix 1

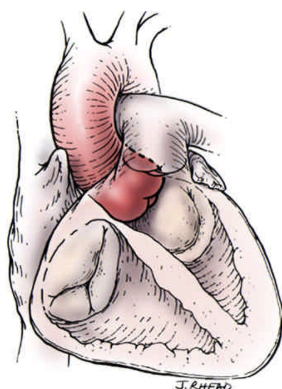
Basic Principles of Adult Cardiac Surgery

The heart can be seen as a mechanical device designed to pump blood around the body. Like any pump that pumps liquid it requires two particular sets of components. Firstly, a series of one-way valves to ensure the blood goes in one direction, and secondly a fuel-supply to provide the energy for pumping. The heart has its own fuel lines, the coronary arteries, which provide oxygen and nutrients for the heart muscle. The heart is, in fact, two pumps. The right side receives blood from the body which it pumps through the lungs, where the blood picks up oxygen, and back to the left side of the heart where the blood now containing new oxygen is then pumped around the whole body. The left side of the heart is stronger because it has to pump blood further.

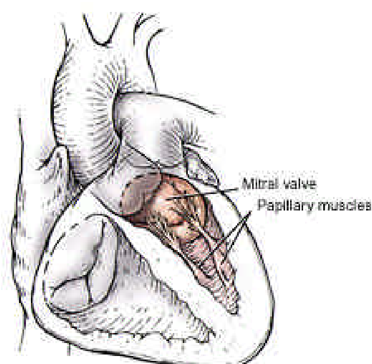
Valvular heart disease

The heart is a muscle pump, which contains four one-way valves to ensure blood flows in one direction. These valves may become narrowed (***stenotic***) or leaky (***regurgitant***) and one or more may need to be repaired or replaced.

The right side of the heart contains two valves: the ***tricuspid valve*** where blood enters the main pumping chamber, the right ventricle, and the ***pulmonary valve*** where the blood leaves the right ventricle to go to the lungs. Similarly when blood returns from the lungs it enters the main pumping chamber, the left ventricle, through the ***mitral valve*** and is then pumped out of the heart through the ***aortic valve***. All this requires energy, which is delivered to the heart muscle in the form of nutrients and oxygen by the coronary arteries.



The aortic valve



The mitral valve

Coronary artery disease

The coronary arteries may become narrowed or blocked reducing the blood supply to the heart muscle depriving the heart of oxygen (***ischaemia***) and giving rise to chest pain (***angina***). A heart attack (***myocardial infarction***) occurs when the reduction in oxygen supply is so bad that a portion of heart muscle dies. This may go unnoticed or be so severe that the person dies. Varying degrees of oxygen deprivation may impair the pumping efficiency of the heart. "*Ejection fraction*" is a term used to describe how well a heart is functioning. A good heart ejects 50-70% of blood from its main pumping chamber with each beat. Decreasing percentages therefore indicate hearts in worse condition.

Surgical correction of valvular and coronary artery disease

Surgery of the heart is best conducted on a heart that is still and empty of blood. This is effected by artificially pumping blood around the body with a heart lung machine (***cardiopulmonary bypass***) and stopping the heart either electrically or with a chemical solution for the duration of the operation.

In a coronary artery bypass graft operation (***CABG***) a blood vessel is taken from elsewhere in the body, cut to an appropriate length and then one end is plumbed into the diseased coronary artery upstream of the narrowing and the other end downstream of the narrowing, hence the term "***bypass graft***". This restores the blood supply to the area of heart normally supplied by the diseased artery. The number of grafts constructed in any operation depends on the number of diseased coronary arteries. These operations may have to be

repeated some time later if the disease in the coronary arteries becomes worse, or if the bypass graft itself becomes narrowed. A repeat operation is more difficult to perform and carries a greater risk to the patient than the initial operation.

Types of bypass grafts

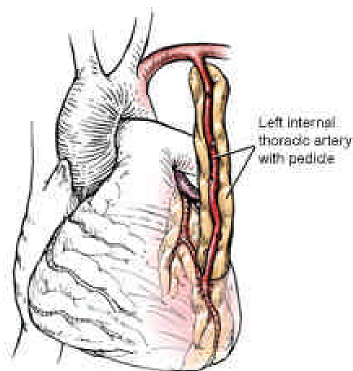
Bypass grafts can be contsructed from either arteries or veins. **Arteries** are blood vessels that convey high-pressure blood, containing oxygen and nutrients, away from the heart to the rest of the body. The aorta, the main artery of the body, is about an inch in diameter. The coronary arteries are the first branches off the aorta, and are about 1-2 mm in diameter. Arteries divide into smaller and smaller branches in order to reach all parts of the body; finally, they become microscopic **capillaries**.

Once blood has passed through the tissues and organs of the body, the small blood vessels join to form larger blood vessels called **veins**, which convey the blood, now depleted of oxygen and nutrients, back to the heart. These vessels are of a different structure to arteries, mainly because the blood, after passing through the tiny capillaries in the tissues, is at a fraction of the pressure.

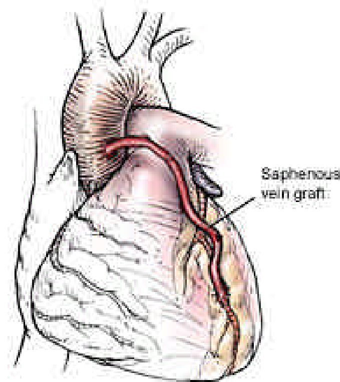
On the whole, each bypass graft requires about 6-7 inches of additional blood vessel. It is easier to find such lengths of vein than it is to find such lengths of artery. Particularly in the leg there is one vein, the l**ong saphenous vein**, that runs near the surface of the skin, from ankle to groin, and it is easily removed. For these reasons, the long saphenous vein is the most commonly used blood vessel in the construction of bypass grafts.

There are also two arteries in the chest, which normally provide blood to the breastbone, the left and right internal mammary arteries. These arteries can be detached, cut at one end, swung down and attached to a diseased coronary artery, downstream of the narrowing. However, they are not long enough to reach all of the coronary arteries. Of theses two arteries, it is the **left internal mammary artery** that is used most often. As it is an artery, it is accustomed to arterial blood pressures, and it is also the same diameter as the coronary arteries. It seldom suffers any narrowing itself. This combination of factors makes it an excellent bypass graft. Therefore, it is generally used to bypass the **left anterior descending coronary artery,** which is the most important artery of the heart. For the reasons above, the left internal mammary artery also lasts longer than a vein bypass graft.

Veins are most commonly used to bypass the other coronary arteries. However, there is a slowly growing trend towards the use more arteries for these grafts as well, such as the right internal mammary artery, the radial artery from the arm and another artery that normally provides blood to the stomach.



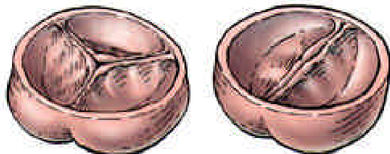
An internal mammary artery bypass graft



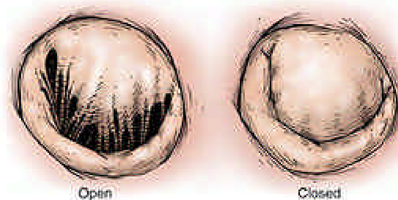
A saphenous vein bypass graft

Operations on the heart valves are a little more complicated because the valves are deep inside the heart and therefore the heart must be opened in order to gain access to the valves.

The two most common valves to be replaced or repaired are the aortic and mitral valves. These have very different structures as seen below.



Two common types of aortic valve



An open and closed mitral valve

Each of the valves can be either replaced or repaired. A valve can usually be replaced with another animal valve (***bioprosthesis***), a human valve (***homograft***) or most commonly a ***mechanical valve***. Common abbreviations are used for valve replacements: aortic valve, ***AVR***; mitral valve, ***MVR***; tricuspid valve ***TVR*** and pulmonary valve ***PVR***.

Despite being simple in concept these are major operations that carry a variable risk to the patient.

Additional details on the different types of heart operations can be found on the US Society of Thoracic Surgeons website at: www.sts.org/section/stspatientinfo

Appendix 2

The Parsonnet Scoring system

The Parsonnet score was the first simple, validated, additive scoring system for predicting risk in cardiac surgery. It is widely used in the UK, but its weakness is that it allows subjective scoring (shaded variables). These have been omitted for the centrally calculated score used in this report.

Parsonnet score

A method of Uniform Stratification of Risk for evaluating the results of surgery in acquired adult heart disease

Circulation (1989) **79**: Suppl I: 3-12

An additive score of 0-4 translates to an operative mortality of 1% (*low risk*); a score of 5-9 an operative mortality of 5% (*elevated risk*); a score of 10 – 14 a mortality of 9% (*significantly elevated risk*), a score of 15 – 19 a mortality of 17% (*high risk*) and a score of over 19 a mortality of 31% (*very high risk*).

	Factor	*Definition*	*Score*
Patient-related factors	*Gender*	Female	1
	Morbid obesity	Body mass index >35	3
	Diabetes	Any history of diabetes regardless of duration or treatment. Latent diabetes of pregnancy excluded	3
	Hypertension	A history of blood pressure greater than 140/90mmHg on two occasions, or lower if on medication	3
	LV dysfunction	Good (≥50%) Fair (30-49%) or Poor (<30%) if known	0 2 4
	Age	70-74 years old 75-79 years old > 80 years old	7 12 20
	Re-operation	1 Second operation 2 Third (or more)	5 10
	Intra aortic balloon pump	Prior to surgery. Do NOT include IABP's inserted prophylactically just prior to surgery because these represent post-operative support.	2
	Left ventricular aneurysm	Aneurysmectomy	5
	Recently failed intervention	1 Within 24 hours of operation 2 > 24 hours, op on same admission	10 5
	Renal	Dialysis dependency	10
	Catastrophic states	*e.g.* acute structural defect, cardiogenic shock, acute renal failure	10-50
	Other rare circumstances	*e.g.* paraplegia, pacemaker dependency, congenital heart disease in adults, severe asthma	2-10
Surgery-related factors	*Mitral valve surgery*	Systolic PA pressure <60 mmHg	5
		Systolic PA pressure ≥60 mmHg	8
	Aortic valve surgery	AV pressure gradient ≤120 mmHg	5
		AV pressure gradient >120 mmHg	7
	CABG at the time of valve surgery		2

In addition, the impact of the variables used in the Parsonnet score has changed over time. Consequently there is a tendency to over predict operative risk, hence the move to develop newer scoring systems such as the E*uroSCORE* and the UK Bayes scores illustrated overleaf.

Appendix 3

The EuroSCORE

The *EuroSCORE* project, led by Mr Sam Nashef, has recently reported. This is a weighted, additive score similar in concept to the North American Parsonnet score but based on a pan-European sample of cardiac surgical patients and represents a considerable improvement on the Parsonnet score.

EuroSCORE

European System for Cardiac Operative Risk Evaluation Score

European system for cardiac operative risk evaluation

Eur. J. Cardiothorac. Surg. 1999 **16**; 1; 9-13

weights add up to an approximate percentage predicted mortality

	Factor	*Definition*	*Score*
Patient-related factors	*Age*	Per 5 years or part thereof over 60	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 surgery on the abdominal aorta, limb arteries or carotids	2
	Neurological dysfunction	Disease severely affecting ambulation or day-to-day functioning	2
	Previous cardiac surgery	Previous 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 preoperative state	Ventilation before arrival in the anaesthetic room, preoperative inotropic support, intra aortic balloon counterpulsation (IABP) or preoperative acute renal failure (anuria or oliguria <10ml/hr)	3
Cardiac related factors	*Unstable angina*	Angina requiring iv nitrates until arrival in the operating room	2
	LV dysfunction	Moderate (EF 30 - 50%) Poor <30%	1 3
	Recent myocardial infarct	<90 days	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 operation other than or in addition to CABG	2
	Surgery on thoracic aorta	Ascending, arch or descending aorta	3
	Post infarct septal rupture		4

Appendix 4

SCTS simple, 5-factor CABG Bayes table; trained on 1998 data

Risk Factor	Criteria	Death	Survival	Contrib'n	Incidence	Count	Odds Ratio	Weight
OVERALL		2.6%	97.4%	0.0%	100.0%	15,106	0.027	-36.3
Age	*<56 years old*	9.0%	20.8%	-1.4%	20.5%	3,099	0.43	-8.4
	56-60 years old	9.5%	16.8%	-1.1%	16.6%	2,508	0.57	-5.7
	61-65 years old	17.7%	21.1%	-0.4%	21.0%	3,171	0.84	-1.7
	66-70 years old	22.9%	20.9%	0.2%	20.9%	3,158	1.10	0.9
	71-75 years old	22.9%	14.3%	1.5%	14.6%	2,198	1.60	4.7
	>75 years old	18.0%	6.0%	4.7%	6.3%	956	2.99	10.9
Body Surface Area	*<1.70 m^2*	12.6%	8.3%	1.3%	8.5%	1,277	1.51	4.1
	1.70-1.89 m^2	25.7%	20.5%	0.6%	20.7%	3,120	1.25	2.3
	1.90-2.39 m^2	42.4%	50.2%	-0.4%	50.0%	7,553	0.84	-1.7
	>2.39 m^2	4.4%	7.3%	-1.0%	7.3%	1,098	0.59	-5.2
Ejection Fraction	*Good EF* [i]	37.5%	60.1%	-1.0%	59.5%	8,991	0.62	-4.7
	Fair EF [ii]	30.1%	24.7%	0.5%	24.8%	3,753	1.22	2.0
	Poor EF [iii]	21.9%	5.5%	7.0%	5.9%	891	3.99	13.8
Priority	*Elective*	44.5%	65.8%	-0.8%	65.3%	9,859	0.68	-3.9
	Urgent	29.3%	23.7%	0.6%	23.8%	3,599	1.24	2.1
	Emergency	14.9%	2.5%	11.0%	2.8%	427	5.95	17.8
Previous operations	*None*	78.4%	86.1%	-0.2%	85.9%	12,972	0.91	-0.9
	One or more	12.1%	3.7%	5.3%	4.0%	597	3.23	11.7

[i] Good ejection fraction: ≥50%

[ii] Fair ejection fraction: 30-49%

[iii] Poor ejection fraction: <30%

Appendix 5

SCTS simple, 5-factor CABG Bayes table; re-trained on 1998-99 data

Risk Factor	Criteria	Death	Survival	Contrib'n	Incidence	Count	Odds Ratio	Weight
OVERALL		2.5%	97.5%	0.0%	100.0%	33,392	0.026	-36.6
Age	*<56 years old*	10.1%	20.1%	-1.2%	19.8%	6,626	0.50	-6.9
	56-60 years old	8.4%	15.9%	-1.2%	15.7%	5,250	0.53	-6.4
	61-65 years old	16.0%	20.1%	-0.5%	20%	6,670	0.80	-2.2
	66-70 years old	21.9%	20.1%	0.2%	20.2%	6,730	1.09	0.9
	71-75 years old	23.4%	14.6%	1.4%	14.8%	4,952	1.60	4.7
	>75 years old	18.3%	6.7%	4.1%	7%	2,325	2.75	10.1
Body Surface Area	*<1.70 m^2*	14.1%	8.7%	1.5%	8.8%	2,941	1.63	4.9
	1.70-1.89 m^2	24.1%	20.8%	0.4%	20.9%	6,979	1.16	1.5
	1.90-2.39 m^2	42.5%	49.6%	-0.3%	49.4%	16,490	0.86	-1.5
	>2.39 m^2	4.7%	6.9%	-0.8%	6.8%	2,284	0.68	-3.9
Ejection Fraction	*Good EF* [i]	38.0%	59.4%	-0.9%	58.9%	19,652	0.64	-4.5
	Fair EF [ii]	29.7%	25.1%	0.4%	25.2%	8,410	1.18	1.7
	Poor EF [iii]	22.2%	5.7%	6.6%	6.1%	2,044	3.88	13.6
Priority	*Elective*	44.8%	63.7%	-0.7%	63.2%	21,098	0.70	-3.5
	Urgent	29.6%	24.2%	0.5%	24.4%	8,142	1.22	2.0
	Emergency	15.1%	2.4%	11.3%	2.7%	914	6.23	18.3
Previous operations	*None*	81.3%	87.8%	-0.2%	87.7%	29,278	0.93	-0.8
	One or more	10.4%	3.8%	4.0%	4%	1,335	2.72	10.0

[i] Good ejection fraction: ≥50%

[ii] Fair ejection fraction: 30-49%

[iii] Poor ejection fraction: <30%

Appendix 6

SCTS complex, 9-factor CABG Bayes table; trained on 1998 data

Risk Factor	Criteria	Death	Survival	Contrib'n	Incidence	Count	Odds Ratio	Weight
OVERALL		2.6%	97.4%	0.0%	100.0%	15,106	0.027	-36.3
Age	*<56 years old*	9.0%	20.8%	-1.4%	20.5%	3,099	0.4	-8.4
	56-60 years old	9.5%	16.8%	-1.1%	16.6%	2,508	0.6	-5.7
	61-65 years old	17.7%	21.1%	-0.4%	21.0%	3,171	0.8	-1.7
	66-70 years old	22.9%	20.9%	0.2%	20.9%	3,158	1.1	0.9
	71-75 years old	22.9%	14.3%	1.5%	14.6%	2,198	1.6	4.7
	>75 years old	18.0%	6.0%	4.7%	6.3%	956	3.0	10.9
Body Surface Area	*$<1.70\ m^2$*	12.6%	8.3%	1.3%	8.5%	1,277	1.5	4.1
	$1.70\text{-}1.89\ m^2$	25.7%	20.5%	0.6%	20.7%	3,120	1.3	2.3
	$1.90\text{-}2.39\ m^2$	42.4%	50.2%	-0.4%	50.0%	7,553	0.8	-1.7
	$>2.39\ m^2$	4.4%	7.3%	-1.0%	7.3%	1,098	0.6	-5.2
Diabetes	*No diabetes*	66.6%	73.6%	-0.2%	73.4%	11,089	0.9	-1.0
	Diabetes	18.8%	15.0%	0.6%	15.1%	2,282	1.3	2.2
Hypertension	*No HT*	42.9%	48.4%	-0.3%	48.3%	7,291	0.9	-1.2
	HT	51.4%	46.0%	0.3%	46.1%	6,970	1.1	1.1
Left Main Stem disease	*No LMS*	51.4%	61.0%	-0.4%	60.7%	9,175	0.8	-1.7
	LMS	14.4%	9.6%	1.2%	9.8%	1,476	1.5	4.0
Ejection Fraction	*Good EF* [i]	37.5%	60.1%	-1.0%	59.5%	8,991	0.6	-4.7
	Fair EF [ii]	30.1%	24.7%	0.5%	24.8%	3,753	1.2	2.0
	Poor EF [iii]	21.9%	5.5%	7.0%	5.9%	891	4.0	13.8
Priority	*Elective*	44.5%	65.8%	-0.8%	65.3%	9,859	0.7	-3.9
	Urgent	29.3%	23.7%	0.6%	23.8%	3,599	1.2	2.1
	Emergency	14.9%	2.5%	11.0%	2.8%	427	6.0	17.8
Renal system	*Dialysis*	1.8%	0.4%	7.9%	0.4%	67	4.4	14.8
	Raised creatinine [iv]	9.3%	3.7%	3.6%	3.9%	584	2.5	9.1
	No renal disease	77.1%	84.6%	-0.2%	84.4%	12,752	0.9	-0.9
Previous operations	*None*	78.4%	86.1%	-0.2%	85.9%	12,972	0.9	-0.9
	One or more	12.1%	3.7%	5.3%	4.0%	597	3.2	11.7

[i] Good ejection fraction: ≥50%

[ii] Fair ejection fraction: 30-49%

[iii] Poor ejection fraction: <30%

[iv] Raised creatinine: pre-operative creatinine greater than 200 $\mu mol\ l^{-1}$ and no dialysis recorded.

Appendix 7

SCTS complex, 9-factor CABG Bayes table; re-trained on 1998-99 data

Risk Factor	Criteria	Death	Survival	Contrib'n	Incidence	Count	Odds Ratio	Weight
OVERALL		2.5%	97.5%	0.0%	100.0%	33,392	0.026	-36.6
Age	*<56 years old*	10.1%	20.1%	-1.2%	19.8%	6,626	0.50	-6.9
	56-60 years old	8.4%	15.9%	-1.2%	15.7%	5,250	0.53	-6.4
	61-65 years old	16.0%	20.1%	-0.5%	20.0%	6,670	0.80	-2.2
	66-70 years old	21.9%	20.1%	0.2%	20.2%	6,730	1.09	0.9
	71-75 years old	23.4%	14.6%	1.4%	14.8%	4,952	1.60	4.7
	>75 years old	18.3%	6.7%	4.1%	7.0%	2,325	2.75	10.1
Body Surface Area	*<1.70 m^2*	14.1%	8.7%	1.5%	8.8%	2,941	1.63	4.9
	1.70-1.89 m^2	24.1%	20.8%	0.4%	20.9%	6,979	1.16	1.5
	1.90-2.39 m^2	42.5%	49.6%	-0.3%	49.4%	16,490	0.86	-1.5
	>2.39 m^2	4.6%	6.9%	-0.8%	6.8%	2,280	0.66	-4.1
Diabetes	*No diabetes*	66.9%	70.4%	-0.1%	70.3%	23,486	0.95	-0.5
	Diabetes	19.4%	15.0%	0.7%	15.1%	5,055	1.29	2.6
Hypertension	*No HT*	37.1%	44.4%	-0.4%	44.3%	14,776	0.84	-1.8
	HT	55.3%	47.0%	0.4%	47.2%	15,773	1.18	1.6
Left Main Stem disease	*No LMS*	50.1%	58.4%	-0.3%	58.2%	19,431	0.86	-1.5
	LMS	16.5%	11.6%	1.0%	11.7%	3,919	1.42	3.5
Ejection Fraction	*Good EF* [i]	38.0%	59.4%	-0.9%	58.9%	19,652	0.64	-4.5
	Fair EF [ii]	29.7%	25.1%	0.4%	25.2%	8,410	1.18	1.7
	Poor EF [iii]	22.2%	5.7%	6.6%	6.1%	2,044	3.88	13.6
Priority	*Elective*	44.8%	63.7%	-0.7%	63.2%	21,098	0.70	-3.5
	Urgent	29.6%	24.2%	0.5%	24.4%	8,142	1.22	2.0
	Emergency	15.1%	2.4%	11.3%	2.7%	914	6.23	18.3
Renal system	*Dialysis*	1.4%	0.4%	6.2%	0.4%	138	3.71	13.1
	Raised creatinine [iv]	10.2%	3.0%	5.4%	3.2%	1,071	3.36	12.1
	No renal disease	71.9%	80.1%	-0.3%	79.9%	26,677	0.90	-1.1
Previous operations	*None*	81.3%	87.8%	-0.2%	87.7%	29,278	0.93	-0.8
	One or more	10.4%	3.8%	4.0%	4.0%	1,335	2.72	10.0

[i] Good ejection fraction: ≥50%

[ii] Fair ejection fraction: 30-49%

[iii] Poor ejection fraction: <30%

[iv] Raised creatinine: pre-operative creatinine greater than 200 µmol l^{-1} and no dialysis recorded.

Appendix 8

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Public Confidence and Cardiac Surgical Outcome

Cardiac Surgery: the fall guy in medical quality assurance

The General Medical Council has recently been grappling with the problem of measuring and comparing surgical outcomes after complex surgery in a heterogeneous patient population with differing severities of illness. Cardiothoracic surgery, with its immediate, obvious, and sometimes catastrophic outcomes, is the first surgical speciality to come under such forensic scrutiny. Inevitably the associated media coverage has dented public confidence in the ability of the medical profession to police itself, and in particular this has been focused on Cardiothoracic Surgery [34]. Yet, the irony is that in the United Kingdom cardiothoracic surgery has better data and is more subject to internal scrutiny than perhaps any other specialty.

The Society of Cardiothoracic Surgeons has a long history of audit. In 1977 Sir Terence English established the United Kingdom Cardiac Surgical Register [1], which collects activity and mortality data on all cardiac surgical procedures performed in each NHS cardiac surgical unit, amounting to 35,000 procedures a year. Although apparently simple in concept, the process represented the first attempt in Britain by any speciality to collect national activity and outcome data. All data are anonymised, since this was a prerequisite for encouraging voluntary data submission from all units. Similarly the United Kingdom heart valve registry has collected national valve surgery data since 1986. Linkage of this registry to the office for national statistics means we now have unique 10-year survival data following heart valve replacements in the NHS [5, 35].

Both registries return aggregated data to each member of the society as an annual report containing national activity and mortality data for a wide range of cardiac operations. Since inception the presumption has been that access to national information would draw each surgeon's attention to his own performance and encourage introspection and action. So what has gone wrong? Why have we apparently failed to identify those few surgeons whose performance has fallen below acceptable standards?

Firstly, the data in the cardiac surgical register relate to individual units, not individual surgeons. Hence, a unit's figures can easily camouflage an errant performer. Secondly, poor individual performance could be dismissed as a case-mix problem, since risk stratification algorithms were not available. Thirdly, reliable data collection facilities have not been available in every unit, and failure to track every death may have resulted in the reporting of unrealistically low operative mortalities for some procedures.

Nevertheless, the register represented a spearhead endeavour both internationally and within Britain and provided a reasonable indication of national activity and mortality. Even so, the Society of Cardiothoracic Surgeons recognised the shortcomings of the system, particularly in the light of transatlantic developments. The Freedom of Information Act in the US had forced individual cardiac surgeon's outcomes into the public domain [8, 36] and the release of raw mortality data by public health agencies had caused considerable alarm within the speciality. This stimulated interest in understanding outcome measures and developing risk stratification algorithms [37, 38] and prompted a reappraisal of our own national system.

Acknowledging the need to be able to measure Casemix and severity of illness, the society established a national database in 1994, to run in parallel with the existing, simpler register. This database collects some 150 data-points on all adults undergoing cardiac surgery in selected units across Britain, with the aim of developing reliable comparative UK orientated risk stratification models in conjunction with the MRC Biostatistics Unit in Cambridge. This year the national database accepted data from just over half of all British units. It now provides a unique repository of comprehensive data on 30,000 patients for risk stratification modelling and which is available to contributing units. At present the database does not collect surgeon identifiers, since in 1993-4 this would have provided an insurmountable stumbling block to its launch.

However, the tide of public and professional opinion is changing rapidly and the society has this year added a paediatric surgical database to its endeavours. The Chief Medical Officer has made it clear that the public have a right to know that standards are under scrutiny and that the profession cannot hide behind anonymity. The society supports this stance, but believes that measurement and interpretation should be governed by the speciality, and most members feel that comparisons between surgeons should be risk stratified to take account of casemix. At the same time the society recognises a conflict. A mechanism for professional assurance needs to be put in place promptly to reassure the public, but not all units have the information technology or staff to collect the detailed information required for risk stratification. To force these units to

collect complex data in the absence of adequate facilities would either dilute the reliability of the data or risk reducing the dataset to the lowest common denominator and thereby reduce its value.

To balance these apparently conflicting aspirations the society has asked all NHS units to return annual, raw, surgeon-specific mortality data on marker operations for adult cardiac surgery, thoracic surgery and paediatric cardiac surgery from 1 April, 1997 as an extension to the cardiac surgical register. These data will be analysed independently and the results scrutinised through an internal mechanism within the society. Individual surgeons will be notified and required to respond if their performance appears to be outside predetermined limits. This will provide an effective, speciality driven early warning system at little or no additional cost to individual units.

The comprehensive data collection required for risk stratification may be intimidating to some. However, surgeons from a unit with risk stratification in place will find themselves in a stronger position to respond to the society's new early warning system. Herein lies an inequity even for those committed to good data collection. The standard NHS patient management systems are generally not sophisticated enough to process these types of data. Most cardiac surgical units have already demonstrated commitment by either developing a bespoke system or purchasing a proprietary system capable of performing benchmarking against national standards by both simple [39, 40] and complex risk modelling [41] with logistic regression [42] Bayesian analysis [43, 44] and individual risk adjusted CUSUM [26, 27]. The changing climate is encouraging remaining units to do the same and submit comprehensive data to the national database. The limiting feature is that good data collection requires local resources in the form of appropriate software and staff together with commitment from consultants.

In parallel with the society's initiative the department of health is exploring the feasibility of centralised on-line data collection and warehousing for all interventional cardiology and cardiac surgical procedures through the Central Cardiac Audit Database project. This is entering its third year, in six pilot centres, and will be reporting soon [45].

Most cardiac surgeons have long recognised their responsibility to collect reliable and comprehensive data on their performance. This will be facilitated by the development of an international cardiac surgical dataset currently being drawn up between the Society of Thoracic Surgeons in the United States and the European Association for Cardiothoracic Surgery. This will help to standardise risk factor data collection and facilitate the development of robust comparative risk modelling between populations, procedures, institutes, and individual surgical teams.

Evidence based medicine indicates that those patients most likely to benefit from cardiac surgery are usually the sickest, with the most damaged hearts, who therefore have greatest surgical risk. So, auditing performance without correction for casemix will subject the surgeon to unfair comparisons and ensure that a proportion of patients, who might otherwise benefit, will be denied surgery [46]. However, good risk stratification will reduce the chances of high risk patients being turned down for surgery and encourage fully informed pre-operative consent. Furthermore, although operative mortality is always attributed to the surgeon, this ignores the subtle but important influences of cardiological management and referral, anaesthetic care and intensive care resources.

Although the climate is changing these remain complex and sensitive issues, but these new mechanisms should go some way to restoring public confidence. Our outcome statistics have been in the public domain for many years and are now published on our Web Page [35] along with American outcome data [47]. We will soon be adding a coronary surgery risk calculator based on UK data, which will introduce the concept of operative risk calculation into the public domain. This year the Society of Cardiothoracic Surgeons has gone a stage further and democratically assumed responsibility for quality control of individual surgical practices – a new role for any specialist society within the United Kingdom. However, our speciality represents the tip of the iceberg in medical quality assurance, and the major challenge will be determining realistic, measurable and auditable outcomes for other medical and surgical specialities where poor outcomes also occur, but the process is less transparent.

Society of Cardiothoracic Surgeons of Great Britain & Ireland
Bruce.E. Keogh, Chairman, Database and Information Committee **Jules Dussek, President**
Patrick Magee, Postgraduate Dean in Cardiothoracic Surgery **Deirdre Watson, Secretary**

European Association for Cardiothoracic Surgery
Kenneth M. Taylor, Chairman, database committee

David Wheatley, Vice-President

Appendix 9

Guidelines for the Audit of Cardiothoracic Surgical Practice

Background

The Society of Cardiothoracic Surgeons of Great Britain and Ireland was the first professional body to co-ordinate national data collection in the United Kingdom with the introduction of the United Kingdom Thoracic Surgical Register in 1976 and the Cardiac Surgical Register in 1977. These voluntary registers collect simple activity and mortality data from all NHS cardiothoracic and thoracic surgical units in the UK in an anonymous fashion. The evolution of cardiothoracic surgical practice has been attended by an understanding of the influence of cardiac and non-cardiac factors on survival from cardiac and thoracic surgery. Mortality is mainly influenced by severity of illness and associated co-morbidities, but appropriateness of treatment and in-hospital quality of care also play a significant role. It has become clear that greater complexity of surgery in an increasingly diverse population severely undermines the value of simple surgical mortality as a measure of quality of care. Over the last few years various statistical algorithms have become available that relate operative mortality and morbidity to casemix.

A combination of marketplace competition together with public and political awareness has raised vigorous debate on issues relating to quality of care and institutional and individual surgical performance. The Society of Cardiothoracic has chosen to take the initiative and recommend that all cardiothoracic surgical units throughout the UK should undertake regular review of their practice in a risk stratified fashion. We believe that this approach represents good risk management policy for Trusts, hospitals, individual units and their surgeons and will raise the overall quality of clinical care.

The implementation of such an approach and the responsible interpretation of the resultant data requires national and local agreement and co-ordination of responsibilities.

Individual and institutional responsibilities

The Hospital Trust should provide the hardware, software and personnel to allow patient orientated data collection for risk stratification, and downloading of data into the Society's National Cardiac and Thoracic Surgical Databases.

The Cardiothoracic Surgical Unit should define the strategy for data collection, collation and presentation, and should dedicate time each month for presentation and discussion of surgical activity and results. The unit should identify one consultant with overall responsibility for co-ordinating and developing the audit programme.

Each Consultant Surgeon must assume full responsibility for collection of complete, accurate and honest data on all cases under his/her care, provided the Trust has met the obligations outlined above.

The Society of Cardiothoracic Surgeons of Great Britain and Ireland will provide individual clinicians and Trusts with guidance on contemporary standards of care. To this end the Society will:

- define a recommended dataset for each surgical patient
- develop and provide statistical models enabling individual and group risk prediction and outcome comparison
- define contemporary levels of performance based on these statistical models
- circulate an annual audit report to members
- publish summarised and aggregated data on the internet at www.scts.org

The Royal College of Surgeons Specialist Advisory Committee for Higher Surgical Training will seek evidence during inspections that effective audit meetings have taken place, all surgical staff have attended regularly, appropriate records have been kept and that adequate audit assistance and computer systems are available.

The audit process

Data collection

Data collection remains the joint responsibility of the Trust and the Surgeon. To facilitate effective risk stratification data should be collected in line with the appended Minimum Dataset (MDS) defined by the Society of Cardiothoracic Surgeons. The current MDS, and its associated definitions, is compatible with all existing initiatives in the UK such as the UK Heart Valve Registry, the Central Cardiac Audit Database (CCAD) and the British Cardiac Intervention Society database (BCIS). The definitions and data fields are also compatible with evolving European initiatives and the Society of Thoracic Surgeons (USA), American College of Cardiology and the Healthcare Financing Administration (HCFA) in the United States.

The Society strongly encourages collection of the "Recommended Dataset" which allows robust risk stratification together with tracking of several aspects of surgical practice including surgical training, and measurement of outcomes other than mortality alone.

Data collection strategies must be determined locally. However, algorithms for risk stratification are becoming more complex and numbers of patients will grow. A networked computerised system with good statistical capabilities is recommended.

Data validation

Local validation should be performed by random selection of case notes to reduce gaming / fraud

External validation of data will be performed by the Society on 3-5 yearly cycle. Details of the validation process will be forwarded to individual units.

Audit meetings

should be held monthly in allocated and dedicated time. All consultants should attend meetings and should take it in turn to chair the meetings and should foster an air of constructive analysis and criticism. Specialist registrars should be involved as part of their training, and attendance of nursing, technical and other staff should be encouraged. A register of attendance should be kept. The form of presentation and discussion should be agreed and developed locally, but meetings should address:

- Total surgical activity
- Risk stratified activity
- Mortality and morbidity
- Intermittent detailed review of specific issues and outcomes in order to improve practice.

Surgeon specific review

By unanimous agreement within the speciality surgeon-specific outcome data for marker operations has been returned to the Society of Cardiothoracic Surgeons from 1st April 1997. This will be collected annually in a format defined by the Society and will be collated and analysed as part of the established UK Cardiac and Thoracic Surgical Registers. The President of the Society will seek clarification from any surgeon whose performance lies outside predefined limits. Clearly this clarification will be greatly simplified for all parties if facilities for comprehensive data collection and risk adjustment are in place. If concern persists then the Medical Director of the Trust will be contacted and the Society will provide, in conjunction with the Royal College of Surgeons, a discrete and supportive external review by senior cardiothoracic surgeons. The aim of such a visit would be to determine the nature and severity of the perceived problem and to develop a collaborative strategy for resolution of the problem.

In addition to the mandatory return of surgeon-specific data to the Society individuals should continuously review their own progress using risk stratified data. Surgeon specific data should be reviewed jointly by the consultant surgeons on at least an annual basis. The Society will respond supportively to an approach from a concerned member, his colleagues or the Trust recognising that in some instances this may simply be an issue of rebuilding personal or institutional confidence and credibility.

The Society of Cardiothoracic Surgeons of Great Britain & Ireland accords the highest priority to surgical audit and requests that all concerned give due consideration to the value and importance of the professional responsibilities outlined above.

Appendix 10

Quality Accreditation Scheme for Adult Cardiac Surgery

The Society of Cardiothoracic Surgeons of Great Britain and Ireland; Standards of Care Subcommittee March 2000

With this document, the Society of Cardiothoracic Surgeons of Great Britain and Ireland launches a pioneering scheme for quality accreditation of units and hospitals performing adult cardiac surgery. The Society hopes that many, and eventually all, units performing adult cardiac surgery will participate voluntarily in the scheme. The purpose of this document is to explain the reasons for the scheme, the quality criteria adopted in it and the methods by which it will be implemented.

Why the scheme?

The Society can be justly proud of its track record in quality monitoring when compared to that of other medical specialities. The national register for adult, paediatric and thoracic surgery procedural mortality has been one of the earliest examples of self-regulation and quality monitoring in any medical field. More recently, the introduction of index procedure mortality data gathering for individual surgeons' performance has expanded the remit of the Society's monitoring system. The development of the Society database for adult cardiac surgery has further enlarged the scope of data gathering and looks set to be the first project to succeed in developing a national, risk stratified database with over 80% of all units currently submitting at least partial data to the project.

Nevertheless, the current medico-political climate allows no room for complacency in this important field. The existing systems are valuable, but their value is limited by the absence of data validation and comprehensive data collection and, in the case of the register and index procedural results, also from a lack of a suitable measure of casemix. This is particularly important if surgeons are expected to continue to offer potentially life-saving surgery to high risk patients. This scheme aims to address these issues by offering public recognition of those units in which quality is monitored by a robust system of measurement of risk stratified outcomes with clear performance targets and mechanisms for dealing with underperformance as measured against such targets.

The scheme has two further, important aims. The first is to promote a culture in which quality monitoring as outlined above becomes the norm in surgical practice, thus providing the incentive for hospital management and purchasers to supply the resources necessary for surgical units to qualify for accreditation. The second is to act as a model for extending quality monitoring to other aspects of our own speciality (thoracic surgery, paediatric cardiac surgery and transplantation) and to other surgical and medical specialities.

The Society Executive wishes to encourage members of the Society to read this document carefully and to give serious consideration to the participation of their hospital or unit in the scheme.

Participation

Any unit or hospital performing adult cardiac surgery in Britain and Ireland is eligible to apply for accreditation. Participation is wholly voluntary and the process is only initiated at the request of an individual unit. Members of the Society are encouraged to examine the criteria for accreditation to ensure that their unit has the necessary mechanisms in place before applying and, if not, to take steps to install these mechanisms.

Principles of accreditation

The Society will grant quality accreditation to participating units provided they satisfy the Society that there are in place

a. robust mechanisms for quality monitoring.
b. satisfactory clinical quality.
c. sound mechanisms for dealing with instances where there are quality concerns.

Accreditation criteria

The Society must be satisfied that the unit fulfils all of the ten criteria listed below:

1. There are reliable data on the number of adult heart operations performed in the unit.
2. There are reliable data on the number of adult heart operations performed under the care of every consultant surgeon in the unit.
3. There are reliable data on the breakdown of these operations by broad category types, such as coronary surgery, valve surgery, combined coronary and valve surgery and others.
4. There is a valid system of assessing casemix. This can be a simple system, such as one based on age and sex, an additive risk stratification system, such as Parsonnet or *EuroSCORE*, or a more complex system such a regression analysis system or a Bayesian model. (The collection of the Society minimum dataset is encouraged but this is not a prerequisite to accreditation).
5. There are reliable data on clinical outcome measures. At the very least, these must include hospital or 30-day mortality.
6. There is a preset level of minimum acceptable performance in relation to the casemix measure. This level must be acceptable to the visitors. Examples are mortality within 70% of Parsonnet predicted mortality, or within 2 standard deviations of *EuroSCORE* predicted mortality.
7. The pre-set minimum acceptable performance must be applied to the unit's performance as a whole as well as to that of individual consultant surgeons.
8. The data on numbers (1, 2, 3, and 5 above) are reliable and can be validated by review of an appropriate sample of case notes or by the presence of a robust local system of data validation.
9. The casemix data (4 above) are reliable and can be validated by review of an appropriate sample of case notes or by the presence of a robust local system of data validation.
10. There is in place a clear and effective mechanism to investigate and appropriately to deal with any performance that falls outside the minimum acceptable performance level (6 above). The mechanism must include identification of the nature of the problem, measures to correct the problem, reassessment after a predetermined period and an action plan to be followed should initial measures fail.

Mechanism

A unit, which volunteers to participate, will inform the Standards of Care Subcommittee (SoCS) of its application for accreditation. The SoCS will nominate two cardiac surgeons, neither of whom will be employed at that unit, to carry out an inspection visit.

The visitors will arrange a mutually convenient time for an inspection visit to the unit. They will invite a member of the NHS regional office to be present at the visit as an observer who is external to the speciality. The visitors will assess the unit by a combination of interview, data review, data validation and any other mechanism necessary to satisfy them that the unit in question fulfils the criteria for quality accreditation as detailed above. They will then submit a confidential report to the SoCS of the Society

Accreditation

The visitors may make three recommendations to the SoCS: to grant accreditation, to grant accreditation with specific suggestions for improvement or to withhold accreditation, giving reasons and suggestions for achieving accreditation at a later date. The SoCS will consider the visitors' report and recommendations and, if satisfied, will then grant accreditation to the recommended units on behalf of the Society.

Accredited units may make public their accreditation to purchasers, patients and health authorities and may use the Society's quality accreditation logo on notepaper, in correspondence and elsewhere if appropriate.

Accreditation will be valid for a period of five years. Continuance will require a further visit along the same lines.

Cost of the scheme

The Society's limited resources do not allow it to fund the scheme entirely from its own budget. The cost of the visits will therefore have to be borne by the participating units. The visitors will give their time without charge, and it is expected that the cost to the unit will only extend to covering the modest travel and subsistence expenses associated with the inspection visits.

Scheme development

The scheme was approved by both the SoCS and the Society Executive at their regular meetings in February 2000 and is being launched at the Society annual general meeting in March 2000. The Society expects the first participating units to be visited in the summer of 2000. Subject to the success of the scheme, the Society will seek endorsement of the scheme by the Royal Surgical Colleges, the General Medical Council and the Department of Health.

Further information

For any additional information, or to apply for accreditation, contact:

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