Archives of Anesthesiology

Volume 1, Issue 1, 2018, PP: 8-16

Anesthesia and Cardiovascular Disease

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Abstract

In this Review article, we have discussed the anesthesia considerations in a case of pre-existing cardiac disease. Successful anesthesia in these patients revolves around careful planning, team work, communication and perioperative formulation of plan, execution and management.

Keywords: *Anesthesia, Cardiovascular Disease.*

Introduction

Administering anesthesia to patients with preexisting cardiac disease is an anesthetic challenge. Most common cause of peri-operative morbidity and mortality in cardiac patients is ischemic heart disease (IHD). IHD is number one cause of morbidity and mortality all over the world.Successful perioperative management of ischemic heart disease patients undergoing non cardiac surgery requires careful team work and communication between patient, primary care physician, anesthesiologist and surgeon.

In assessing the risks and benefits of a perioperative intervention strategy, risks associated with non-cardiac surgery must be individualized. Therefore the anesthesiologist must exercise judgment to correctly assess perioperative surgical risks and the need for further evaluation.Care of these patients require identification of risk factors, pre-operative evaluation & optimization, medical therapy, monitoring and the choice of appropriate anesthetic technique and drugs

Coronary Artery Disease (CAD)

Prevention of myocardial ischemia during surgery decreases the incidence of perioperative myocardial infarction (MI). Optimizing oxygen delivery to the myocardium is equally important for hemodynamic management.

- **Myocardial Oxygen Demand:** The principal determinants of myocardial oxygen demand are wall tension and contractility. The increase in stress during perioperative period causes. An adrenergic surge leading to an imbalance in myocardial O_2 supply-demand ratio. This in turn causes ischemic myocardium. It is primarily affected by:

  a) Tachycardia

  b) increased wall tension

  c) increased preload

  d) increased after load

  e) increased myocardial contractility

- **Myocardial Oxygen Supply:** Increase in oxygen requirement of myocardium can be met by increasing coronary blood flow. It can be affected by:

- **Decreased Coronary Blood Flow:** which in turn is affected by following:

  a. Tachycardia which cause decrease in diastolic perfusion time

  b. Hypotension especially because of fall in diastolic BP

  c. Incrreased Pre load by causing decreased perfusion pressure

  d. Hypocapnia by causing coronary vasoconstriction

  e. Coronary Vasopasm

- **Decreased Oxygen Content And Availability:** which in turn is affected by

  a. Anemia

  b. Hypoxia.

Hemodynamic Goals

1. Although the precise relationship between intraoperative myocardial ischemia and postoperative MI remains controversial, there is consensus that a primary goal of a successful anesthetic is the prevention of myocardial ischemia.
2. A well balanced approach of combination of anesthetics, sedative agents, muscle relaxants and vasoactive agents are chosen to decrease myocardial oxygen requirements and decrease the likelihood of myocardial ischemia.
3. Pharmacologic agents which may benefit patients with cardiovascular disease include statins and angiotensin-converting enzyme (ACE) inhibitors (stabilize atherosclerotic plaques) and volatile anesthetics (anesthetic preconditioning).

Monitoring for Ischemia

A. The preferable monitoring technique (as per availability) for detecting myocardial ischemia involves: (Table-1)

- Electrocardiogram (ST segment analysis of leads V5 and II)

Table 1. *Relation between areas of myocardial ischemia and ECG leads*[1]

ECG leads	Coronary artery	Area of ischemia
I, AVL	Circumflex artery	Lateral aspect of left ventricle
II, III, AVF	Right coronary artery	Right atrium, Right ventricle
V3 - V5	Anterior descending artery	Anterolateral aspect of left ventricle

- Heart rate and blood pressure (not a sensitive predictor of myocardial ischemia)
- Pulmonary artery catheter (V waves reflect ischemia-induced papillary muscle dysfunction
- Transesophageal echocardiography (regional wall motion abnormalities are the most sensitive indicator of myocardial ischemia)

Selection of Anesthesia

There is no ideal anesthetic agent of choice in patients with Ischemic Heart Disease. Choice of anesthetic depends on the extent of pe existing myocardial dysfunction and pharmacological properties of specific drugs.

I. Opioids such as fentanyl in higher dosage in the range 50-100 µg/kg intravenously are preferred in severe myocardial dysfunction as they lack myocardial depressant effect. In patients with good left ventricular function, opioids may be inadequate to depress sympathetic nervous system activity, requiring the addition of a volatile anesthetic or vasoactive drug.

II. Inhalation anesthetics have the advantages of dose dependency; easily reversible, titratable myocardial depression; amnesia; and reliable suppression of sympathetic nervous system responses to surgical stress. Disadvantages include myocardial depression, systemic hypotension, and lack of postoperative analgesia.

Combinations of opioids and volatile anesthetics may produce the advantages of each with minimal undesirable side effects. It is likely that any volatile anesthetic could be used as a balanced technique. Isoflurane is a coronary vasodilator (more so than other volatile anesthetics), but this effect is clinically insignificant in doses below 1 minimum alveolar concentration (MAC). There is no evidence of an increased incidence of myocardial ischemia or worsened outcome. Desflurane and sevoflurane possess hemodynamic profiles similar to isoflurane but have the advantage of faster recovery. A sudden increase in the inspired concentration of desflurane may result in increased plasma epinephrine concentration.

Treatment of Ischemia

Anesthetics or vasoactive drugs that enable the heart to return to a slower rate, and well-perfused state are frequently essential during anesthesia.

a) Nitrates. Nitroglycerin is the drug of choice

for the treatment of coronary vasospasm. As a venodilator, this drug decreases venous return and decreases ventricular filling pressures and thus wall tension.

b) Vasoconstrictors. Phenylephrine increases myocardial oxygen requirements, but this increase is offset by improvements in oxygen delivery produced by the increased coronary perfusion pressure.

c) β-blockers: β-blockade improves myocardial oxygen balance by preventing or treating tachycardia and by decreasing contractility. Atenolol improves long-term survival in patients with heart disease undergoing noncardiac surgery.

d) Calcium channel blockers are useful in slowing the ventricular response in atrial fibrillation and flutter, as coronary vasodilators, and in the treatment of perioperative hypertension.

Preoperative Clinical Evaluation

This includes history, physical examination, investigation, clinical risk predictors, risk assessment, and functional capacity.

History

1. History of Angina: NYHA Grading
    i. Angina at unaccustomed work. No limitation of physical activity
    ii. Angina on moderate exertion. Mild limitation of physical activity
    iii. Angina on mild exertion. Marked limitation of physical activity
    iv. Angina at rest.
2. History of Dyspnea
3. Oedema
4. History of Myocardial infarction
5. Family History of CAD
6. Current medications

Physical Examination

Look for cyanosis, pallor, dyspnea during conversation, nutritional status, skeletal deformities, tremors & anxiety, assessment of vital signs, JVP pulsation, carotid bruit, and oedema.

Investigations

1. Haemogram
2. Cardiac specific tests – ECG, ECHO
3. Blood glucose levels
4. Blood urea , Serum Creatinine
5. LFT

Supplemental Evaluation

Done in specific situations. It includes:

1. Resting LV function
2. Exercise/ Pharmacological Stress Testing
3. Ambulatory ECG monitoring
4. Coronary Angiography
5. In patients with abnormal resting ECG LBBB,LVF)
    a. Exercise Echo
    b. Exercise Myocardial perfusion imaging
6. In patients who cannot exercise:
    a. Dobutamine stress Echo
    b. Thallium Scintigraphy

Functional capacity

Exercise tolerance is assessed by history and is expressed as metabolic equivalents (MET). (MET; 1 MET = 3.5 ml O2/kg/min) on a scale defined by the Duke Activity Status Index in order to estimate the patient's maximal oxygen consumption capacity (Table 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

Preoperative coronary angiography

Indicated in certain conditions like patients with proven CAD, unstable angina, angina resistant to medical therapy, urgent surgery in a patient resolving from acute MI.

Table 2: *Metabolic Equivalents*[2]

MET (metabolic equivalents)	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)

Risk Assessment

Several cardiac indices are used in clinical evaluation to predict postoperative cardiac complications in patients with ischemic heart disease (IHD: (Table3, 4)

A. Goldman Multifactorial Cardiac Risk Index

Table 3. *Goldman Risk Index*[3,5]

S.No.	Cardiac risk variables	Points	Cardiac complication Rate
1	Third heart sound or jugular venous distension	11	
2	Recent myocardial infarction	10	
3	Nonsinus rhythm or premature atrial contraction on ECG	7	
4	More than 5 premature ventricular contractions	7	0-5 points = 01%
5	Age more than 70 years	5	6-12 points = 07%
6	Emergency operations	4	13-25 points = 14%
7	Poor general medical condition	3	>26points = 78%
8	Intrathoracic, intraperitoneal or aortic operation	3	
8	Aortic Stenosis	3	

B. The Revised Cardiac Risk Index (RCRI) is another tool used to estimate a patient's risk of perioperative cardiac complications. Compared with the Original Cardiac Risk Index, the RCRI was easier to use and more accurate. The RCRI is used widely in clinical practice, research, and was incorporated in a modified form into the 2007 preoperative cardiac risk evaluation guideline from the American Heart Association and American College of Cardiology. The ACC/AHA guidelines use the 5 clinical RCRI criteria in their screening algorithm.

Table 4. *Revised Cardiac Risk Index*[4]

Revised Cardiac Risk Index	
1	History of ischemic heart disease
2	History of congestive heart failure
3	History of cerebrovascular disease (stroke or transient ischemic attack)
4	History of diabetes requiring preoperative insulin use
5	Chronic kidney disease (creatinine > 2 mg/dL)
6	Undergoing suprainguinal vascular, intraperitoneal, or intrathoracic surgery
Risk for cardiac death, nonfatal myocardial infarction, and nonfatal cardiac arrest: 0 predictors = 0.4%, 1 predictor = 0.9%, 2 predictors = 6.6%, ≥3 predictors = >11%	

Risk Stratification

A combination of various high risk factors, the functional capacity and the type of surgery are then used to formulate a plan (figure1) for further decision for surgery.

Low Risk Surgery	Intermediate Risk Surgery	High Risk surgery
No CAD markers	1-2 CAD markers	>3 CAD markers
Active Life Style	CAD: symptoms controlled on drugs	Major CAD: not controlled on drugs
Age< 70 yrs	LV dysfunction: well controlled on drugs	Severe /poorly controlled LV dysfunction

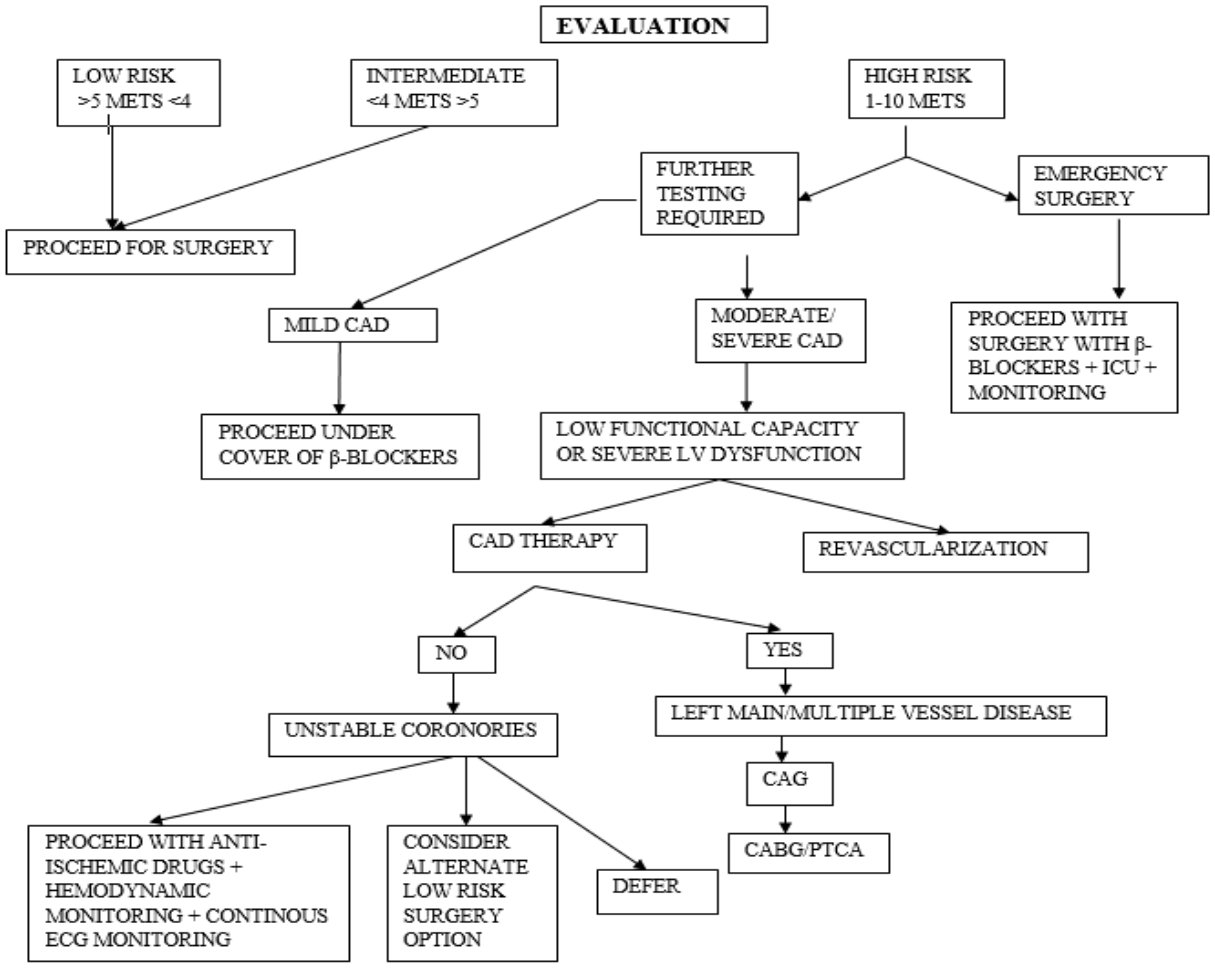

Figure 1. *Risk Stratification*[6,7]

Anesthetic Management

Preoperative Management

At risk patients need to be managed with pharmacologic and other perioperative interventions that can ameloriate perioperative cardiac events. Three therapeutic options are available before elective non cardiac surgery:

1. Optimization of medical management
2. Revascularization by PCI or
3. CABG

Optimization of Medical Management

Many randomized controlled trials provide a firm foundation for the use of beta blockers to prevent

perioperative ischemic events in high risk and intermediate risk patients for the reason that:

- Peri operative beta blockade significantly reduces cardiac death & MI and may decrease the need of revascularization before non-cardiac surgery.
- Tight heart rate control with beta blockade dispenses the need for routine non invasive pre-op testing (intermediate grade & prophylactic coronary re-vascularisation in high risk patients.
- To achieve 24 hrsefficacies with once daily dosing beta selective agent with long life (bisoprolol) or a formulation providing extended plasma concentration (metaprolol succinate) is suggested.
- There is a protective effect of perioperative statins on cardiac complications during non- cardiac surgery. (2007 AHA/ACC)
- It is reasonable to start bisoprolol 2.5 mg daily or metaprolol 25-50 mg daily. These drugs should be started 30 days prior to surgery.

To summarize various recommendations from many trials:

1. To add or continue, beta blockers in high risk and intermediate risk patients titrated to HR of 50 –60/mt
2. Alpha 2 agonists by virtue of their sympatholytic effects can be useful in patients where beta blockers are contraindicated.
3. Other agents like calcium channel blockers, ACE inhibitors, aspirin insulin & statins prove to be beneficial peri-operatively
4. To continue drugs like beta blockers,anti-hypertensives (except ACE inhibitors) digitalis, Ca^{2+} blockers till the day of surgery
5. NSAIDS should be discontinued 1 week prior to elective procedures.
6. Most surgeries can be performed safely at an INR <1.5
7. Stop warfarin 5 days before and LMWH 12-24 hours prior.
8. Stop clopidogrel at least 5 days before surgery.

Preoperative Coronary Revascularization

Indicated in high risk CAD and in who long term would likely be improved by CABG (AHA/ACC 2007)

Percutaneous Coronary Intervention

After balloon angioplasty to wait for 1 week for non-cardiac surgery and 4 – 6 weeks after coronary stent.

Anesthesia Goals

The primary goal of the anesthetic management of a patient with IHD for non-cardiac surgery is avoidance of myocardial ischemia and infarction. This is accomplished by preventing ischemia through measures that improve the myocardial o2 supply demand balance, primarily by controlling the patient hemodynamics and by detecting and treating myocardial ischemia when it occurs.

Premedication

Preoperatively patient should be explained the risk of surgery &anesthesia. The premedication should prevent increase in B.P and H.R which can disturb myocardial O_2 supply and demand and can induce ischemia. Any combination of benzodiazepine and opioid like morphine should be given an hour prior to arrival in O.T

Intraoperative Management

Incidence of ischemia is low in the intraoperative period as compared with pre and post operative period.

Monitoring

1. ECG: 5 lead ECG will be useful.V5 leads detects M.I in the distribution of LAD Lead II detects M.I in the distribution of RCA and also arrhythmias. The ST Segment trending also helps in the detection of ischemia.
2. Pulse oximetry, ETCO2, urine output, temp monitoring, NIBP
3. Intra-arterial cannulation
4. CVP – essential in all except minor procedures.
5. Pulmonary artery catheter and cardiac output (indicated in intrathoracic or abdominal vascular surgeries as a guide for fluid management, if EF < 40% or if PHT is present).
6. Esophageal Stethoscope and TEE: not advocated for routine use.

Choice of Anesthesia

The anesthesiologist should select drugs with the object of minimizing demand and supply of oxygen. Along with the anesthetic agents, cardiac drugs should be readily available to maintain hemodynamics to prevent and treat ischemia if it occurs.

General Anesthesia

Preoxygenation for 3-5 minutes is must.

Induction

Induction should have minimal hemodynamic effects. In patients with good LV function, Induction with fentanyl and thiopental or propofol can be preferred. Fentanyl is given in doses of 2-3 mcg/kg prior to induction with propofol or etomidate.

- Propofol 2-2.5 mg/kg is preferred if Systolic BP (SBP) more than 125 mmHg and Etomidate 0.2 mg – 0.3mg/kg if SBP is 110 or less. For SBP between 110-125 mm Hg either low dose propofol or combination of propofol and etomidate or etomidate alone is preferred.
- Thiopentone- reduces myocardial contractility, preload and blood pressure with slight increase in HR. Administer slowly in doses of 3-5 mg/kg with caution.
- In Patients with LV Dysfunction: High dose opioids induction is preferred.

Muscle Relaxants

- Vecuronium produces minimum hemodynamic alterations and is short acting, therefore suitable for use in cardiac patients. Rocuronium is newer non depolarizing muscle relaxants without any significant cardiovascular side effects.
- Obtundation of Intubation Response: Achieved with 2% 1.5 mg/kg lignocaine 90 seconds before intubation. Laryngoscopy has to be done after good relaxation of jaw muscles. Cords are sprayedwith 2 cc of 2% lignocaine and intubated with well lubricated endotracheal tubes to prevent sympathetic surge.

Maintenance of Anesthesia

- Patients with Normal LV function- O2+ N2O+Volatile anesthetics and muscle relaxants
- Patients with COMPROMISED LV FUNCTION- Short acting opioids are preferred for maintenance of anesthesia
- MUSCLE RELAXANT of choice is VECURONIUM because of its minimal hemodynamic alterations
- Isoflurane is acceptable volatile anesthetic, sevoflurane or desflurane are acceptable, 0.5 or higher MAC dosage of volatile agent limits the extent of myocardial injury if MI occurs.
- Narcotic drugs preferred include morphine, fentanyl, alfentanyl and sufentanyl
- Ideal Hemodynamic status include a lower heart rate, normal blood pressure and adequate coronary perfusion pressure.

Reversal

Accomplished with Neostigmine &Glycopyrrolate in normal doses.Glycopyrrolate is preferred over atropine since it produces less tachycardia.

Intraoperative Ischemia

ECG criteria for diagnosis of ischemia in anaesthetized patients include:

- Upsloping ST segment : 2mm depression, 80 msec after J point
- Horizontal ST segment : 1mm depression 60 – 80 m sec after J point
- Downloading ST segment : > 1mm from top of curve to PQ junction
- ST elevation
- T wave inversion

Treatment

- Sinus Tachycardia – Propranolol 1mg / Esmolol 100 – 500 mcg/kg -1mg/kg (intermittent or continuous) /metoprolol up to 15 mg
- Hypertension-deepeninganesthesia/Vasodilators – NTG 1mcg/kg/min/ Labetolol – (intermittent) 5-10 mg bolus
- Hypotension–Vasoconstrictor/Volumeingestion/ Inotropes
- Ischemia – A) stable – beta blockers/IV NTG/ Heparin

  B) Unstable- Inotropes/IABP/Earliest possible cardiac catheterization

Post-Operative Management

The period after surgery is associated with increased levels of catecholamine's 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.The patient's normal cardiac medication should be restarted as soon as possible. The goals in immediate postoperative periods must be:

1. Prevent ischemia

2. Monitor for MI

3. Treat M.I

4. Continuous ECG monitoring – for the first 36 – 72 hours.

5. Temperature control

6. Maintenance of hemodynamic status

General Anesthesia vs Regional Anesthesia

Regional Anesthesia (RA) is a good choice in intermediate and low risk surgeries and in procedures involving extremities, the perineum and lower abdomen. RA is acceptable as it causes low filling pressures and reduces myocardial wall tension.

Epidural anesthesia reduces preload and afterload, coagulation responses, and in the case of thoracic epidurals, causes coronary vasodilatation. Good epidural analgesia may reduce the incidence of tachycardia arising due to postoperative pain. However, the hypotension which follows the regional anesthesia if severe and rapid may reduce the coronary perfusion pressure & blood flow. Any fall in BP below 20% baseline should be promptly treated with fluid infusion or vasopressors like ephedrine (if associated with bradycardia) or phenylephrine.

In a patient with IHD, local anesthetic techniques such as brachial plexus block should be encouraged in order that the hemodynamic responses to general anesthesia are avoided. Trying to cover for a patchy or incomplete block with excessive sedation or other methods defeats very purpose of selecting regional anesthesia. In such cases it is advisable to convert to General anesthesia as soon as feasible.

Conclusion

Patients with cardiac disease are presented for anaesthesia for non cardiac surgery more frequently because of better screening and treatment modalities available with advancement of medical science and anaesthesia. Since their perioperative courses are associated with greater morbidity and mortality, it is important to provide a hemodynamically stable anaesthesia best suited for altered physiology of diseased cardiovascular system.

This requires in-depth knowledge of the pathophysiology of the disease, and of the drugs and procedures with their effects on the patient. Meticulous preoperative screening and therapy with beta blockers or α-2 agonist and careful maintenance of intraoperative hemodynamics monitoring, postoperative analgesia with epidural or PCA and continuous post op monitoring are key for better outcome in these patient.

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Citation: **Bhavna Gupta, Lalit Gupta.** *Anesthesia and Cardiovascular Disease. Archives of Anesthesiology. 2018; 1(1): 8-16.*