Perioperative cardiac complications: myocardial ischemia – recognition and management.

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Perioperative myocardial infarction (PMI) is one of the most important causes for short and long term morbidity and mortality associated with non cardiac surgery. Prevention of a PMI is therefore of great importance in improving the overall outcome after non cardiac surgery. In the last few years, extensive research has been conducted into the causes of PMI. Yet, the exact causes of PMI remain an area of debate and controversy. In addition, identifying PMI is difficult as the classical changes associated with myocardial infarction (MI) in the non surgical settings are often missing. This article deals with the probable causes of PMI, the diagnostic criteria and the preventive and treatment measures.

Perioperative myocardial infarction.

PMI often has peculiarities:

1. PMI peaks in the immediate postoperative period and is often associated with MI and cardiac complication. The majority of the MI presents during the first 4 days after surgery and 90% by day 7 after surgery (2). Intraoperative plaque rupture is less common and infrequently associated with PMI. This puts to rest the earlier argument that the type of anesthesia (general or regional anesthesia), if properly delivered, is not a risk factor for high risk cardiac patients undergoing non-cardiac surgery.
2. PMI is almost exclusively associated with ST depression type myocardial ischemia. ST elevation type MI which is almost exclusively seen in the non-surgical setting is uncommon in the perioperative period.
3. PMI is often silent and often a NQMI is seen rather than a QMI.
4. The majority of the PMI's occur within the first 48 hours after surgery
5. Mortality after PMI is < 10-15%, similar to the mortality after non-surgical NQMI. This is in contrast to earlier concerns that PMI is associated with very high mortality.

The above statements gives rise to the following questions concerning PMI: Is the pathophysiology of PMI different from that of the non-surgical MI? Does the understanding of the pathophysiology affect the ability to prevent, diagnose or treat MI?

Pathogenesis of MI in non surgical settings.

One of the central concepts in the pathogenesis of MI is the distinction between "stable" and unstable" plaques. Studies have shown that a rapidly growing atheromatous plague consists of a large inner core composed of substantial thrombogenic lipids and macrophages and covered by a thin fibrous plague. The thin fibrous plague shows signs of inflammation, degradation and repair of its matrix. A stable plague on the other hand is made of a thin fibrous core and covered by a thick fibrous matrix. In the unstable plague, the inflammatory process that leads to erosion of the fibrous matrix exceeds the reparative process, it becomes unstable and susceptible to fissuring and rupture of the fibrous cap.

Cycles of fissuring and disruption of the fibrous cap, leading to mild degrees of thrombosis, platelet aggregation, myocyte migration and healing of the fibrous matrix are believed to be part of the growing atheromatous plague. By this process, an atheromatous plaque may grow to critical or even complete closure of major coronary arteries *without causing MI* as the process is often accompanied by simultaneous growth of collateral coronary circulation. Rupture of the unstable plague with large lipid core may also occur exposing the thrombogenic material to the circulation. Rupture of atheromatous plagues may occur secondary to shear forces acting on it from within the lumen or inflammatory and degradation process within the plague itself. Once an atheromatous plaque with large thrombogenic core ruptures, the interaction between the thrombogenic material and blood components may result in thrombus generation and complete occlusion of the vessel.

The differences in the clinical picture of the various acute coronary syndromes (ACS) can be explained on the basis of the degree and duration of plague rupture, thrombus deposition and coronary occlusion. Minor repeated plague rupture accompanied by relatively short term or partial coronary occlusion by thrombosis or vasoconstriction causes unstable angina pectoris (1). More severe plague rupture with prolonged but reversible coronary occlusion in patients with good coronary collateral circulation causes non Q wave myocardial infarction (NQMI). In patients with severe and prolonged coronary occlusion in major territory with poor coronary collateral circulation lead to Q wave myocardial infarction (QMI).

The sudden and rather non random causes of rupture of plague and MI are probably related to:

1. Plague disruption triggered by surges in sympathetic activity and associated with increase in heart rate (HR), blood pressure, contractility and coronary blood flow

2. Coronary thrombosis on previously ruptured or complicated plagues caused by fluctuations in systemic thrombotic activity because of platelet hyperaggregability, hypercoagulability and impaired fibrinolysis.
3. Vasoconstriction either locally around an unstable coronary plague or generalized secondary to sympathetic stimulation

Mechanism of perioperative MI.

Two distinct mechanisms can lead to PMI: *acute coronary syndrome (Type 1)* and prolonged *oxygen demand supply imbalance (type 2)* in the presence of stable coronary artery disease (3).

Type 1 : Acute coronary syndrome.

ACS occurs when an unstable or vulnerable plaque undergoes fissuring, rupture leading to acute thrombosis, ischemia and infarction. The following conditions are known to influence the onset of plaque rupture during the perioperative period

1. Physiological and emotional stress is thought to promote sympathetic discharge, coronary vasoconstriction and prothrombotic states in the immediate postoperative period.
2. Tachycardia and hypertension common in the immediate postoperative period may exert shear stress, leading to rupture of the plaque.
3. Increased postoperative pro-coagulants (fibrinogen, factor VIII coagulant, von Williebrand factor and α1-trypsin) increased platelet activity, decreased endogenous anticoagulants (protein C, antithrombin 111, α2 macroglobulin) have been reported. Postoperative hypercoagulability is notorious for venous complications precipitated by stasis and immobilization.

It is generally believed that the risk of MI posed to the patients with a given coronary artery disease is directly related to the severity of the coronary stenosis. However, studies that looked at the degree of coronary stenosis before and after an AMI, showed the majority of the culprit coronaries had a lesion of < 70% (4). This discrepancy between angiographic evidence of coronary severity and likelihood of MI is explained by the inability of the angiogram to identify unstable plaques that are at high risk of rupture and distinguish them from significant but stable coronary plaques. These findings also substantiate the fact that younger and less mature plaques are the ones most likely to rupture and cause acute MI.

Type 11: Oxygen supply-demand imbalance.

Postmortem studies in patients who developed PMI showed that the perioperative events that lead to PMI was evenly distributed between plaque rupture and oxygen demand-supply imbalance. It is possible that

in the perioperative settings, the later may have a greater role in the cause of PMI. This statement is further substantiated by the finding that there was no evidence of plaque rupture in 83% of patients who developed PMI within the first 3 days and 77% of patients in the first 4 days. This could mean that oxygen demand-supply imbalance is the predominant cause of PMI in the first few days after surgery (5). Plaque rupture as a cause of PMI was evenly distributed over the entire postoperative period. Although PMI occurred in the background of significant coronary artery disease, total coronary occlusion with thrombus occurs in only 50% of the patient. This suggests that low flow states secondary to significant coronary stenosis is an important contributor to the cause of PMI.

Perioperative hyopertension is uncommonly associated with perioperative MI while perioperative hypotension is associated with an increased incidence of MI, cardiac arrests and cardiac deaths. The duration of hypotension may be a significant factor in the incidence of perioperative MI.

Studies in patients with significant CAD undergoing surgery has shown that silent, heart rate related ST segment depression is common postoperatively and is associated with in-hospital and long term mortality and morbidity (6, 7). Postoperative cardiac complications including sudden death occurred after prolonged, silent ST-segment depression. These changes were reflected in cardiac troponin levels. Cardiac troponin levels are elevated after prolonged or transient ST depression in the postoperative period. The severity in elevation of the cardiac troponin levels correlated with the duration of ST segment elevation. ST segment elevation was very uncommon. Hence, prolonged ST segment depression type myocardial ischemia is the most common cause of PMI.

It has also been shown that low level but prognostically significant elevations in troponin levels occur in high risk cardiac patients without any significant ECG signs of ischemia. Troponin levels above the cut off value (>0.03 ng/ml) occurred in 24% of patients early after vascular surgery, only 32% of whom had ECG evidence of ischemia whereas among 8.7% patients with PMI (troponin >0.1 ng.ml) 88% had ischemia on continuous ECG monitoring (8). Higher troponin levels correlated with longer duration of ischemia. *Thus, type 11 PMI spans a spectrum ranging from silent, minor cardiac injury with low level elevation in cardiac troponin and low incidence of ST changes to prolonged overt changes in multiple ECG leads, marked elevations in cardiac troponin and PMI.*

Tachycardia is the most common cause for postoperative myocardial oxygen demand-supply imbalance mediated ischemia (3). Increase in HR in patients with significant coronary artery disease can lead to subendocardial ischemia through the imbalance created by the increase in oxygen demand while reducing the oxygen supply through shortening of the diastolic interval. HR of 80-90 is poorly tolerated by high risk cardiac patients having resting HR's of 50-60, leading to prolonged ischemia. Hypotension,

hypertension, anemia, hypoxemia, hypercarbia aggravate coronary ischemia. Hypotension more commonly leads to ischemic changes than hypertension. Prolonged intraoperative hypotension (> 20 mmHg reduction in mean arterial pressure for > 60 min) results in significant increases in myocardial infarctions, deaths and cardiac arrests. Stress induced and ischemia induced coronary vasoconstriction further impairs cardiac perfusion.

QMI versus NQMI.

Differentiation between NQMI and QMI is important to understand the pathophysiology of PMI. The preponderance of NQMI in the postoperative settings suggests the role of prolonged ischemia rather than thrombotic occlusion as cause of PMI. Some of the well known concepts of NQMI include:

1. NQMI involves a smaller volume of myocardial tissue than QMI
2. Short term (in-hospital) mortality of NQMI is less than that of QMI.
3. NQMI has a greater incidence of recurrent angina than QMI and this reflects the larger volume of jeopardized myocardium involved with NQMI.
4. The long term mortality and morbidity of NQMI is at least equal if not higher than QMI.

Since it is not possible to distinguish whether a patient will develop a QMI on arrival in the emergency room, the concept of NQMI versus QMI is being regarded as meaningless by many cardiologists. The concept of ST elevation versus ST segment depression MI is more important as the management criteria at the moment are entirely different.

Diagnosis of PMI.

Diagnosis of PMI in the operating room or in the immediate postoperative period is difficult and often missed. As per the World Health Organization, at least 2 of the 3 criteria mentioned must be fulfilled before a diagnosis of MI can be made. These include i) typical ischemic chest pain ii) increased serum creatine kinase (CK- MB isoenzyme, and iii) typical ECG changes.

The standard ECG used in the OR or in the ICU often uses a high degree of filter to prevent wandering of the signals up and down the screen. Unfortunately, low frequency filtering may distort the ST segment and render it unusable for ST segment analysis for ischemia. Secondly, standard calibration of the ECG signal is 1 cm/mV. At this calibration 1 mm of ST segment depression equals 0.1 mV. However, a 1 mm change in ST segment is very difficult to see on the monitor. Thirdly, the standard leads that are monitored in high risk cardiac patients are often the Lead 11 and V5. Although the combination is good, many of the changes that occur in the perioperative period is often seen in V2-V4 that may be missed. Finally, anaesthesiologists being fully occupied within the operating room may miss the changes

appearing on the monitor. Fortunately automated ECG segment analysis has overcome many of these limitations.

The development of assays for cardiac troponin T (cTnalT) and I (cTnI) that are highly specific and sensitive for myocardial injury formed the basis of the revised definition of MI by Universal Definition of Myocardial Infarction (9). According to this criteria the definition of MI may be entertained when i) *definition of a rise and or fall of cardiac biomarkers (preferably troponin) with at least one value above the 99th percentile of the upper reference limit together with evidence of myocardial ischemia with at least one of the following a) symptoms of ischemia b) ECG changes indicative of new ischemia (new ST changes or LBBB) c) development of pathological Q waves on ECG d) imaging evidence of new loss of viable myocardium or new regional wall motion abnormality.*

Debate continues at arriving at an appropriate cut off value for cardiac troponin which can lead to a clinically relevant diagnosis of MI. The question also arises that when a diagnosis is made based on biomarkers alone whether it would lead to an overestimation of the incidence of PMI or when traditional definitions are used for diagnosis of PMI it would lead to an underestimation of the incidence of PMI. Initial cut off values (cTnT > 1ng/ml and cTnI >0.1 ng/ml) were based on patient population which had clinically relevant MI. However, subsequent studies have shown that even minimal increases in cardiac troponin levels without any ST changes are associated with adverse cardiac outcomes. It has been suggested that due to the specificity of cardiac troponin, in the presence of documented myocardial ischemia, even minor increases in cardiac troponin above the 99th percentile normal should be considered as MI. Postoperative increases in cardiac troponin (cTnT) correlated with cardiac morbidity after vascular surgery. In 229 patients, an increase in postoperative cTnI above 0.15 ng/ml within the first 3 days was associated with a 6-fold increase in mortality and a 27-fold increase in risk for MI (10). A dose response relationship was observed between the elevation of cTnI and mortality. Patients with postoperative cTnI levels above 0.30 ng/ml had significantly higher mortality than patients with cTnI levels < 0.35 ng/ml.

A minor increase in cardiac troponin levels (cTnI > 0.6 and or cTnT > 0.03 ng/ml) or an increase in CK-MB (CK >170 IU or CK-MB/CK >5%) in the first 3 days after surgery should be considered as significant and is indicative of long term mortality.

Transesophageal echocardiography is a very sensitive to identify RWMA. When new RWMA persists through the end of surgery, they should be assumed to predict postoperative cardiac complications. The major disadvantage with TEE is that it cannot be used in the awake patient in the ICU where transthoracic echocardiography will have to be used.

Clinical signs and symptoms suggestive of PMI.

Other clinical signs of PMI which manifest usually late after a PMI includes fluctuations in blood pressure, tachycardia or heart blocks. An emergency 12-lead ECG may be diagnostic. The anesthesiologist should in the meantime rule out any anesthetic or pain related causes of hypertension or hypotension, tachycardia. In patients with cardiac risk undergoing high risk procedures it is recommended that an ECG should be obtained at baseline, immediately after surgery and the first two postoperative days.

Prevention of PMI.

Beta blockers (BB's) are considered as top priority cardio-protective agents in high risk cardiac patients. Many beneficial effects, including anti-arrhythmic, anti-inflammatory, altered gene expression and receptor activity and protection against apoptosis have been attributed to the beneficial effects of BB's. One major cardio-protective mechanism attributed to BB's include their ability to prevent plaque rupture by reducing mechanical and hemodynamic stress on vulnerable plaques (1). In addition, BB's prevent MI by preventing prolonged, stress induced (or tachycardia induced) ST depression type myocardial ischemia even in the presence of stable yet severe non-vulnerable plaques. All BB's except those with intrinsic sympathomimetics activity reduce mortality in heart failure and MI probably by reducing the infarct size and reduction of ventricular arrhythmias.

Catecholamines increase each of the four components of cardiac activity (HR, contractility, preload and afterload). BB's have the potential to reduce myocardial oxygen consumption by decreasing sympathetic tone and myocardial contractility, in turn reducing HR and arterial pressure. Furthermore, by reducing beta receptor mediated release of intra-cardiac norepinephrine during ischemia, they attenuate exercise induced coronary vasoconstriction.

Effect on perioperative cardiac mortality.

There are two studies that have set the ignited the perioperative protective effects of BB's (11, 12). In the first study 200 patients at risk of cardiac events were given intravenous atenolol just before major surgery and continued till discharge or 7 days postoperatively (11). The primary end points of study were cardiac events and cardiac deaths during a two year study period. The BB group showed a 55% relative risk reduction (10% Vs 21%) during this period which was primarily related to reduction in cardiac deaths during the first 6 months after surgery. The study was criticized for many reasons (13). The study took into account adverse events only after discharge from the hospital although 6 patients died in the hospital. If these patients were taken into account then the beneficial effect on BB's would have lost statistical

significance. Female gender was under-represented in the study. The potential for acute BB withdrawal was not accounted as eight patients in the control group were deprived of their BB's due to randomization, There was a trend towards more effective cardiac therapy in the atenolol group whereas there was a tendency for more sick cardiac patients in the control group.

A subsequent study looked at 1352 patients for cardiac risk factors undergoing major vascular surgery (12). 846 patients were identified with at least one cardiac risk factor of which 173 patients had a positive Dobutamine Stress Echocardiography (DSE). 61 of these patients were excluded as they had severe coronary artery disease or because they were already taking BB's. The remaining 112 patients were randomized to either a group receiving bisoprolol started at least 37 days before surgery or placebo group. The study showed a surprising 10-fold decrease in the perioperative cardiac events in the bisoprolol protected group compared with the standard group. The study was criticized for its small sample size, early termination of study as the interim analysis showed a large treatment effect and because the study was not blinded (13). A large complication rate in the standard group was also questionable.

The Polderman study has subsequently undergone a number of re-analysis. Taking all these reviews into consideration, it can be suggested that BB's would be helpful in the vast majority of patients with at least one cardiac risk factor undergoing major surgery. Perioperative BB's would not be of benefit in patients without any cardiac risk factors undergoing major surgery. BB's would reduce the incidents of cardiac events in patients with three or more clinical risk factors (defined as age > 70 years, current angina, prior MI, congestive heart failure, diabetes mellitus, renal failure or past cerebrovascular event). Within this subset of patients with three or more cardiac risk factors, patients who had less than four new regional wall motion abnormalities on DBE were again protected by the use of BB's. In a small subset of patients with more than three cardiac risk factors and more than 5 new RWMA on DSE is unlikely to be protected by BB's alone and may require additional coronary angiography and coronary intervention (13).

The POISE study in 2009 with > 8000 patients showed that although the acute use of BB's was associated with reduced cardiac events (PMI by 26%), the mortality was higher (by 31%) and incidence of stroke was higher (by 100%) in patients receiving extended release BB's in the perioperative period (14). The increased mortality and morbidity was associated with increased incidence of hypotension and bleeding. BB's aggravate hypotension during surgery and interfere with the ability to maintain adequate cardiac output during active bleeding, anemia or infection. Consequently there is a strong debate regarding the use of BB's during the perioperative period.

Following the POISE study publication, the ACC / AHA came up with a focused update on perioperative BB therapy (15). They have mentioned that BB therapy titrated to HR and blood pressure may be useful

in patients undergoing vascular surgery in whom preoperative assessment identifies high cardiac risk as defined by the presence of one or more clinical risk factor (Class 11A). They also mention that routine administration of BB in the absence of dose titration is not useful and may be harmful in patients who are not taking BB's currently (Class 111)

Should BB's be used along with other sympatholytic therapies?

The safety of administering BB's along with thoracic epidural or α2 agonists has not been established. It is conceivable that the synergistic effect between the two classes of drugs can cause unacceptable hypotension or bradycardia counteracting any potential benefit of BB's alone. If the combination is used it should be with extreme caution.

Is there a BB of choice for the perioperative period?

The beneficial effect on BB's is related to *its ability to* block or suppress the adrenergic response during surgery and in the postoperative period. In this respect, the type of BB with respect to their receptor affinity, lipophilicity etc should not be an issue. In clinical practice, one would prefer to use a BB which has been used in actual trial. The most common of these are the cardio selective BB's like metoprolol, bisoprolol or atenolol.

When should perioperative BB be started?

Based on the outcome of POISE study and the studies discussed earlier, BB's should be started well in advance of any planned surgery. This may be as early as one month before surgery or as short as 7-10 days before surgery.

What should be the therapeutic goal?

The primary aim of perioperative BB therapy should be to titrate the HR. Perioperative BB therapy should be aimed at achieving a target HR of 50-60 (resting). Postoperative HR should be maintained < 80/minute or 20% less than the preoperative ischemic threshold.

For how long should BB therapy be continued?

For patients who have been placed on BB therapy with clear indications, it is preferable to continue with BB therapy indefinitely. In patients who have been placed on BB with less clear indications, therapy should be continued for at least the time of hospitalization and preferably up to a month after surgery. In patients who are to be withdrawn from BB's, the dose should be gradually reduced to avoid any withdrawal syndromes.

Is routine BB therapy continued preoperatively as effective as acutely initiated closely monitored HR targeted perioperative BB therapy?

There is no definite data to substantiate this point. However, based on analysis of Polderman study, there is suggestive evidence that chronic BB therapy is as effective as acutely initiated, closely monitored, HR targeted therapy initiated before surgery. Ultimately, the protective effect of BB therapy is related to the target HR achieved.

Who should receive perioperative BB therapy?

In high risk patients with more than 3 clinical risk factors and positive non-invasive cardiac stress test (DSE), BB's alone is unlikely to be protective and further coronary intervention is required. In high risk patients with negative stress testing or in patients with intermediate risk factors, with good functional capacity and no evidence of angina or peripheral vascular disease, BB's would be helpful in reducing perioperative morbidity and mortality. In patients with intermediate risk factors but poor functional capacity or evidence of angina or PVD, additional coronary intervention may be required. BB's are unlikely to give any additional benefit in patients with no cardiac risk factors.

Alpha-2 agonists.

Alpha 2 agonists may be useful as they attenuate perioperative hemodynamic instability, inhibit central sympathetic discharge, reduce peripheral NE release and dilate post stenotic coronary vessels. However, the beneficial effects of these group of drugs are seen only with drugs having rate limiting effects.

Antiplatelet therapy.

Aspirin which blocks the thromboxane pathway is a weak but useful antiplatelet agent. The continued use of aspirin alone is not associated with significant perioperative bleeding while the beneficial effects of the drug are substantial. Clopidogrel, the thienopyridine has more severe bleeding issues if continued into the perioperative period. As per the present guidelines, dual antiplatelet therapy (clopidogrel with aspirin) should be continued for at least 4 weeks after bare metal stent implantation and at least for one year after drug eluting stent placement. Elective surgery during this period is discouraged. If discontinuing antiplatelet therapy is mandatory, aspirin should be continued and "bridging therapy" should be considered during the interim period. Glycoprotein 11b/111a inhibitors (abxicimab, tirofibran or eptifibatide) may be considered in this situation.

Statins.

"Pleiotropic effects" of statins independent of their lipid lowering effects have been found to be useful in preventing myocardial ischemia. These effects include reversal of endothelial dysfunction, modulation of macrophage activation, immunological effects and anti-inflammatory, anti-thrombotic and anti-proliferative actions. Aggressive statin therapy in patients who suffer myocardial ischemia is associated with significant reduction in the composite end point of death, non fatal myocardial infarction, cardiac arrest with resuscitation and recurrent symptomatic myocardial ischemia. If statins are withdrawn after an acute coronary syndrome, mortality rates and non fatal infarction rates are increased compared to patients who continue receiving them.

Perioperative management.

The importance of preventing tachycardia in the perioperative and postoperative period cannot be over emphasized. All causes of tachycardia, hypotension, hypertension, anemia and pain should be effectively treated. Treatment of tachycardia with hypotension is particularly challenging and needs a complete understanding of the patient's baseline and periperative myocardial, vascular and coronary physiology. Vasopressors to maintain blood pressure with BB's to reduce HR along with volume replacement, along with attention to pain and respiratory care can resolve many of the situations. In our own unit we use intravenous nitroglycerine as an infusion in all patients with known coronary artery disease during the perioperative period. Emergency coronary intervention, use of glycoprotein 11b/111a receptor inhibitors or anticoagulants are rarely required in the postoperative period and may be dangerous because of the risk of bleeding unless ST segment elevation or intractable cardiogenic shock sets in.

Anemia independently predicts mortality within 30 days in coronary patients. There is considerable controversy regarding transfusion requirements in high risk cardiac patients especially when the hematocrit is between 25%-33%. Hemodynamically unstable postoperative patients with ischemia may benefit from transfusions. Pain if present should be treated with narcotics preferably fentanyl or morphine. Adequate pain relief will suppress the adrenergic surge seen with intense pain and which is also characteristic of early stages of PMI and thereby reduce myocardial oxygen consumption.

Treatment of established myocardial ischemia.

Myocardial ischemia should be viewed with the same degree of urgency as hypoxemia and hypotension as there is imminent risk of death. There is no established management protocol for the management of intraoperative or immediate postoperative onset of myocardial ischemia. In general, the principals would include i) evaluation and correction of anaesthetic depth, and adequacy of pain management and

ventilation (if patient is in OR) ii) correction of hemodynamic instability iii) anti-angina therapy and iv) institution of invasive maneuvers like intra-aortic balloon pump or coronary angioplasty.

The adequacy of anesthetic depth should be evaluated if the ischemia onset in within the OR. The depth of anesthesia, adequacy of pain relief and ventilation status should be assessed. In adequate alveolar ventilation can result in hypercarbia and sympathetic stimulation which can result in increased HR and blood pressure both of which can precipitate myocardial ischemia.

Management of HR takes priority as an increase in HR is associated with increased myocardial oxygen demand while the coronary supply becomes inadequate due to shortening of the diastolic interval.HR may be controlled by administration of fentanyl or titrated doses of BB's. Use of BB's in this situation should be with caution as inadvertent high dose may result in bradycardia and hypotension which may be detrimental in the final outcome. Esmolol with its short duration of action is a favored drug although most centers now use intravenous metoprolol quite effectively.

The etiology of hypotension is the key to determining the management strategy. Hypovolemia should be managed by volume therapy. Even in cases where a central venous pressure is not available for assessment and there is no obvious blood loss a fluid challenge would not be a wasted effort. Undue vasodilatation causing hypotension may be managed by additional vasopressor administration (phenylephrine). While adequate filling is a prerequisite, the negative impact of overfilling should also be understood. The coronary perfusion pressure is the difference between the aortic diastolic pressure (ADP) and the left ventricular end diastolic pressure (LVEDP). In many coronaries with significant obstruction the upper pressure may be much less than the actual ADP and if the LVEDP is high because of over filling, there may be practically no coronary perfusion.

Reduction in myocardial oxygen consumption is also a target. This may be reduced by reduction of contractility as well as reduction in ventricular wall tension. Myocardial contractility can be reduced with drugs like BB's or reduction in afterload (inhalation anesthetics, afterload reducing agents like milrinone) although this may be detrimental when the ADP becomes too low. Wall tension can be reduced by controlled volume therapy or use of intravenous nitroglycerine.

Role of intravenous nitroglycerine.

Intravenous nitroglycerine has a rapid onset and short duration of action. It reduces preload to the heart, reduces LVEDV and ventricular wall tension. Reduction in LVEDV should reduce the left ventricular end diastolic pressure and myocardial wall tension. Nitroglycerine also dilates the large epicardial coronary arteries even when significant stenosis is present. These beneficial effects should enhance the coronary

perfusion. If nitroglycerine fails to improve the ischemic changes and tachycardia is persisting, then titrated doses of BB's may be used.

Intra-aortic balloon pump.

Even in the non cardiac setting an IABP may be useful. It augments the diastolic blood pressure and thereby increases the coronary perfusion. The sudden deflation of the balloon during the onset of ventricular systole results in significant reduction in LV afterload and reduces the myocardial oxygen consumption. The only situation where IABP may not be useful is when there is undue drop in systemic resistance when the augmentation may not adequately improve coronary flow.

Role of coronary intervention.

In the perioperative setting a conservative approach is recommended. In case of STEMI, although fibrinolytic therapy is indicated for patients with a diagnosis within 12 hours of presentation in the non-operative settings, it is a poor reperfusion choice after non cardiac surgery due to the high risk of postoperative bleeding. In the setting of perioperative STEMI, percutaneous intervention would be the treatment of choice due to its lower risk for major hemorrhage. Patients with PMI most likely to benefit include from percutaneous intervention or coronary bypass surgery are those with acute thrombotic coronary occlusion reflected by sudden onset of symptoms and ST segment elevation on ECG. In most situations PCI involves placement of a stent. However, even PCI involves use of anticoagulation which is mandatory in this mode of treatment. It involves use of heparin, clopidogrel, aspirin, BB's and analgesics.

In NSTEMI, coronary intervention is not generally recommended unless the patient is at high risk or hemodynamically unstable. Supportive therapy including use of BB's, aspirin, clopidogrel, statins and hemodynamic support are generally used unless patient is in cardiogenic shock and coronary intervention is mandated.

Summary

1. PMI is most common seen in the immediate postoperative period and is precipitated by sympathetic surge commonly seen during this period.
2. ST segment depression type myocardial ischemia is most commonly seen after non cardiac surgery although a significant number of patients with classical plaque rupture may also be seen.
3. Diagnosis of PMI is very vague and difficult. Elevation in cardiac biomarkers with or without ST changes should portend postoperative cardiac complications.
4. BB's may be protective in prevention of PMI. However, unmonitored perioperative use of BB may be harmful

5. Intravenous nitroglycerine in the perioperative and postoperative period is useful in prevention and during treatment for myocardial ischemia.
6. IABP and coronary intervention should be sought primarily in patients with ST elevation type ischemia whereas ST depression type ischemia should be managed conservatively.

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