Preoperative assessment for cardiac surgery

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Cardiac surgical patients are one of the most extensively investigated group of patients that an anaesthetist will encounter. However, evidence from studies using intraoperative transoesophageal echocardiography (TOE) suggest that as many as 5% of patients have additional and hitherto undocumented pathology (e.g. valvular disease, patent foramen ovale).[1 2] Therefore, there is no place for complacency and a thorough preoperative evaluation by the anaesthetist remains an essential component of perioperative care. Apart from granting the patient the basic courtesy of meeting a key member of the medical team, information gathered during this process allows perioperative management to be tailored to suit the patient's specific needs.

In recent years, there has been a trend towards the assessment of elective patients in 'pre-admission' clinics, typically 1–2 weeks before surgery. This approach allows most of the routine paperwork, laboratory tests and radiological imaging to be completed before admission, provides an opportunity to organize additional investigations without delaying surgery, alerts support services (e.g. transfusion) to likely demand and permits the option of admission on the day of surgery. The results of all investigations should be filed in the patient's notes before admission. In principle, stationing an anaesthetist in the pre-admission clinic seems sensible, but it is unlikely that patients will meet the anaesthetist who will provide their perioperative care. Therefore, most preoperative anaesthetic visits take place either on the day before, or on the day of, surgery.

Case note review

In all elective and the majority of emergency cases, the diagnosis will have already been established. For this reason, preoperative assessment invariably begins with a review of the patient's medical record; information gathered is used to form the basis of the first part of the patient interview.

Table 1 The Canadian Cardiovascular Society angina scale.[3] http://www.ccs.ca

Grade	Activity
I	'Ordinary physical activity does not cause angina'; for example, walking or climbing stairs. Angina occurs with strenuous/rapid/prolonged exertion at work/recreation
II	'Slight limitation of ordinary activity'; for example, angina occurs walking/climbing stairs after meals, in cold, in wind, under emotional stress, or only during the few hours after awakening, walking >2 blocks on the level or climbing >1 flight of stairs at a normal pace and in normal conditions
III	'Marked limitation of ordinary physical activity'; for example, angina occurs walking 1–2 blocks on the level and climbing one flight of stairs at a normal pace and in normal conditions
IV	'Inability to carry on any physical activity without discomfort—angina syndrome *may* be present at rest'

The presence of risk factors known to be associated with increased perioperative mortality and morbidity should be sought. These include: age >60 yr, arterial and pulmonary hypertension, BMI <20 or >35 kg m^{-2}, congestive cardiac failure, peripheral vascular disease, aortic atheroma, diabetes mellitus, renal insufficiency, acute coronary syndromes, chronic pulmonary disease, neurological disease and previous cardiac surgery. Any records of previous cardiac surgery should be scrutinized for evidence of adverse events or airway management difficulties. In addition to antianginal, antihypertensive, diuretic and antiplatelet drugs, it is not unusual to find that patients are taking oral hypoglycaemics, histamine (H_2) antagonists, proton pump inhibitors, bronchodilators, corticosteroids or psychotropic drugs. The use of these drugs may indicate other pathology and should be taken into account when prescribing premedication. Of particular importance is discovering whether the patient has recently been exposed to drugs that interfere with coagulation (e.g. aspirin, non-steroidal anti-inflammatory drugs, clopidogrel, glycoprotein IIb/IIIa antagonists, thrombolytics, heparin and warfarin) and the interval since cessation.

Key points

Preoperative anaesthetic assessment of the cardiac surgical patient remains an essential component of perioperative care.

Despite extensive preoperative investigation, a small number of cardiac surgical patients may have significant undiagnosed cardiovascular pathology.

Conventional indices and scales should be used when documenting symptoms, functional capacity and physical signs.

Some understanding of the basic principles, sensitivity and specificity of routine cardiac investigations is essential.

Some of the most sophisticated risk assessment tools in medicine are available for these patients.

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Table 2 The NYHA classification of functional capacity and American Heart Association objective assessment.[4] Examples: Class I-D—asymptomatic patient with an aortic gradient >100 mm Hg, Class IV-A—angina at rest with normal coronary arteries, Class IV-D—cardiogenic shock. http://www.americanheart.org

Functional capacity		Objective assessment	
Class	Description		
I	Patients with cardiac disease but without resulting limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, dyspnoea, or anginal pain	A	No objective evidence of cardiovascular disease
II	Patients with cardiac disease resulting in slight limitation of physical activity. They are comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnoea, or anginal pain	B	Objective evidence of minimal cardiovascular disease
III	Patients with cardiac disease resulting in marked limitation of physical activity. They are comfortable at rest. Less than ordinary activity results in fatigue, palpitation, dyspnoea, or anginal pain	C	Objective evidence of moderately severe cardiovascular disease
IV	Patients with cardiac disease resulting in inability to carry on any physical activity without discomfort. Symptoms of heart failure or the anginal syndrome may be present even at rest. If physical activity is undertaken, discomfort is increased	D	Objective evidence of severe cardiovascular disease

Direct questioning

Armed with the information provided by the case notes, the anaesthetist can now introduce himself to the patient. After assessing the patient's understanding of both their disease and the planned surgical procedure, it is usual to summarize the salient points of the medical notes. This gives the patient an opportunity to provide new information or correct any inaccuracies. The principle aim is to confirm the presence, progression and severity of documented symptoms and signs of the primary cardiac pathology and other significant co-morbidities. Symptoms of cardiorespiratory disease [e.g. angina, dyspnoea, orthopnoea, impaired exercise tolerance, (pre)syncope] should be actively sought, and previously undocumented disease or new intercurrent illness excluded. The severity of symptoms and effort tolerance should be documented using conventional indices; for example, the Canadian Cardiovascular Society angina score[3] (Table 1), the New York Heart Association (NYHA) classification of functional capacity[4] (Table 2) and the Duke activity status index[5] (Table 3). A recent or rapid progression in symptom severity, particularly the onset of class IV angina, should alert the anaesthetist to the possibility of perioperative ventricular dysfunction.

A brief systematic enquiry should then be conducted to exclude any gastrointestinal, renal, hepatic, neurological, metabolic or haematological disease. A history or symptoms suggestive of gastro-oesophageal reflux may prompt the use of strategies to reduce the risk of regurgitation and pulmonary aspiration during anaesthesia. Furthermore, a history of upper gastrointestinal pathology, such as hiatus hernia, may contraindicate the use of TOE. Particular religious or cultural beliefs (e.g. Jehovah's witnesses) have the potential to influence many aspects of care; this should be documented and taken into account during the consent process.

Table 3 The Duke activity status index and approximate metabolic equivalents (METs).[5] One MET represents an oxygen consumption of 3.5 ml kg^{-1} min^{-1}

Activity	Weight	METs
Poor		
Walk indoors, such as around your house	1.75	<4
Do light work around the house—strip and make a bed, dusting, washing dishes	2.70	
Take care of yourself—eating, dressing, bathing, using the toilet	2.75	
Intermediate		
Walk one or two blocks on level ground	2.75	4–7
Do moderate housework—vacuuming, sweeping floors, carrying groceries	3.50	
Do garden work—raking leaves, weeding, pushing a power-mower	4.50	
Having sexual relations	5.25	
Climb a flight of stairs or walk up a hill	5.50	
Participate in golf, bowling, dancing, doubles tennis, football, throwing a baseball	6.00	
Good		
Participate in swimming, singles tennis, football, basketball, skiing	7.50	>7
Run a short distance at 5 mph	8.00	
Do heavy housework—scrubbing floors, lifting/moving heavy furniture	8.00	

Physical examination

Physical examination should be focused on the cardiovascular and respiratory systems. As before, it is important to confirm previous findings, assess disease progression and exclude new pathology. Examination should, at a minimum, include measurement of heart rate, arterial blood pressure and ventilatory frequency; characterization of the heart rhythm; palpation of the carotid, femoral and peripheral arteries, and auscultation of the precordium, carotid arteries and lung fields. While in theory all patients likely to undergo radial artery cannulation should undergo an Allen's test to confirm the presence of an adequate collateral (ulnar) circulation, the test is usually only performed when radial artery harvest is contemplated. Assessment of dentition, extent of jaw opening and cervical mobility should allow prediction of difficulties with airway management and tracheal intubation. In patients with neurological disease, it is important to document the extent and severity of any neurological impairment, as this will act as a baseline for postoperative assessment. Formal examination of the central and peripheral nervous system should be undertaken as necessary.

Investigations

Preoperative investigations can be conveniently considered in two groups—those that are performed routinely in most patients and those that are performed in specific circumstances dictated by the patient's pathology and medical history. As many diagnostic procedures are themselves not without risk, it is essential that investigations are not performed unnecessarily or needlessly repeated.

A blood count, coagulation studies, blood group determination, measurement of serum electrolytes, urea, creatinine and hepatic enzymes, a 12-lead ECG, and a left heart catheter should be regarded as routine preoperative investigations in virtually all patients. The blood count should exclude significant anaemia and any quantitative platelet or leucocyte abnormality. In the absence of anticoagulant administration, the finding of a seemingly trivial prolongation of the activated partial thromboplastin time should prompt further investigation as it may indicate the presence of a coagulopathy (e.g. factor IX deficiency) that may place the patient at an increased risk of excessive perioperative bleeding. Chronic diuretic therapy may produce total-body sodium and potassium depletion, and uraemia. Hypokalaemia is a relatively common finding in cardiac surgical patients and not infrequently associated with hypomagnesaemia. It should be borne in mind that, while normal plasma concentrations of urea and creatinine virtually exclude significant renal pathology, they give no indication of renal reserve. A plain posteroanterior chest radiograph provides information about heart size, pulmonary vasculature, lungs and bony anatomy of the chest.

Left heart catheterization typically comprises coronary angiography, aortography, left ventriculography and manometry. This provides information about the sites and severity of coronary artery stenoses, mitral and aortic valve function, and left ventricular (LV) morphology and function. Direct measurement of LV end-diastolic pressure (LVEDP) provides indirect evidence of LV function, and measurement of aortic and ventricular pressure allows the severity of aortic stenosis to be quantified. Right heart catheterization permits measurement of pulmonary artery pressure and cardiac output, and calculation of the transpulmonary gradient and vascular resistances (Table 4). In cases where there is a communication between the pulmonary and systemic circulations, serial blood sampling allows computation of the shunt fraction. The cardiac anaesthetist must not only be familiar with the techniques and complications of cardiac catheterization, but also be able to place the findings in their clinical context.

Exercise (treadmill) testing is frequently used as a screening test before coronary angiography. While it has relatively low sensitivity and specificity (60–70%) for coronary artery disease, it does provide some indication of effort tolerance.

Transthoracic echocardiography (TTE) is frequently used to define cardiac anatomy and assess ventricular and valvular function. The non-invasive nature of TTE makes it a useful tool for monitoring disease progression and assisting in determining both the timing and type of surgical intervention. It should be borne in mind that TTE assessment of LV function represents a 'static' measure and gives no indication of functional reserve. Therefore, a TTE report stating 'poor LV function' may be consistent with reasonable or good effort tolerance.

Table 4 Normal values for left and right cardiac catheterization. Transpulmonary gradient = mean pulmonary artery pressure minus pulmonary artery wedge pressure. Pulmonary vascular resistance is frequently expressed in Wood units. One Wood unit=80 dyne s cm^{-5}

Parameter	Measurement	Normal values
Systemic (aortic) pressure	Systolic/diastolic (mean)	140/90 (105) mm Hg
LV pressure	Systolic/end-diastolic	140/12 mm Hg
Right atrial pressure	Mean	6 mm Hg
Right ventricular pressure	Systolic/end-diastolic	25/2 mm Hg
Pulmonary artery pressure	Systolic/diastolic (mean)	25/12 (16) mm Hg
Pulmonary artery wedge pressure	Mean	12 mm Hg
Cardiac index		2.5–4.2 litre min^{-1} m^{-2}
Systemic vascular resistance		800–1200 dyne s cm^{-5}
Pulmonary vascular resistance		~100 dyne s cm^{-5}
Transpulmonary gradient	Mean	~6 mm Hg

Additional investigations such as respiratory function tests, arterial blood gas analysis, carotid ultrasonography and angiography, creatinine clearance and evaluation of a permanent pacemaker or cardio-defibrillator[6] should be conducted, as appropriate.

The emergency patient

Emergency cardiac surgery presents the anaesthetist with a series of challenges. Important information, documentation and the results of investigations may not be available, and the patient may be unable to contribute. There may be cardiovascular instability with established or impending multiple organ-system failure, and the patient may well have been recently exposed to anticoagulants or thrombolytics. Furthermore, patients transferred from another hospital may already be colonized with antibiotic resistant strains of bacteria. In this situation, the anaesthetist can do little more than elicit information from those sources that are available that is family members, referring physicians, copies of admission notes, physical examination, unreported investigations. In the case of acute dissection of the ascending aorta, where there is a cumulative mortality of 1% for every hour of conservative management, the desire for exhaustive perioperative assessment has to be balanced against the need to expedite surgery.[7]

Risk assessment

Despite advances in surgical techniques, anaesthesia and critical care, cardiac surgery still carries a finite risk of death and serious complications. However, the majority of patients can reasonably expect to survive without long-term sequelae. Helping the patient to weigh the risks of surgery against the symptomatic and prognostic benefits is largely the responsibility of the

surgeon. Nevertheless, it is essential that the anaesthetist understands how risk is assessed and that the patient is not given conflicting or contradictory information.

Cardiac surgeons have some of the most sophisticated risk assessment tools in medicine at their disposal. As a result, the ASA functional status classification is completely redundant in the setting of cardiac surgery. In the late 1980s, Parsonnet and colleagues[8] identified 14 independent risk factors for death after cardiac surgery. The so-called Parsonnet score (Table 5) was adopted by many centres worldwide and is still in use today.

However, most present day cardiac surgeons 'out-perform' Parsonnet by a factor of 2, reducing the usefulness of the scoring system as both a measure of risk and surgical performance. The European System for Cardiac Operative Risk Evaluation (EuroSCORE),[9] developed in the late 1990s, provides a more robust risk assessment, which like its predecessor, can be readily calculated at the bedside (Table 6). The EuroSCORE has been validated in the UK, Europe and North America, and has been shown to be predictive of major complications, duration of critical care and resource utilization.

For high-risk patients, the logistic EuroSCORE[10] provides a more accurate prediction than the simple additive score. This can be calculated using the formula:

$$\frac{e^{-4.789594+\sum \beta_i X_i}}{1+e^{-4.789594+\sum \beta_i X_i}}$$

where β_i is the coefficient of the variable X_i in the logistic regression equation given in Table 6. If a categorical risk factor is present $X_i = 1$, otherwise $X_i = 0$. For age, $X_i = 1$ if age <60 yr otherwise X_i = age − 58. For example, a fit 60-yr-old man with asymptomatic critical left main stem coronary artery stenosis and normal LV function undergoing elective surgery has a EuroSCORE predicted mortality of 1% (0.94% logistic). In contrast, a 75-yr-old woman with poor LV function, chronic pulmonary disease and class IV angina undergoing emergency coronary artery bypass has a predicted mortality of 13% (38.74% logistic). If operated on by the same surgeon, both patients would contribute to their results for *first-time* coronary artery bypass surgery.

When discussing risk, Gigerenzer[11] and others have shown that patients (and indeed doctors) are much more able to understand and recall information when it is presented in natural frequencies (i.e. 'out of 100 patients like you, 25 will feel nauseated') rather than conditional probabilities (i.e. '25% of patients are sick after surgery').

Table 5 The Parsonnet additive risk stratification model for cardiac surgery.[8] LV, left ventricle; LVEF, LV ejection fraction; CABG, coronary artery bypass graft

Factor	Points	Factor	Points
Age		LV function	
70–74 yr	7	Good (LVEF ≥50%)	0
74–79 yr	12	Moderate (LVEF 30–49%)	2
>84 yr	20	Poor (LVEF <30%)	4
Diabetes mellitus	3	LV aneurysm	5
Hypertension	3	Redo procedure	
		First	5
Morbid obesity	3	Second/subsequent	10
Female	1	Preoperative intra-aortic balloon pump	2
Dialysis dependent	10	Mitral valve surgery	5
Catheter laboratory complication	10	Pulmonary artery pressure ≥60 mm Hg	3
'Catastrophic state'	10–50	Aortic valve surgery	5
'Rare conditions'	2–10	Aortic valve gradient >120 mm Hg	2
		Valve + CABG surgery	2

Table 6 EuroSCORE—The European System for Cardiac Operative Risk Evaluation additive risk stratification model. [9] http://www.euroscore.org. VT, ventricular tachycardia; VF, ventricular fibrillation; IABP, intra-aortic balloon pump; CABG, coronary artery bypass graft

Factor		Points	β
Age	Per 5 yr or part thereof more than 60	1	0.0666354
Sex	Female	1	0.3304052
Chronic pulmonary disease	Long-term use of bronchodilators or steroids for lung disease	1	0.4931341
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	0.6558917
Neurological dysfunction	Severely affecting ambulation or day-to-day functioning	2	0.841626
Previous cardiac surgery	Requiring opening of the pericardium	3	1.002625
Serum creatinine	>200 μmol litre^{-1} before operation	2	0.6521653
Active endocarditis	Patient still under antibiotic treatment for endocarditis at the time of surgery	3	1.101265
Critical preoperative state	*Any one or more of the following:* VT or VF or aborted sudden death, preoperative cardiac massage, preoperative ventilation before arrival in the anaesthetic room, preoperative inotropic support, IABP, or preoperative acute renal failure (anuria or oliguria <10 ml h^{-1})	2	0.9058132
Unstable angina	Rest angina requiring i.v. nitrates until arrival in the anaesthetic room	2	0.5677075
LV dysfunction	Moderate (LV ejection fraction 30–50%)	1	0.4191643
	Poor (LV ejection fraction <30%)	3	1.094443
Recent myocardial infarct	Within 90 days	2	0.5460218
Pulmonary hypertension	Systolic pulmonary artery pressure >60 mm Hg	2	0.7676924
Emergency operation	Carried out on referral before the beginning of the next working day	2	0.7127953
Other than isolated CABG	Major cardiac procedure other than or in addition to CABG	2	0.5420364
Surgery on thoracic aorta	For disorder of ascending arch or descending arch	3	1.159787
Post infarct septal rupture		4	1.462009

Conveying information

At the end of the evaluation process, the anaesthetist should briefly summarize what the patient can expect on the day of surgery for example abstinence from food, premedication, transfer to the operating suite, insertion of cannulae before induction. A discussion of immediate postoperative care should include some mention of weaning from mechanical ventilation, provision of analgesia and prevention of nausea. It is usually advisable to tell the patient which of their regular cardiac medications should be taken before surgery. Common anaesthetic sequelae (e.g. bruising, phlebitis, hoarseness, nausea, vomiting) should also be mentioned.

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Please see multiple choice questions 14–16.