ANAESTHESIA FOR ADULT CARDIAC PATIENTS UNDERGOING NONCARDIAC SURGERY

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Patients with cardiac disease presenting for noncardiac surgery are at increased risk of intraoperative complications such as myocardial infarction (MI), cardiac arrhythmias, pulmonary insufficiency, and death. It is well established that the number of patients with cardiac disease presenting for anaesthesia and surgery are on the increase. This may be due to the fact that the surgery is being performed on older patients in whom the incidence of coronary artery disease (CAD) is higher, and secondly, recent advances in diagnostic technology have allowed us to detect CAD in asymptomatic or mildly symptomatic patients. With increased awareness and improved cardiac surgical results, a substantial number of patients who have undergone corrective cardiac surgery are also presenting for noncardiac surgery. A thorough preanaesthetic evaluation (PAE) is essential to stratify the risk of anaesthesia and surgery.

PREANAESTHETIC EVALUATION

The PAE of a surgical patient consists of a thorough history, physical examination and appropriate laboratory tests. Goldman et al identified two significant and independent predictors for perioperative complications based on the history of 1001 patients: age and history of MI within 6 months. This has never been validated prospectively even in the same institution and did not take into consideration any anaesthetic factors. Since then there have been a series of similar studies to identify significant historical predictors. These include age, history of previous MI, preoperative congestive heart failure (CHF), diabetes and a history of arrhythmias. In the overall assessment of perioperative cardiac risk, the presence of angina, hypertension (HTN), valvular heart disease (VHD), peripheral vascular disease (PVD), cigarette smoking, previous cardiac surgery and current cardiac medications must be considered. A complete physical examination will yield important information about the cardiac status of the patient. Jugular venous distension and S3 gallop are significant findings in the diagnosis of CHF. Hypertension is known to contribute to perioperative morbidity. The predictive value of laboratory/ diagnostic tests continues to be an issue for investigation. Routine electrocardiogram (ECG) offers little value but serves as a baseline for intraoperative and postoperative comparisons. In addition, majority of the patients with CAD may have "silent ischaemia" previously thought to be common in diabetics only. Up to 70% of the ischaemic episodes occurring in patients with CAD are asymptomatic and 10-15% of acute MIs are painless. A chest X-ray may show cardiomegaly, an indicator of left ventricular dysfunction in

patients with CAD or pulmonary congestion, which may indicate overt CHF. Exercise tolerance test (Treadmill) is helpful in deciding which ECG leads should be monitored to detect intraoperative ischaemia. The 2-dimensional echocardiography is an invaluable tool for measurement of global left ventricular (LV) ejection fraction and for detection of regional wall motion abnormalities (RWMA). The presence of RWMA constitutes evidence of CAD with some exceptions. Echocardiography and Doppler are also the best means of evaluating valvular abnormalities and congenital cardiac defects. A resting radionuclide ventriculogram (MUGA) will also provide an accurate assessment of global and regional LV function. Cardiac catheterization is considered to be the "gold standard" for assessment of LV function and determination of the extent of CAD. This invasive test has been found to be useful in determining those patients who should be offered coronary artery bypass graft (CABG) surgery prior to undergoing elective noncardiac surgery. Once the initial preoperative evaluation is complete, the patient is assigned an ASA physical status classification. A number of other risk indices are being used e.g. The cardiac risk index (CRI), the New York Heart Association (NYHA) classification, the Canadian Cardiovascular Society Classification (CCSC) of angina and Detsky's modified approach to the Goldman index. The ASA and CRI classifications are used commonly. Several disease states such as HTN, CAD, VHD, CHF, arrhythmias and prior cardiac transplantation are of particular interest and are briefly discussed here in relation to PAE prior to noncardiac surgery.

Hypertension

HTN (defined as a diastolic BP>90mmHg or a systolic BP>140mmHg in adults) is the most common of all the cardiovascular diseases. Most patients are under adequate control preoperatively and their medication should be continued till the day of surgery. Poorly controlled or uncontrolled hypertensives are at increased risk of perioperative complications such as ischaemia, MI, arrhythmias and cerebrovascular accidents (CVA). In mild hypertensive patients a single dose of long acting beta-blocker may reduce the risk of myocardial ischaemia during stressful periods. However, in patients with moderate to severe HTN, cardiology consultation should be obtained and BP brought under control prior to elective surgery.

CAD

Many patients with CAD are subjected to noncardiac surgery. Unstable angina is a contraindication to anaesthesia and surgery unless it is a lifesaving procedure. It is advisable to postpone surgery in such patients till symptoms are controlled and a detailed evaluation is completed. The clinical variables that determine the risk include the duration since the MI, the presence of angina and the severity of LV dysfunction. It has been traditionally recommended that elective surgery be delayed for at least 3 and preferably 6 months after MI for the fear of recurrent MI. Now with the availability of thrombolytic therapy and primary PTCA for acute MI, previous data on the risk of reinfarction may no longer be applicable. If the patient does well after MI and has a good exercise tolerance one can proceed with the non-cardiac surgery 6 weeks after MI. However, if the patient has a poor exercise tolerance or symptoms of LV dysfunction then further evaluation is necessary to determine the degree of myocardial damage. A

guideline for the use of cardiac diagnostic test based on patient symptomatology is shown in Table 1. The ultimate aim is to optimize patients' medical condition and properly inform them of perioperative risks involved during the operation. An obese, CAD patient should also be queried about any history of sleep disorder, as coronary spasm is known to occur in such individuals.

CHF

A history of both previous and current CHF is associated with increased incidence of perioperative cardiac morbidity. Decompensated CHF is a contraindication for anaesthesia. Control of CHF (with the use of diuretics, inotropes and vasodilators) should be optimized prior to surgery.

Arrhythmias

The presence of bundle branch block does not appear to increase perioperative risk. Similarly atrial fibrillation or atrial flutter are not considered as independent predictors of adverse outcome. Presence of frequent premature ventricular contractions or ventricular tachycardia is probably a reflection of underlying CAD. Further preoperative workup of these patients should be similar to those with evidence of CAD.

Prior CABG

A history of CABG is not a contraindication for anaesthesia. Asymptomatic patients undergoing non-cardiac surgery do not pose additional risk of complication. If the patient is suffering from angina or recent MI or is in CHF, his line of management is similar to that described for the subgroups above.

Prior Cardiac Transplantation

The primary reason why heart transplant patients require surgery is of infection in origin. Common surgical procedures performed in these patients are exploratory laparotomy (for pancreatitis, cholecystitis, GI bleeding, perforation) bronchoscopy, wound debridement, craniotomy and vascular surgery or amputation for lower limb ischaemia. Preoperative evaluation of patients with a transplanted heart should include a review of recent follow-up clinical visit. Hypertension is commonly seen and is often attributed to cyclosporine therapy. A recent history of CHF is often related to rejection. Arrhythmias are commonly seen, including the presence of two P waves (originating from donor and recipient sinus node) and incomplete and right bundle branch block. The risk of infection and sepsis is very high in these immuno-compromised patients; hence strict aseptic techniques should be adopted. Denervated heart physiology and pharmacology should be kept in mind. These patients are more vulnerable to stresses normally met via a neurally mediated chronotropic response. They are more vulnerable to myocardial depressants because of greater dependence on Frank-Starling mechanism. Profound sympathetic blockade should be avoided in such patients. The effect of direct acting agents is more predictable as compared to indirect acting agents in denervated heart.

Current Cardiovascular Therapy

Antianginal, antihypertensive or antiarrhythmic medications should be continued upto and including the day of surgery. Abrupt discontinuation of beta blockers, methyl dopa, clonidine, nitrates or calcium channel blockers may lead to increased sensitivity of the systemic and coronary vasculature and can precipitate myocardial ischaemia, hypertensive episodes or arrhythmias. Patients with hypertension and/or CAD clearly benefit from pretreatment with beta blockers, whereas calcium channel blockers do not offer adequate protection from intraoperative myocardial ischaemia. Of all the calcium antagonists, verapamil is most likely to interact unfavorably with beta-blockers, particularly in patients with conduction system abnormalities and impaired LV functions. Digitalis is the time honored therapy for CHF and atrial fibrillation with fast ventricular response. In addition to digitalis, patients with CHF are often on diuretics, vasodilators and ACE inhibitor. Serum potassium should be closely monitored in patients who are on digitalis and diuretics. In patients with artificial cardiac valves, oral anticoagulants should be replaced with intravenous heparin.

INTRAOPERATIVE MONITORING

Selection of adequate intraoperative monitoring is one of the foundations of anaesthetic management of a cardiac patient undergoing non-cardiac surgery. The presence of qualified anaesthesia personnel at all times is mandatory. A continuous ECG, repeated BP measurements, precordial stethoscope, end-tidal CO_2 measurement, pulse oxymetry and body temperature measurement should be routine throughout the anaesthetic procedure. Invasive haemodynamic monitoring may be appropriate for prolonged or major intraabdominal or thoracic procedures, but the same may do more harm than good for a minor surgical procedure. No specific monitoring technique has been shown to improve patient outcome. Intraoperative monitoring varies widely among anaesthesiologists. Important issues to be discussed here include specific ECG lead placement and ST segment analysis, invasive BP measurement, transesophageal echocardiography (TEE), central venous pressure (CVP) and pulmonary artery pressure (PAP) measurement.

ECG Monitoring

Continuous ECG monitoring allows the detection of intra-operative ischaemia and arrhythmias. Initially lead V5 was used to detect myocardial ischaemia with a sensitivity of 89%. Recently London et al used a 12 lead system and found that combining leads V4 and V5 resulted in a sensitivity of 90%, which increased to 96% when leads II, V4 and V5 were monitored. Recent advances in computer technology have introduced the concept of automated ST segment analysis. Significant intraoperative ischaemic episodes have been shown to correlate with postoperative MI. Presumably, early detection and treatment of intraoperative and postoperative ischaemia will reduce the incidence of perioperative MI and improve morbidity and mortality.

Blood Pressure Monitoring

Noninvasive BP (NIBP) monitoring consists of continuous and intermittent methods. Intermittent measurements may be manual (Riva-Rocci method) or automated (e.g. Dinamap) and should be used when the fluctuations in BP or intraoperative blood loss are minimal. Continuous NIBP measurement is a newer alternative that may provide additional benefits in the future. Direct arterial cannulation remains the gold standard and should be considered when there is need for beat to beat BP monitoring and perioperative blood gas analysis, however, risk of vascular insufficiency and infection should always be kept in mind. Tests of vascular insufficiency (including Allen's test and its modification) are probably not helpful in deciding which patient is at risk for vascular complications, as most of these are embolic in nature

TEE

TEE allows the detection of intracardiac air, evaluation of cardiac functions, real time assessment of RWMA, wall thickening, ejection fraction (EF), and therefore ventricular function. The RWMA were shown to occur within seconds of onset of ischaemia and prior to changes in PAP or ECG. The disadvantages are the cost and expertise required to arrive at a meaningful conclusion. In addition, it cannot be used during intubation and extubation when the incidence of ischaemia is highest. Whether TEE monitoring can reduce perioperative cardiac morbidity and mortality in non-cardiac surgery, remains to be seen.

CVP

CVP monitoring provides the estimate of blood volume and right heart function, but it is influenced by changes in vascular tone. It provides a reliable access for infusion of vasoactive drugs. CVP has been shown to correlate well with pulmonary capillary wedge pressure (PCWP) in patients with normal LVEF.

PAP

Use of a pulmonary artery catheter (PAC) in patients with cardiac disease undergoing non-cardiac surgery has been shown to decrease mortality in ASA class III and IV patients. Kaplan and Wells described early detection of ischaemia as compared to ECG by appearance of 'A' waves of >15mmHg and 'V' waves of >20mmHg on PAP tracing. The PAP functions to monitor preload, cardiac output (CO) and afterload. It allows measurement of mixed venous oxygen saturation, PCWP, calculation of intracardiac shunt, and diagnosis of cardiac tamponade. Most important use of PAC is in patients with LV dysfunction, as it allows the optimization of preload and CO either mechanically (by volume loading) or pharmacologically (inotropes and vasodilators) during the perioperative period. Placement of PAC should be considered in patients with major cardiac disease undergoing extensive surgical procedure (such as abdominal aortic aneurysm), under emergency conditions, with associated respiratory failure, sepsis and trauma. Infrequent use of PAC can lead to higher complication rate and there can be high incidence of misinterpretation of data.

ANAESTHETIC DRUGS AND TECHNIQUES

The selection of an anaesthetic technique in a cardiac patient must be based on the type of surgery and the desired haemodynamic goals during anaesthesia. There is little, if any, evidence that a particular anaesthetic technique is superior to others in terms of outcome.

Local Anaesthesia

LA with appropriate IV sedation is often a useful technique in cardiac patients undergoing non-cardiac surgery. Large doses of anaesthetic should be avoided as cardiac toxicity may manifest in the form of dysrrhythmias and myocardial depression. Use of epinephrine with LA will increase the maximum safe dose but will often result in tachycardia, which is undesirable and should be avoided. Patients under LA should be monitored with an ECG, BP and a pulse oxymeter. Supplemental oxygen therapy and a regular verbal contact with patient are important.

Regional Anaesthesia

A number of studies have shown that the rates of intraoperative adverse cardiac events do not differ when general or regional anaesthesia is used. However certain procedures have shown better outcome under RA. Reinfarction rate in a group of patients undergoing eye surgery under retrobulbar block was nil. McLaren et al found no mortality under spinal anaesthesia for fracture neck femur, versus 25%mortality after GA. Patients with prior MI undergoing transurethral resection of prostate had <1% reinfarction rate after spinal versus 2-8% after GA. RA due to loss of sympathetic efferent tone can result in rapid haemodynamic deterioration in some patients, for example, those with severe aortic stenosis or hypertrophic obstructive cardiomyopathy. Similarly in a patient with a failing heart who is dependent on sympathetic tone or otherwise unable to compensate for a decrease in BP, central neural blockade can precipitate cardiac arrest.

Combined Regional-General Anaesthesia

The combined technique requires a lot of experience on the part of anaesthesiologist. For lower abdominal surgery, a combination of lumbar epidural analgesia and GA can be considered when long surgical procedure, large blood loss or marked hypothermia is anticipated. The combination of thoracic epidural and GA can be used for upper abdominal, thoracic and major vascular surgery. The main advantages of epidural blockade are superior postoperative analgesia and less diminution of vital capacity. Epidural analgesia by suppressing pain improves transmural distribution of regional myocardial blood flow and thus minimizing myocardial ischaemia.

General Anaesthesia

General anaesthesia is the most common anaesthetic technique used for cardiac

patients undergoing noncardiac surgery. Pre-anaesthetic medication should be an integral part of anaesthetic practice, particularly in patients with CAD and hypertension. Benzodiazepines carry a low risk of cardiovascular and respiratory depression. Intravenous narcotics (e.g. Fentanyl) may be given prior to giving a regional block to supplement premedication. Both intravenous as well as inhalational anaesthetic techniques can be used for induction and maintenance of anaesthesia. Rapid IV induction with a sleep dose of hypnotic, followed quickly by a muscle relaxant, laryngoscopy and intubation, provokes intense stimulation of the sympathetic nervous system leading to tachycardia, hypertension and myocardial ischaemia. Adequate depth of anaesthesia should be ensured prior to intubation. Fentanyl 5-8 mgm/kg can be given to blunt the sympathetic responses to laryngoscopy and intubation. One must remember that the use of narcotics requires a concomitant reduction in the dose of hypnotic agent. Careful titration of IV or inhalational agent should result in smooth, safe induction without coughing, bucking, tachycardia and hypertension or significant decrease in heart rate, BP or CO. It is generally agreed that the more depressed the heart function, larger should be the opioid dose contribution in induction, and smaller the complimentary dose of hypnotic agent. The particular induction technique or agent is probably less important than the manner in which it is given. IV induction agents that have been used with varying efficacy include thiopentone, methohexitone, midazolam, etomidate, propofol fentanyl and ketamine. Ketamine should be administered after one of the narcotics to avoid tachycardia and hypertension. Thiopentone should be administered slowly and cautiously in patients with LV dysfunction. Midazolam provides excellent amnesia and is widely used for premedication and for outpatient anaesthesia. Haemodynamic changes with etomidate are the least and are therefore considered an excellent induction agent for patients with poor myocardial reserve. Propofol may be used for outpatient anaesthesia (due to quick recovery) in patients with good LV functions. Muscle relaxant should be selected as per the desired haemodynamic goals. Succinylcholine is notorious in producing arrhythmias. Pancuronium may be used in patients with CAD who have a slow heart rate (due to beta blockade or following opioid administration). Vecuronium provides minimal haemodynamic alterations. Similarly, atracurium, pipecuronium, mivacurium and doxacurium do not have any significant cardiovascular effects. Use of rocuronium should be considered during rapid sequence induction technique. All potent inhalational agents depress myocardium, cause arterial and venous dilation and decrease sympathetic nervous activity. It results in dose dependent decrease in BP and CO, and thus decrease in myocardial oxygen consumption. These effects, though considered advantageous in patients with CAD, may produce cardiovascular collapse in patients with poor myocardial reserve. The experimental finding of isoflurane induced coronary steal has not been shown to be relevant in clinical setting, even in patients with steal prone coronary anatomy. Nitrous oxide has been shown to provide stable haemodynamics, but has detrimental effects in patients with CHF, pulmonary hypertension and regional myocardial ischaemia. During surgery, hypothermia and shivering should be avoided. Haematocrit should not be allowed to go below 30%. The haemodynamic variables must be maintained within 20% of their preinduction value, beyond which they should be treated promptly by volume replacement, vasodilators, inotropes and beta blockers as required.

VALVULAR HEART DISEASE

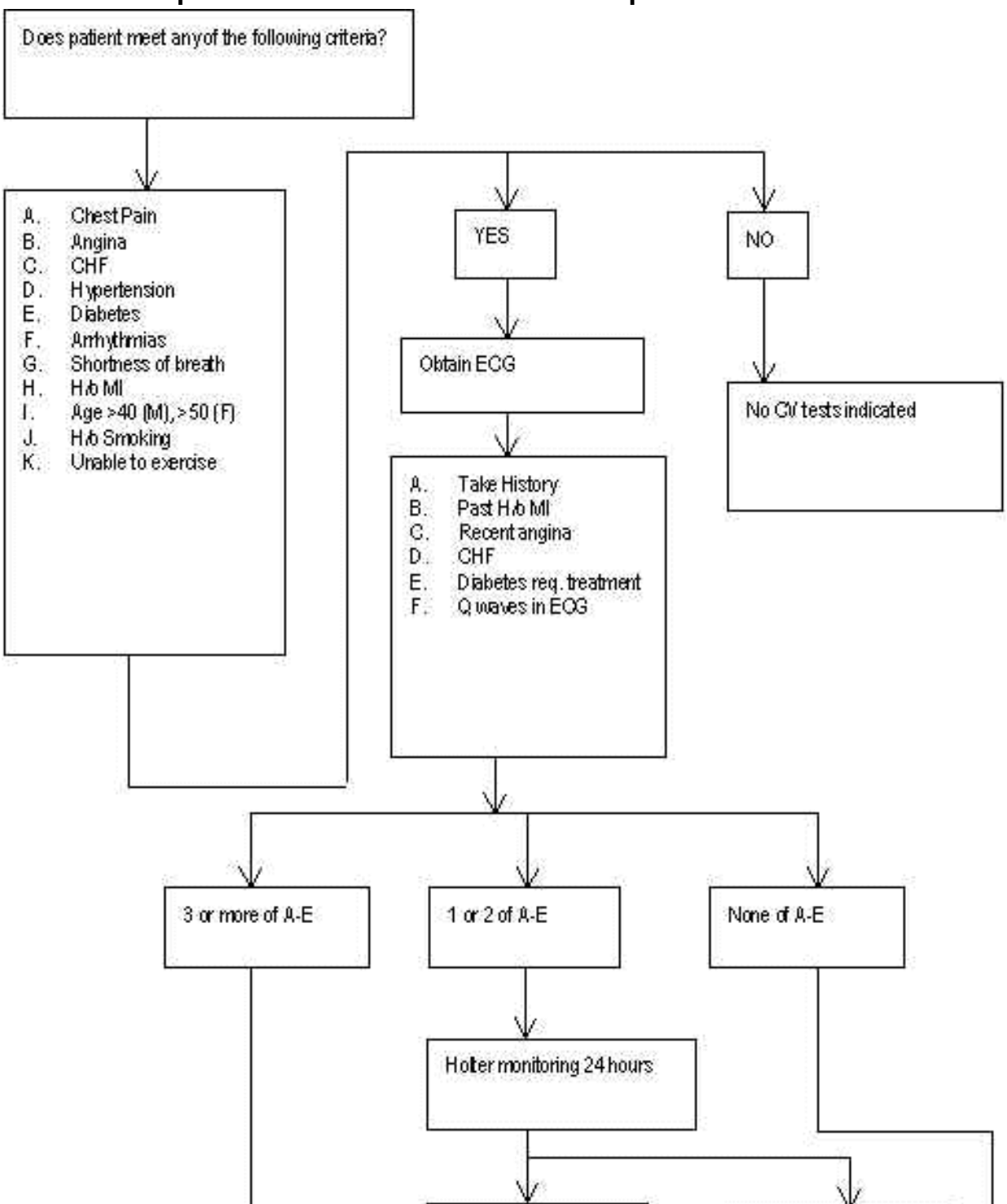
Valvular heart disease is very common in India due to high incidence of rheumatic fever. Most of the patients have more than one cardiac valve involvement, making selection of anaesthetic drugs difficult. However, in such cases, top priority should be given to aortic stenosis (AS), which is associated with high perioperative mortality. As mentioned earlier, balloon valvuloplasty should be considered for AS and mitral stenosis (MS) prior to noncardiac surgery to reduce the incidence of perioperative adverse outcome. Preoperative considerations include prophylactic antibiotic to protect against endocarditis, review of exercise tolerance and assessment of presence and severity of CHF. Intraoperative monitoring, anaesthetic and cardiovascular management should be based on the pathophysiology of individual valve lesion and desired haemodynamic goals. In patients with AS, sinus rhythm and normovolemia must be maintained and evidence of myocardial ischaemia watched for. Tachycardia, bradycardia and hypotension should be avoided. In the event of loss of sinus rhythm, potassium and magnesium infusion should be resumed to achieve high normal concentration. Other alternatives include atropine, glycopyrrolate, transvenous pacing and cardioversion. Myocardial ischaemia should be treated with nitroglycerine infusion. Lower concentration of inhalational agents should be used, as they tend to produce nodal rhythm and myocardial depression. In patients with aortic regurgitation (AR), bradycardia should be avoided as the regurgitant jet can increase LV diastolic pressure. Accordingly pancuronium, isoflurane, desflurane and similar agents with vagolytic properties should be considered. Arteriolar vasodilatation (e.g. with sodium nitroprusside) increases forward blood flow in patients with AR, provided filling pressure is maintained. Similarly in mitral regurgitation (MR), reduction in systemic vascular resistance with nitroglycerine or nitroprusside can markedly improve forward blood flow and diminish both regurgitant flow and pulmonary hypertension. Mitral stenosis is the commonest of all VHD. The anaesthetic goals include avoidance of tachycardia, pulmonary vasoconstriction and restoration of sinus rhythm. In addition, systemic vasodilatation should be avoided and intravascular volume maintained. Atrial fibrillation with fast ventricular rate should be controlled with potassium/magnesium supplement, digoxin, beta blocker, verapamil or cardioversion assuming sufficient anaesthetic depth and absence of hypovolemia. Intraoperative stressors (intubation, incision, extubation) are associated with pulmonary hypertension, leading to pulmonary oedema and can be minimised by additional opioids and nitroglycerine infusion. Balloon mitral valvotomy is particularly advised in pregnant patients with moderate to severe MS. Patients with mild to moderate MS should do well with epidural or GA for elective caesarian section. However, patients with severe MS undergoing emergency caesarian section should not receive spinal or epidural anaesthesia. Opioid-based GA maintains haemodynamic stability, but one should watch for neonatal respiratory depression. Patients with prosthetic cardiac valves do not pose any haemodynamic problem, but functioning of the valve should be assessed by preoperative echocardiogram. These patients are on anticoagulant therapy (warfarin) which should be stopped a week before elective surgery and replaced by heparin, which should be stopped 4-6 hours before surgery.

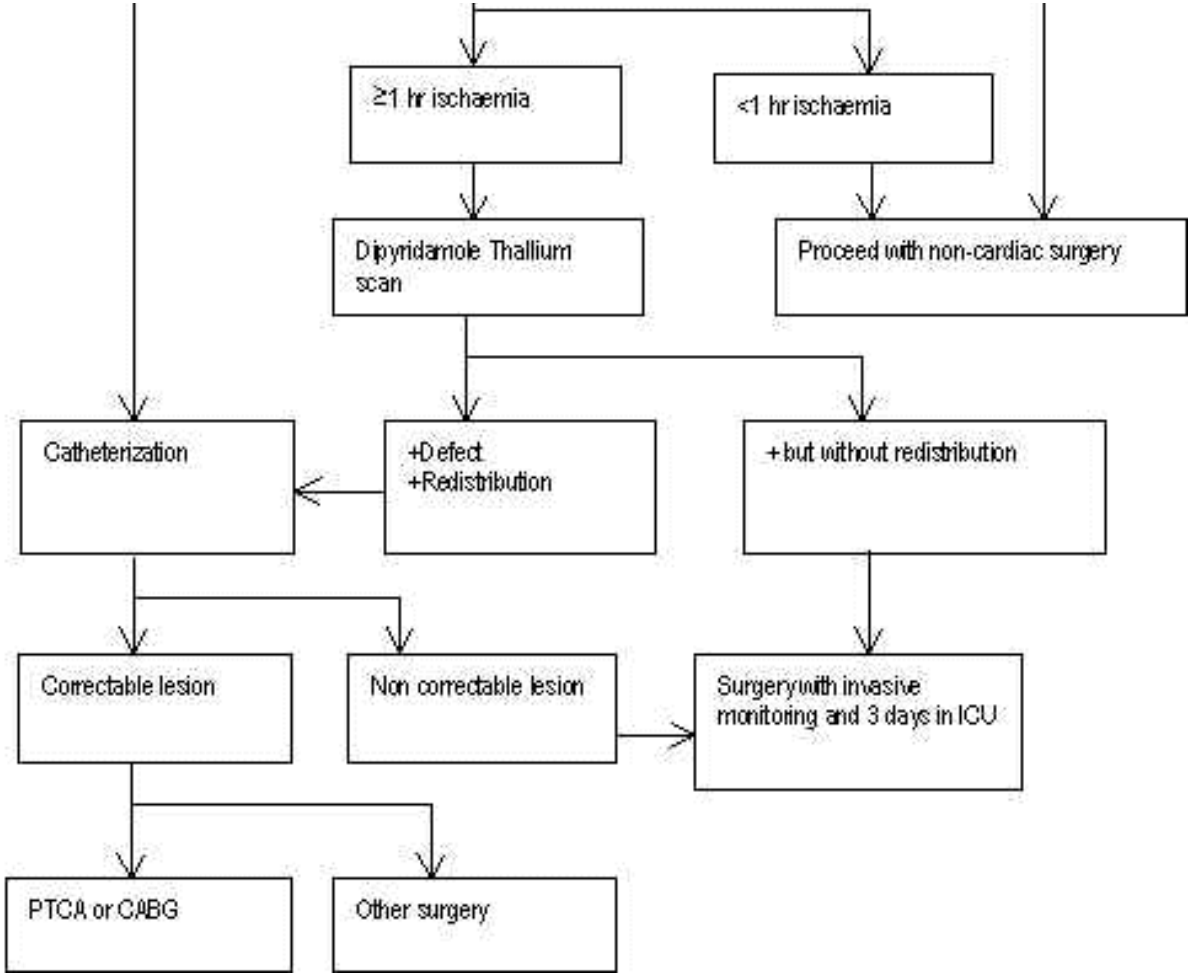
POSTOPERATIVE CARE

As pointed out earlier, patients with preoperative ischaemic episodes are at greater risk

of postoperative complications, whereas those without ischaemia are at low (<1%) risk of perioperative MI. Postoperative MI is directly related to the number and duration of intraoperative ischaemic episodes. Majorities of the MIs occur on the third postoperative day. That emphasizes the need for continuous monitoring of 'at risk' patients. Serial 12 lead ECG and serial cardiac enzymes are done for a week in suspected cases. Aggressive monitoring for 48-72 hours in an ICU has been shown to reduce perioperative reinfarction rate from 36 to 5.8% in patients with previous MI. Control of heart rate, relief of postoperative pain and maintenance of patients body temperature are important for diminution of ischaemic episodes. Elective postoperative ventilation must be considered in patients with haemodynamic instability, respiratory insufficiency, pulmonary oedema and hypothermia.

Table 1. Preoperative evaluation of the cardiac patient.




≥1 hr ischaemia
<1 hr ischaemia
Dipyridamole Thallium scan
Proceed with non-cardiac surgery
Catheterization
+Defect +Redistribution
+ but without redistribution
Correctable lesion
Non correctable lesion
Surgery with invasive monitoring and 3 days in ICU
PTCA or CABG
Other surgery