Anaesthesia for patients with cardiac disease undergoing non-cardiac surgery

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Abstract

One of the biggest challenges for anaesthetists today is the safe conduct of anaesthesia for patients who might be elderly, have pre-existing cardiac disease and are scheduled to undergo non-cardiac surgery. Within the financial constraints of today's health services, the appropriate investigations need to be decided and performed for these patients in order to inform the anaesthetist, surgeon and the patient of the risk of surgery. These should be undertaken only if they will influence management of the patient. The preoperative assessment will help with the formation of a perioperative management plan, including preoperative optimization and postoperative care, in order to minimize the risk of an adverse outcome. The most recent guidelines for preoperative cardiovascular evaluation for non-cardiac surgery are discussed in detail, including assessment of risk factors and cardiac investigations. Current thinking in preoperative therapy, intraoperative management and postoperative management is discussed. Although most patients with cardiac disease have ischaemic heart disease, other specific cardiac conditions and the principles of their management are discussed briefly.

Keywords Cardiac disease; cardiac investigations; non-cardiac surgery; preoperative assessment; preoperative optimization; risk assessment; risk factors

Royal College of Anaesthetists CPD Matrix: 2A03

Learning objectives

After reading this article, you should be able to:

- identify factors which will lead to increased cardiovascular risk for patients undergoing non-cardiac surgery
- decide which patients require further cardiovascular testing prior to non-cardiac surgery
- understand the principles of anaesthesia for patients with cardiac disease

The number of patients with cardiac disease presenting for anaesthesia to facilitate non-cardiac surgery is increasing. These patients present some of the greatest anaesthetic challenges because their cardiac lesions will still exist after the operation, unlike patients undergoing cardiac surgery. Perioperative cardiac morbidity (myocardial ischaemia, infarction, arrhythmias) is the most common cause of death after anaesthesia and surgery. Those who develop cardiac complications are more likely to have non-cardiac complications and vice versa. Despite improvements in anaesthetic technique, the mortality associated with a perioperative myocardial infarction is 40–70%. The prevalence of coronary artery disease increases with increasing age, and it is estimated that about 33% of patients undergoing non-cardiac surgery are at risk of having cardiovascular disease. In many patients, this might not have been diagnosed or quantified; therefore, preoperative assessment is important to identify the disease and its attendant risks. Other forms of cardiac conditions (valvular and congenital heart disease or patients with heart transplant) should also be considered.

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Preoperative assessment

Preoperative assessment is important to:

- assess the risk to the patient
- optimize the patient's condition and identify risk factors requiring long-term management
- form a plan for perioperative management to minimize the risk of an adverse outcome
- inform the patient of the points above

Communication is the key to optimal management.

Assessment of risk

The best known scoring system for estimating the risk of surgery for patients with cardiac disease was developed by Goldman in 1977, and modified by Detsky in 1986. This system is a multifactorial risk analysis that combines clinical and investigative parameters and allows patients to be grouped into four risk categories, for major complications or cardiac death. In 1999, Lee proposed a Revised Cardiac Risk Index (RCRI) that identifies six independent risk factors and has become one of the most widely used risk indices along with the physical status system produced by the American Society of Anesthesiologists (ASA). The latter is somewhat subjective and lacks specificity.

In 2014, the American College of Cardiology and American Heart Association (ACC/AHA) produced updated guidelines for perioperative evaluation and care for non-cardiac surgery (superseding those from 1996 to 2007). Clinical practice guidelines have also been produced by the European Society of Cardiologists and European Society of Anaesthesiology (ESC/ESA) and the recommendations are broadly in agreement with those from ACC/AHA. These guidelines divide clinical predictors of increased perioperative cardiac risk into three categories (Box 1). Recognition of these factors, the functional capacity (Box 2) and the type of surgery are then used to inform the anaesthetist about the need for further cardiac investigation. The definition of the urgency of the operation has been slightly modified (Box 3) as

Clinical predictors for increased perioperative cardiac risk

Active cardiac conditions (major risk factors)

- Unstable coronary syndromes
  - Unstable or severe angina (CCS class III or IV)
  - Recent myocardial infarction (<30 days)
- Decompensated heart failure (NYHA class IV; worsening or new-onset heart failure)
- Significant arrhythmias (including atrioventricular heart blocks, symptomatic ventricular arrhythmias, supraventricular arrhythmias with uncontrolled ventricular rate, symptomatic bradycardia, newly recognized ventricular tachycardia)
- Severe valvular disease
  - Severe aortic stenosis (mean pressure gradient >40 mm Hg; aortic valve area <1 cm^2; symptomatic)
  - Symptomatic mitral stenosis

Intermediate factors (from the Revised Cardiac Risk Index)

- History of ischaemic heart disease
- History of compensated or previous heart failure
- History of cerebrovascular disease
- Diabetes mellitus
- Renal insufficiency

Minor factors

- Age (physiological) >70 years
- Abnormal ECG (left ventricular hypertrophy, left bundle-branch block, ST abnormalities)
- Rhythm other than sinus (e.g. atrial fibrillation)
- Uncontrolled systemic hypertension

CCS, Canadian Cardiovascular Society; NYHA, New York Heart Association.

Box 1

Estimated energy requirements for various activities

Poor functional capacity (1–4 MET)

- Light housework
- Shower or dress without stopping
- Walk at 2–3 mph on level ground

Moderate functional capacity (5–7 MET)

- Climb a flight of stairs without stopping
- Walk briskly (>4 mph) on flat
- Light gardening

Excellent functional capacity (>7 MET)

- Digging in garden
- Carrying shopping upstairs
- More strenuous sports (e.g. cycling uphill, jogging)

MET, metabolic equivalents.

Box 2

Definition of urgency of operation

- Emergency – life or limb threatened if not operated on within 6 hours
- Urgent – should receive operation within 6–24 hours
- Time sensitive – operation could be delayed 1–6 weeks
- Elective – operation could be delayed up to 1 year

Box 3

has the surgical risk in the ACC/AHA Guidelines (see below). A predictive model of Major Adverse Cardiac Event (MACE) which included death and myocardial infarction (MI) was developed in 2011 using the American College of Surgeons Quality Improvement Program database. They found five predictors of perioperative MI/cardiac arrest: type of surgery, functional status, elevated creatinine (>130 μmol/litre or >1.5 mg/litre), ASA class and age. This combined with the RCRI model are complementary prognostic tools. The guidelines propose a stepwise approach to decision-making regarding the need for detailed cardiac investigation (Figure 1).

The history, physical examination, basic haematological tests, 12-lead ECG and chest radiograph should be carried out to identify the:

- presence of heart disease
- severity, stability and previous treatment of the disease
- functional capacity of the patient
- presence of co-morbid conditions.

More detailed cardiac investigations might be appropriate in patients who are awaiting elective or, on occasions, urgent surgery. In the emergency situation, patients with cardiac risk factors and reduced functional capacity have a high perioperative risk, but delaying surgery for detailed investigation does not benefit the patient. Most of the literature concentrates on vascular surgical patients and therefore might not be representative of most patients having non-cardiac surgery.

Patient risk factors

Previous coronary revascularization: patients who have undergone coronary artery bypass grafting (CABG) or percutaneous transluminal coronary angioplasty (PTCA) with or without stent insertion in the previous 5 years, and who have had no recurrence of symptoms with a return to an active lifestyle, do not need further testing. Elective non-cardiac surgery, in which the antiplatelet drugs required to prevent in-stent stenosis might need to be discontinued to prevent bleeding, is not recommended within 14 days of balloon angioplasty, 30 days of bare-metal stent implantation (BMS) or within 12 months after drug-eluting stent (DES) implantation especially in those whose dual antiplatelet therapy will need to be discontinued perioperatively. Elective surgery after DES implantation may be considered after 180 days if the risk of further delay is greater than the risks of ischaemia and stent thrombosis. The presence of antiplatelet drugs, especially some of the newer ones, may provide a challenge for preventing blood loss. A cardiologist's opinion on the

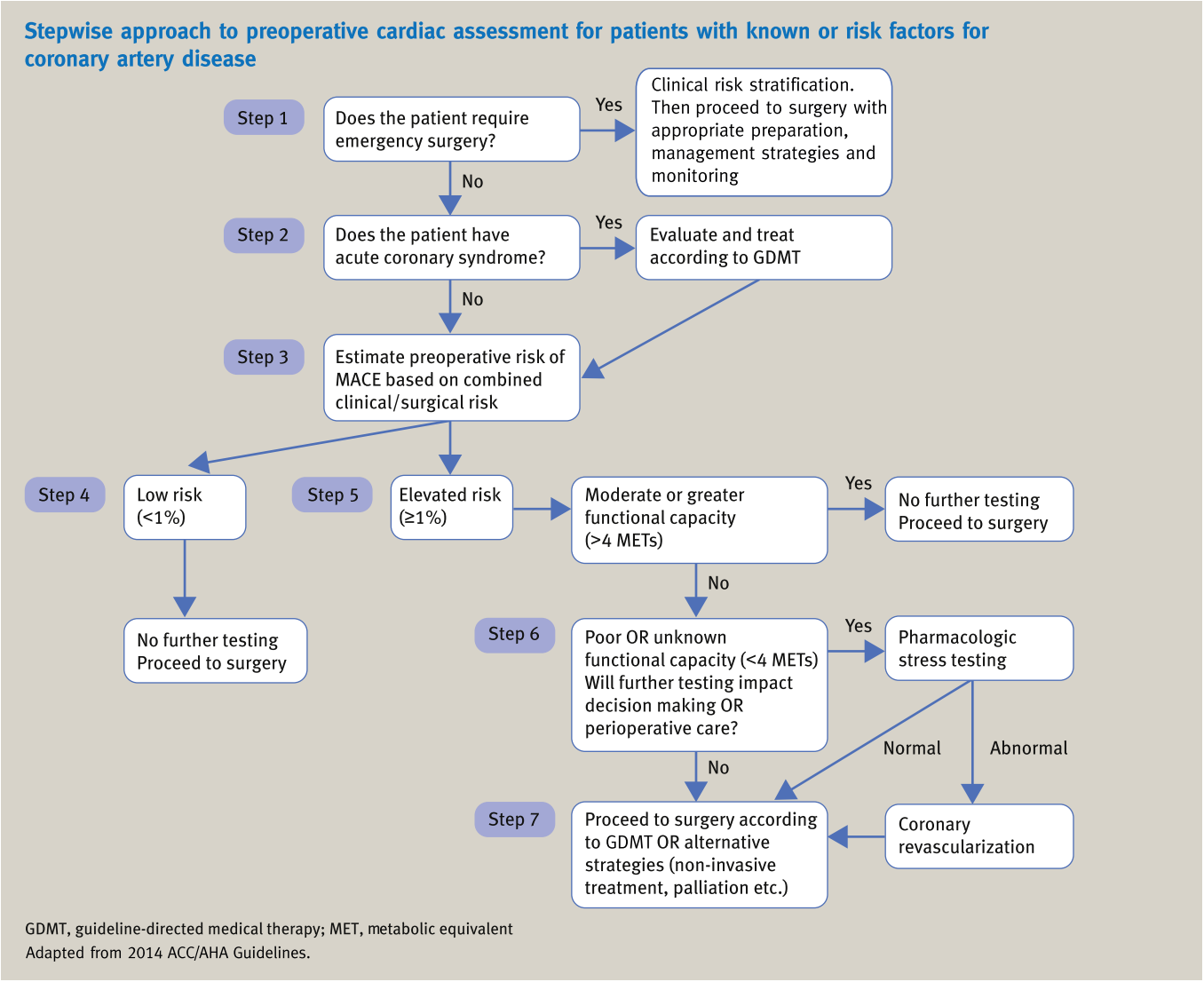

Figure 1

optimal time to schedule elective surgery and thus discontinuation of the antiplatelet agents should be sought.

Previous coronary evaluation: those who have had cardiac evaluation in the previous 2 years should need no further investigation providing their symptoms have not changed and their activity levels have not deteriorated.

Myocardial infarction and ischaemia – advances in the treatment of myocardial infarction (thrombolysis, PTCA with or without stent) have meant that the traditional high-risk period of 6 months following infarction may be reduced, providing there is evidence that no further myocardium is at risk. This is assessed by stress testing (discussed below). The heart takes 4–6 weeks to remodel and heal following infarction, during which time it is more vulnerable to arrhythmias and myocardial stunning. The haemodynamic stresses and hypercoagulability associated with surgery can also lead to extension of the infarct. Patients who have unstable or severe angina (Canadian Cardiovascular Society (CCS) class III or IV) also have a high probability of continuing plaque rupture and thrombosis. Although it is common practice to postpone truly elective surgery until 6 months after a myocardial infarction, patients who have had a myocardial infarction over 6 weeks previously and show no evidence that further myocardium is at risk can proceed with urgent surgery with perioperative cardiac risk-reduction strategies. When at least 6 months have elapsed, those who have resumed normal daily activity and have no post-infarction angina should not need further testing, unless the risk of surgery or the functional capacity warrants it.

Arrhythmias – the cause should be identified and treatment begun, especially for arrhythmias that are symptomatic and cause hypotension. Indications for antiarrhythmic drugs and cardiac pacing are the same as in the non-surgical patient.

Decompensated congestive heart failure – these patients should have their medical therapy optimized to minimize the risk of worsening their pulmonary oedema. If ischaemia is the cause, they are also at risk of developing a perioperative myocardial infarction.

Compensated congestive heart failure – patients with a left ventricular ejection fraction less than 35% are at particular risk of perioperative complications.

Diabetes mellitus – there is a high incidence of silent ischaemia associated with diabetic neuropathy, making the lack of angina with exercise a less reliable symptom. Dyspnoea, especially with minimal exertion, can be a more important symptom. There is proof of increased risks only in those patients on insulin.

Hypertension – inclusion of hypertension as an intermediate or minor risk factor remains controversial. There is some evidence that, if left ventricular hypertrophy is present and blood pressure is not well controlled, the risk is more significant because the increase in left ventricular mass makes it more susceptible to changes in oxygen delivery and demand. Severe hypertension should be controlled before surgery if possible.

Renal impairment – a preoperative creatinine level of more than 180 μmol/litre (2 mg/dl) or reduced creatinine clearance is a significant, independent risk factor for postoperative renal dysfunction and cardiac complications.

Minor risk factors – cerebrovascular disease and renal insufficiency might not be direct risk factors but markers of end-organ damage from the same factors that cause coronary artery disease. The greater the number of minor and intermediate risk factors the greater the risk of the patient having coronary artery disease.

Functional capacity: exercise tolerance is assessed by history and is expressed as metabolic equivalents (MET; 1 MET = 3.5 ml O_2/kg/minute) on a scale defined by the Duke Activity Status Index in order to estimate the patient's maximal oxygen consumption capacity (Box 2). Patients with moderate or excellent functional capacity and low clinical predictors of risk do not need further cardiac investigation. The functional capacity of some patients might be limited by other conditions (e.g. respiratory, peripheral vascular or joint disease). These patients and those with poor functional capacity should undergo detailed cardiac assessment.

Surgical risk factors: the type of surgery and the resultant degree of haemodynamic stress influences the risk to the patient. The ESC/ESA Guidelines have continued dividing the risk of surgery into low (<1%), intermediate (1–5%) and high (>5%) as described in an earlier version of this article (*Anaesthesia & Intensive Care Medicine* 2012; **13**(10): 519–523). The ACC/AHA guidelines have simplified this into those operations where the risk of MACE is less than 1% (low-risk procedure) and those with a risk of 1% or higher (elevated risk procedure).

In peripheral vascular surgery the extent of the cardiac disability can be masked by the limits imposed by intermittent claudication. The risk of not performing the surgery must also be taken into account, as must the experience and skill of the surgeon and anaesthetist.

Further cardiac investigations: all cardiovascular tests have limitations and risks and should be carried out only if the results will change the patient's management.

Coronary angiography and revascularization – the indications for these investigations are the same as for those patients not having surgery (e.g. unstable angina unresponsive to medical treatment, deteriorating severity of symptoms). This also pertains to CABG. Those awaiting an elevated-risk procedure are thought to potentially benefit from prior revascularization. The cumulative risks of both procedures should be considered as the combined risk of both procedures might be greater than that of non-cardiac surgery with perioperative risk-reduction strategies. Preoperative percutaneous coronary intervention (balloon angioplasty or BMS) should be considered in patients with left main stem disease or unstable CAD.

Ambulatory ECG monitoring – has been used to assess silent ischaemia, but in a significant number of patients (up to 50%) resting ECG abnormalities (e.g. bundle-branch block) make the interpretation difficult.

Stress tests – (e.g. exercise ECG, dipyridamole-thallium scintigraphy (DTS) or dobutamine stress echocardiography (DSE)) are dynamic investigations that elucidate the possibility of threatened myocardium and the maximal tolerated heart rate. DTS and DSE are the only non-invasive tests that improve preoperative risk stratification.

Echocardiography and technetium-99 scanning – assess myocardial function but cannot predict ischaemic events. Echocardiography is also used to assess the nature and severity of valvular heart disease. Those who have had an echo within the past year and no deterioration in symptoms do not require further testing. (For further details of tests, see Preoperative Assessment for Cardiac Surgery in *Anaesthesia & Intensive Care Medicine* 2012; **13**(10): 469–474).

Other systems – (e.g. respiratory, renal, endocrine, skeletal, airway) need assessment and possible further investigation. The results may affect the anaesthetic plan.

Preoperative therapy

The patient's condition and medication should be optimized. Most cardiac medication should be continued perioperatively. There is evidence that continuation of angiotensin-converting enzyme inhibitors can increase the incidence of hypotension and some physicians have recommended withholding them for 24 hours preoperatively. Two specific strategies have been suggested to reduce postoperative morbidity and mortality.

- **Heart rate control**: In 2014 ACC/AHA produced a Review on Perioperative β-blockade from an analysis of many studies. The veracity of some previous studies had been disputed and these were excluded in this systematic review. Beta blockade started within 1 day of the operation prevents non-fatal perioperative MI but increases the risk of stroke, death, hypotension, bradycardia and all-cause mortality. They recommended that patients already taking β-blockers should continue them until surgery but starting them in the immediate preoperative period for those who have no coronary disease or risk factors is not recommended. The optimum time from surgery for commencing and discontinuing β-blocker in those with intermediate- or high-risk myocardial ischaemia is less clear and it seems that achieving a target heart rate is more important. Alpha-2 agonists are not recommended for prevention of cardiac events. There is insufficient evidence about the effects of preoperative and intraoperative

nitroglycerine. Treatment with statins has been shown to reduce the risk of perioperative events especially in vascular surgery, as have some ACE inhibitors and calcium channel blockers.

- Goal-directed optimization (preoperative invasive monitoring and manipulation of fluid and inotropic therapy to optimize cardiac index, oxygen delivery and consumption) is less popular now, perhaps due to increased pressure on ICU and HDU beds. It has been shown to decrease postoperative complications and overall mortality.

Premedication should be adequate to allay anxiety, and oxygen therapy preoperatively can be advantageous. Warfarin therapy should be replaced with heparin, and antiplatelet drugs (aspirin, clopidogrel) should be stopped at the appropriate time.

Intraoperative management

Principles

The oxygen supply–demand ratio must be maintained to avoid ischaemia (Box 4), and this should be continued into the postoperative period. In coronary artery disease, the pressure gradient across the fixed stenoses is important because the coronary arteries cannot dilate in response to increased oxygen demand. Maintenance of arterial blood pressure and reduction of heart rate should reduce the risk of ischaemia. This is also important in patients with aortic stenosis. It has been suggested that, in cardiac patients, a haemoglobin level of 10 g/dl or more is needed to optimize the oxygen supply.

In the preoperative plan, it is important to decide which values of preload, heart rate, systemic vascular resistance, pulmonary vascular resistance and rhythm are acceptable, and to anticipate the times when the maintenance of these values will be most difficult (e.g. induction, intubation, blood loss). Strategies to deal with these situations should be considered preoperatively.

Factors affecting myocardial oxygen supply and demand

Supply

- Coronary perfusion pressure (aortic diastolic pressure minus left ventricular end-diastolic pressure)
- Blood oxygen content
- Partial pressure of oxygen in arterial blood (P_aO_2)
- Haemoglobin concentration
- Coronary vascular resistance
- Coronary artery stenosis
- Heart rate and left ventricular end-diastolic pressure
- Autoregulation

Demand

- Heart rate
- Contractility
- Wall tension
- Left ventricular end-diastolic pressure
- Arterial pressure
- Contractility

Box 4

Anaesthetic agents

The choice of anaesthetic agents and techniques does not significantly affect the risks of perioperative complications, providing hypertension, tachycardia and hypotension are avoided. It should be governed by the experience and skill of the anaesthetist and his or her familiarity with the techniques and drugs. Etomidate, which is decreasing in popularity, has the fewest cardiovascular effects, but most people are more familiar with thiopental (thiopentone) or propofol, both of which should be titrated carefully to effect. Pretreatment with a dose of opioid reduces the required dose of induction agent and can attenuate the haemodynamic response to intubation. Remifentanil is a potent, ultra-short-acting opioid, which has a great ability to cause haemodynamic stability and suppress the stress response. It is administered by infusion, and transfer to other methods for postoperative analgesia needs careful consideration. Concerns were previously raised that isoflurane might cause a 'coronary steal' situation, but these have subsided. It should be remembered that N_2O is also a myocardial depressant. The role of regional blockade is keenly debated. It has many advantages, not least in reduction of the stress response and in effective analgesia. Preservation of an adequate perfusion pressure is vital and the vasodilatation caused might be best avoided in some patients. However, incomplete anaesthesia can lead to increased stress response and myocardial ischaemia.

Monitoring

Myocardial ischaemia can be more easily detected with a five-lead ECG. Recent studies have shown that V5 is the most sensitive single lead. ST segments should be monitored in high-risk patients. Invasive monitoring by arterial and pulmonary artery catheters can be useful in those at high risk, especially if they have had a recent MI with cardiac failure, providing the anaesthetist has the experience to insert the catheters and interpret the data. The pulmonary artery catheter, though not recommended for routine use, may be useful in monitoring volume status and cardiac performance, such as cardiac output/index, mixed venous oxygen saturation and systemic and pulmonary vascular resistances. There are other less invasive devices to measure cardiac performance but not volume status. Transoesophageal echocardiography can be used to assess volume status and valvular disease, and is the best way to detect ischaemia early (segmental wall motion abnormalities), but it requires expertise to interpret it. Information received from the monitors (e.g. hypotension, ischaemic changes, left ventricular dysfunction, arrhythmias) needs to be acted on urgently, especially in those with severe disease.

Temperature control

There is a higher incidence of cardiac morbidity in patients who become hypothermic; therefore, active warming measures are often required.

Blood glucose control

Tighter blood glucose control (4.4–6.1 mmol/litre) leads to reduced morbidity and mortality.

Postoperative management

The period after surgery is associated with increased levels of catecholamines and hypercoagulability. Most perioperative

infarcts occur in the first 3 days; therefore, the preoperative plan should include the most appropriate place for postoperative care, and the same management goals should be adhered to in this period. All patients should receive humidified oxygen, for at least 72 hours after major surgery. Postoperative analgesia should be adequate. Anaemia should be treated and thromboprophylaxis continued. The patient's normal cardiac medication should be restarted as soon as possible.

Specific conditions

Valvular heart disease

Stenotic lesions lead to a low, fixed cardiac output, which tolerates poorly any changes in rhythm, tachycardia and decrease in preload and vascular resistance. Replacement of the valve before non-cardiac surgery might need to be considered in those with severe symptomatic disease, especially aortic stenosis. Patients with regurgitant valves benefit from afterload reduction, faster heart rates and maintenance of preload. Antibiotic prophylaxis is necessary for all cases and should be governed by the type of surgery and local regimens.

Congenital heart disease

Anaesthesia for these patients is discussed in the article on Adult Congenital Heart Disease on pages 285–291 of this issue. It is vital to understand the pathophysiology of the particular lesion.

Cardiac transplant

All electrical stimulation in the heart is initiated from the donor sinoatrial node. The resting heart rate is generally 90–120 beats/minute, and there is no response to carotid sinus massage, changes in body position, light anaesthesia or hypotension. An adequate preload should be maintained. Cardiac drugs that act directly on the myocardium or peripheral vasculature are necessary because those acting on the autonomic system have no effect on the denervated heart. Invasive monitoring should be avoided when possible and strict asepsis used at all times. Antibiotic prophylaxis depends on the type of surgery and should include anti-*Staphylococcus* cover. It is imperative that immunosuppressive therapy is continued.

The presence of either hypertrophic cardiomyopathy or pulmonary hypertension leads to an increased risk of perioperative morbid events. They should continue on their current medication where possible and a consultation with a specialist should be considered. The presence of a pacemaker or automated implantable cardioverter defibrillator device requires an understanding of the programming, the indication for its insertion, electrical hazards and a management strategy for the perioperative period. The patient should be on a cardiac monitor for the whole time that the defibrillator is inactive.

Addendum

Another paper from the Canadian Cardiovascular Society outlining Guidelines on this subject has come to light since this article was completed. Recommendations, which have not been noted in the other Guidelines referenced, include measurement of BNP or NT-proBNP in patients over 65 years or those aged 45–64 years with significant cardiovascular disease or an RCRI score >1 followed by daily troponin levels for 48–72 hours postoperatively in those with elevated levels, withholding ACE inhibitors and angiotensin II blockers for 24 hours pre-operatively and non-initiation of beta-blockers and alpha 2 agonists also in that period. ◆

FURTHER READING

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