Review Article

# Perioperative myocardial injury and infarction following non-cardiac surgery: A review of the eclipsed epidemic

**ABSTRACT**

The perioperative period induces unpredictable and significant alterations in coronary plaque characteristics which may culminate as adverse cardiovascular events in background of a compromised myocardial oxygen supply and demand balance. This "ischemic-imbalance" provides a substrate for perioperative cardiac adversities which incur a considerable morbidity and mortality. The propensity of myocardial injury is dictated by the conglomeration of various factors like pre-existing medical condition, high-risk surgical interventions, intraoperative hemodynamic management, and the postoperative care. Perioperative myocardial infarction (PMI) differs from myocardial infarction (MI) in a non-operative setting. PMI can often be notoriously "silent" demonstrating a conspicuous absence of the classic clinical symptoms. Moreover, myocardial injury following non-cardiac surgery (MINS) characterized by an elevation of the cardiac insult biomarkers has demonstrated an independent prognostic significance in the perioperative scenario despite the lack of a formal categorization as PMI. This has evoked interest in the meticulous characterization of MINS as a discrete clinical entity. Multifactorial etiology, varying symptomatology, close differential diagnosis, and a debatable management regime makes perioperative myocardial injury-infarction, a subject of detailed discussion.

**Key words:** Cardiac troponins; ischemic imbalance; major adverse cardiovascular event; myocardial injury after non-cardiac surgery; oxygen supply-demand mismatch; perioperative myocardial infarction

## Perioperative Myocardial injury-Infarction: *An Eclipsed Epidemic*

Cardiovascular management of patients undergoing non-cardiac surgery constitutes an area of widespread clinical interest considering the advancing age and co-morbid status of the surgical patient cohort. Despite almost four decades of active research in this field, perioperative myocardial infarction (PMI) continues to pose unique challenges to a perioperative physician with regards to a comprehensive diagnostic and management approach. The results of various large-scale studies have revealed a diverse incidence of PMI ranging from 0.3 to 16%, considering the heterogeneity of the patient population, study design and the index PMI definition employed.[1,2] PMI is a major cause of short-term and long-term morbidity and mortality.[3] It accounts for about 12–40% in-hospital mortality.[1-3] However, the recent literature elucidates that an accurate burden of perioperative myocardial injury could only be unmasked by a sound categorization of the disease spectrum.[2] Thus, perioperative myocardial injury and infarction truly represents an eclipsed epidemic.

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## Evolution of the Myocardial Injury Characterization: Incorporating the Perioperative Scenario

Myocardial infarction (MI)[4] is classically defined as a characteristic rise and fall in cardiac troponin (cTn) levels with at least one value higher than the 99th percentile of the upper reference limit (UNL) (>0.014 ng/mL), with at least one of the following features:

- Ischemic nature of the chest pain
- Recent significant ECG findings such as ST-segment or T-wave alterations, left bundle branch block (LBBB) or the presence of the Q waves
- New-onset regional wall motion abnormalities (RWMA) on echocardiography
- Demonstration of an intracoronary thrombus on angiography or autopsy.

On the other hand, defining or diagnosing PMI, however, presents peculiar difficulty, considering most of the PMIs manifest without symptoms in patients under general anesthesia (GA) or sedation. Moreover, the ECG changes are transient and/or subtle, and the isoenzyme forms such as the creatine kinase-MB (CK-MB) demonstrate a limited sensitivity and specificity in background of coexisting skeletal muscle injury. Consequently, PMI is often recognized late (postoperative day 3-5), leading to a high attributable mortality.[5]

An improved comprehension of the concept of PMI has evoked interest in a term called myocardial injury after non-cardiac surgery (MINS).[6] MINS has been increasingly popularized by the Vascular Events in Noncardiac Surgery Patients Cohort Evaluation (VISION) group of investigators. MINS[7] has been defined in the recent universal MI definition as a prognostically relevant postoperative troponin level elevation during or within a period of 30 days after non-cardiac surgery with:

- An underlying ischemic origin of troponin elevation (absence of non-ischemic etiology such as rapid atrial fibrillation, pulmonary embolism, sepsis, etc.)
- Absence of other clinical or ECG criteria of PMI.
- The extent of troponin elevation has been generally defined as greater than 99th percentile of the UNL of the particular assay.

## Literature on MINS and PMI: The Clinical Spectrum

The recent studies have demonstrated that MINS is relatively frequent with the incidence ranging from 8 to 19% and confers an augmented morbidity and mortality.[6-9] PMI is eventually diagnosed in nearly 40% MINS in background of a non-high sensitivity cTn evaluation, and in about 20–30% cases when a high sensitivity (hs) assay is employed.[6-9] The recent major research work on MINS reveals the troponin thresholds: (i) a non-high-sensitivity troponin T (TnT) ≥30 ng/L[6] and (ii) hsTnT ranging from 20 to 65 ng/L in background of an at least 5 ng/L absolute TnT elevation or an hsTnT level ≥65 ng/L. These thresholds are independently associated with the risk of 30-day mortality.[8]

## Mechanisms of PMI

The third and the fourth universal definition[7,10] outline the MI classification on the basis of clinical setting, providing a clue towards the etiological background [Table 1]. The type 2 MI here signifies a scenario of supply-demand mismatch which is a harbinger of PMI in most of the cases.

The perioperative period induces a wide range of un-physiological changes in the sympathetic tone, cardiovascular system performance, coagulation, and inflammatory milieu. These changes include unpredictable alterations in the atherosclerotic plaque morphology, function, and the progression. Simultaneous perioperative alterations in homeostasis may trigger myocardial oxygen supply and demand imbalance or better designated as an "Ischemic imbalance". Absence of a timely resolution begets PMI, irrespective of the etiology.

Two different mechanisms lead to PMI.[11] PMI type 1 is caused by sudden rupture of a vulnerable coronary plaque, platelet aggregation or by severe coronary vasospasm, causing either occlusive [ST-segment elevation, STEMI) or non-occlusive (non-ST-segment elevation (NSTEMI)] thrombus, and MI [Figure 1]. Plaque disruption is demonstrated in autopsy studies in approximately 50% of patients who succumb to PMI. PMI type 2 usually occurs due to sustained imbalance between myocardial oxygen supply and demand in coexisting significant, obstructive, although not occlusive CAD. Therefore, majority patients with PMI

**Table 1: The MI categorization as per the 3rd and the 4th universal definition**

| |
|---|
| A spontaneous MI (Type 1): denoting the causal association of plaque disruption and the coronary athero-thrombosis. |
| MI as a consequence of an *Ischemic Imbalance* (Type 2): oxygen supply-demand imbalances unrelated to the coronary athero-thrombosis. |
| Cardiac death owing to MI (Type 3): Peculiar symptomatology of myocardial ischemia, mortality prior to obtainment of the biomarkers |
| Procedure-related MI (Type 4 and 5) |
| MI associated with percutaneous coronary intervention (PCI) (Type 4a) |
| MI associated with stent thrombosis (Type 4b) |
| MI associated with restenosis in a setting of PCI (Type 4c) |
| MI associated with coronary artery bypass grafting (Type 5) |

MI: Myocardial infarction

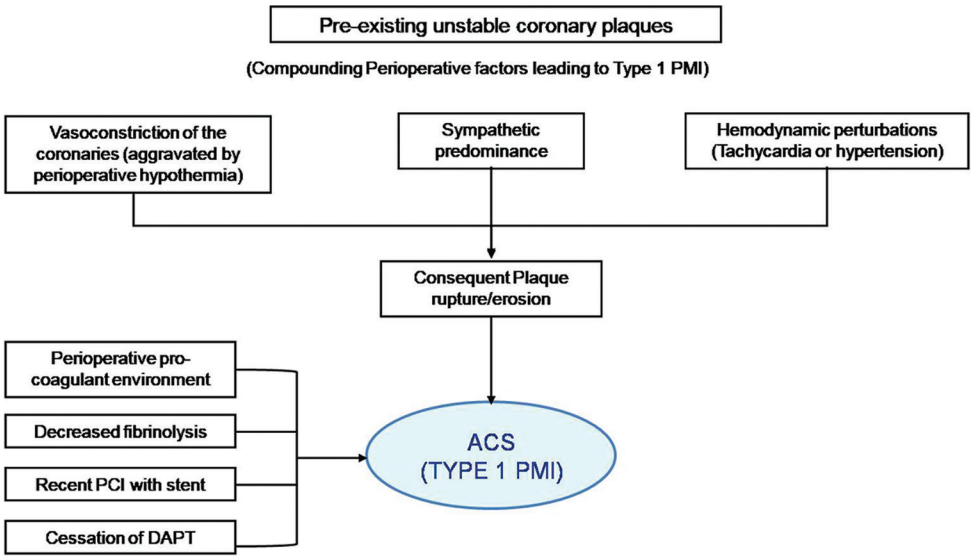


**Figure 1: The pathogenesis of a type-1 PMI. (ACS: Acute coronary syndrome; DAPT: Dual antiplatelet therapy; PCI: Percutaneous coronary intervention; PMI: Perioperative myocardial infarction)**

type 2 demonstrate ST-segment depression (NSTEMI). Twenty percent of PMIs develop in the operating room while most PMIs i.e. 80% manifest 48–72 hours postoperatively.[12-15]

Numerous factors affect the myocardial oxygen delivery ($DO_2$)/myocardial oxygen consumption ($mVO_2$) balance out of which discontinuation of the cardiac medications, electrolyte disturbances, pain, anxiety, stress reactions, bleeding, neuroendocrine response and alterations in the coagulation mechanism are common during the perioperative period [Figure 2].

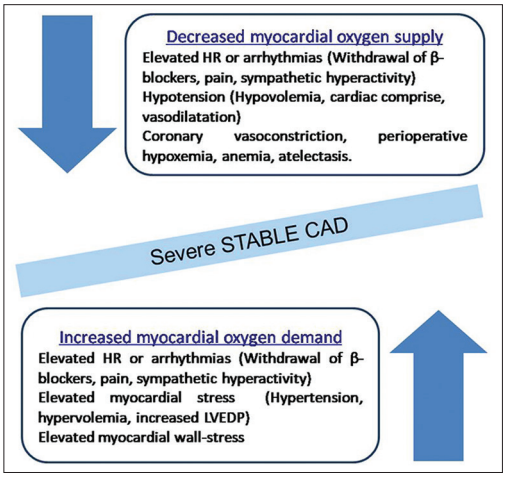


**Figure 2: The pathogenesis of a type-2 PMI. (CAD: Coronary artery disease; HR: Heart rate; LVEDP: Left ventricle end-diastolic pressure)**

## Risk Stratification

Triggering factors for major adverse cardiac event (MACE) are a combination of the patient and procedure-specific parameters.

### (A) Patient specific clinical risk predictors

American College of Cardiology/American Heart Association (ACC/AHA) Task Force on perioperative evaluation of cardiac patients undergoing non-cardiac Surgery have defined the major, intermediate and minor clinical predictors for risk stratification.[16]

***Major factors (markers of unstable coronary artery disease)***

- Acute myocardial infarction (<7 days) or recent MI (7-30 days)
- Unstable severe angina class III and IV
- Decompensated heart failure (NYHA functional class IV or worsening heart failure)
- Significant arrhythmias - High grade atrio-ventricular block (AV block), Mobitz type II AV block, symptomatic ventricular arrhythmias, supraventricular arrhythmias (including atrial fibrillation) with uncontrolled ventricular rate, symptomatic bradycardia, newly recognized ventricular tachycardia.

***Intermediate factors (markers of stable coronary disease)***

- History of ischemic heart disease (IHD) (excluding revascularization)
- History of congestive cardiac failure (CCF)
- History of stroke or transient ischemic attack (TIA)
- Preoperative insulin-dependent diabetes mellitus
- Serum creatinine >2 mg% (renal failure).

***Minor factors (increased probability of CAD)***

- Familial history of CAD
- Poly-vascular status

- Uncontrolled systemic hypertension
- Hypercholesterolemia
- Smoking
- ECG abnormalities (arrhythmia, left ventricle hypertrophy, LBBB)
- Post-infarction (>3 months), asymptomatic without treatment
- Post CABG or PTCA >3 months and <6 years, with no angina symptoms.

### (B) Surgery-specific risks

Type of surgery also influences the risk stratification for perioperative ischemia[17] which includes:

**High-risk procedures** (risk of perioperative adverse cardiac events >5%)

- Emergent major operations
- Aortic and major vascular procedures
- Peripheral vascular surgeries
- Anticipated prolonged procedures associated with large fluid shifts and/or blood loss.

**Intermediate-risk procedures** (risk of perioperative adverse cardiac events 1-5%)

- Carotid endarterectomy
- Head and neck surgery
- Intra-peritoneal and intra-thoracic surgery
- Orthopedic surgery
- Prostate surgery.

**Low-risk procedures** (risk of perioperative adverse cardiac events <1%)

- Endoscopic procedures
- Superficial procedures
- Cataract surgery
- Breast surgery
- Ambulatory day-care surgery.

### (C) Functional capacity

A pre-operative functional capacity of less than 4 METs of activity confers a 4% risk of postoperative cardiac events, whereas the risk is 0.7% in patients with greater than 4 METS of capacity.

In 1999, Lee and colleagues outlined revised Cardiac Risk Index (RCRI)[18] which is found to be superior to earlier indices like Goldman and Detsky cardiac risk indices. It includes 6 parameters like high-risk surgery, history of IHD, history of CCF, history of cerebrovascular disease, preoperative treatment with insulin and a preoperative serum creatinine >2 mg%.

A comprehensive perioperative risk model incorporating the intraoperative factors in addition to the baseline predisposition is presented in Table 2.[19]

## Outcomes Following PMI

PMI has been linked to various short-term and long-term cardiac morbidity and mortality.

### Short-term outcome

A 11% to 25% 30-day mortality rate has been reported in patients suffering a PMI.[13,19] In the Perioperative Ischemic Evaluation Study (POISE) trial,[13] the attributable 30-day mortality rate was five times in the PMI group compared to the non-PMI group.[10] Non-fatal cardiac arrest, CCF, and coronary revascularization interventions were found to be more common in this cohort, with 60% of patients dying within 7 days after MI occurrence.[6] Acute heart failure, cardiogenic shock, and multi-organ dysfunction are the most common causes of mortality following PMI. Patients with MINS have a lower incidence of adverse cardiac events compared to those with PMI, albeit demonstrates a higher rate of death than patients without elevated cardiac biomarkers. The 30-day mortality rate among patients with MINS is reported to be around 9.8%[6] [Table 3].

### *Long-term outcome*

As perioperative myocardial injury is most often silent, many patients remain unnoticed which increases the risk of long-term cardiovascular event. The 1-year mortality rate following vascular surgery is 20% in patients with elevated troponin levels as compared with 4.7% in patients with normal values.[20]

## Diagnosis

### Clinical presentation

Patients under GA are unable to complain of chest pain but may present with hypotension, arrhythmias, and CCF. Most MI occur early after surgery and are asymptomatic.

**Table 2: The seven anescardiocrat scoring factors**

| |
|---|
| 1. History of CAD |
| 2. History of chronic CCF |
| 3. History of cerebrovascular disease |
| 4. Chronic kidney disease |
| 5. Preoperative abnormal ECG (LV hypertrophy, LBBB, ST-T abnormalities) |
| 6. Intraoperative hypotension (≥20 mm Hg or ≥20% fall in MAP for >1 h) |
| 7. Blood transfusion |
| Risk of major adverse cardiac and cerebrovascular events: 0 factors=1.5%; 1 factor=4.5%; 2 factors=8.9%; ≥3 factors=20.6%. |

CAD: Coronary artery disease; CCF: Chronic congestive failure; LV: Left ventricle; LBBB: Left bundle branch block

**Table 3: A mortality score in patients with MINS**

| Predictor | Points |
|---|---|
| Age ≥75 years | 1 |
| Anterior myocardial ischemia evidence | 1 |
| ST-segment elevation or new LBBB | 2 |
| Expected 30-day mortality rates: 0 points=5.2%; 1 point=10.2%; 2 points=19.0%; 3 points=32.5%; 4 points=49.8% | |

MINS: Myocardial injury after non-cardiac surgery; LBBB: Left bundle branch block

### ECG

ECG may show changes of sub-endocardial or trans-mural ischemia (ST elevation >1 mm).[3] The vast majority of PMI is of the non-Q-wave type and preceded by episodes of ST-segment depression and T wave inversion.[21] Routine ICU monitoring with two lead ECG and ST segment trending detects ischemia only in 3% of high-risk postoperative patients when compared to 12 lead ECG. Long-duration (single duration >20-30 min or cumulative duration >1-2 h) ST-segment change, rather than merely the presence of postoperative ST-segment depression, seems to be associated with adverse cardiac outcome.[22]

### Cardiac biomarkers

CK-MB demonstrates a sensitivity of 60-75% and specificity of 80-95% in the perioperative period.[23] The cardiac troponins (troponin T and I) are rapidly released into the circulation after myocyte injury with absolute myocardial tissue specificity and a high sensitivity. According to studies, cardiac troponins, particularly the high sensitivity assays can identify PMI more accurately than the CK-MB isoenzyme.[24]

ACC/European Society of Cardiology joint guidelines recommend ECG to be recorded at baseline, immediately after surgery and on the first 2 days following surgery and biomarkers to be obtained for all high-risk patients.

In accordance with the 2014 European Society of Cardiology/European Society of Anaesthesiology (ESA/ESC) guidelines, the assessment of cTn, both before and 48–72 hours following major surgical procedures, may be considered in high-risk patients (class IIb, level B).[24] Patients with preoperatively higher troponin levels may undergo a baseline transthoracic echocardiogram (for assessing ventricular function and regional wall motion), a cardiology consultation, and deferral of surgery till the troponin levels settle.[24,25]

Preoperative BNP level is an independent predictor of adverse short-term outcome. Postoperative (day 1-3) measurement of BNPs along with preoperative values significantly improves the prediction of MACE. The optimal cutoff of BNPs is not well defined but several studies and meta-analyses suggest a cutoff value of approximately 20–30 pg/mL for BNP (with 95% sensitivity and 44% specificity), and 125 pg/mL for NT-proBNP.[26,27]

### Pulmonary artery pressure

The quantitative increase in pulmonary capillary wedge pressure and characteristic changes in its waveform have been advocated as an ischemia monitor,[28] but it is recommended that right heart catheterization should not be performed primarily for this indication.

### Transesophageal echocardiography (TEE)

TEE is required to assess left ventricle (LV) function and new RWMA for establishment of definitive diagnosis though it may be difficult to distinguish an evolving infarction from a stunned or a hibernating myocardium.[23]

## Preventive Strategies

The prevention constitutes the basis of the overall postoperative improvement considering the silent nature and dismal outcomes following PMI.

In order to reduce the incidence of type 2 PMI, the proposed strategies include the following.

### (A) Coronary revascularization

Coronary artery stenting may add further complexity in the perioperative hemostatic management as it necessitates the perioperative continuation of antiplatelet drugs to prevent stent restenosis. A minimum of 30 and 365 days of antiplatelet therapy is required for bare metal stent and drug eluting stent, respectively.[29-31] Furthermore, the surgical stress induced sympathetic stimulation and hypercoagulable state may add to the risk of perioperative stent thrombosis. Therefore, risk-benefit ratio needs to be meticulously assessed, preoperatively.

### (B) Pharmacological interventions

- **Beta-blockers:** Beta blockers should be used for all the patients with coronary event for decreasing myocardial oxygen demand unless there is significant bradycardia, decompensated CHF, or severe COPD. Cardio protection of β-blockers is attributed to its anti-arrhythmic, anti-inflammatory, altered gene expression, and antiapoptotic effects.[32,33] AHA/ACC recommends perioperative beta-blockade for all cardiac patients undergoing major non-cardiac surgery unless there is a clear contraindication, and also the cohort who test positive for an inducible ischemia on myocardial stress test examination[34-36]
- **Nitrates:** For patients with symptomatic MI, IV nitroglycerine is effective owing to the coronary

dilatation effects. However, there is no evidence about its prophylactic administration before anesthesia and surgery in decreasing the risk of perioperative cardiac complications[37]

- **Antiplatelet agents (APA)**: Aspirin should be administered in a dose of 375 mg orally or through nasogastric tube. Apart from reducing platelet aggregation, its anti-inflammatory effect may be additive to its antithrombotic effect in patients with plaque instability.[38] Perioperative antiplatelet therapy presents a combination of benefits and risks. For elective surgery, the practice of withdrawing all forms of APA has been challenged because of fear of an unopposed and even increased risk of ischemic events. Most experts recommend surgery while continuing APA for most vascular procedures and in settings where bleeding risk is likely to be low. Aspirin being a weak antiplatelet agent, it is advisable to combine with clopidogrel with the subsequent combination incurring an increased risk for major perioperative bleeding by approximately 50%
- **Alpha 2 -adrenoceptor agonists:** Alpha-2 adrenoceptor agonists improve cardiovascular morbidity and mortality following cardiac and non-cardiac surgery. These drugs attenuate perioperative hemodynamic instability, inhibit central sympathetic discharge, reduce peripheral norepinephrine release and dilate post-stenotic coronary vessels[37,39]
- **Statins:** Lipid lowering with statins is highly effective for primary and secondary prevention of cardiac event. The mechanism of benefit of statin therapy may be related to the pleiotropic as well as the cholesterol-lowering effects.[40,41] The recommendation is to continue statins in patients currently taking statins who are scheduled for non-cardiac surgery. (Class I/Level of Evidence: B)[42]
- **Angiotensin-converting enzyme (ACE) inhibitors** have a proven benefit in patients with a recent ACS and also in patients with vascular disease and normal left ventricular function.[43] These benefits extend to patients with diabetes mellitus where there is the added advantage of a reduction in progression to micro-albuminuria. ACE inhibitors demonstrate anti-ischemic actions with a 20% relative reduction for MI.[44]

### (C) Perioperative prevention of myocardial ischemia

- In addition to the ischemia monitoring mentioned above, a close titration of the hemodynamics while achieving the physiological goals and avoiding tachycardia, hypotension, hypoxemia, hypothermia, anemia and myocardial decompensation constitute the cornerstone of perioperative ischemia prevention.

## Management Regime: *Balancing the Risks of Bleeding and Thrombosis*

The major difference between perioperative patients and non-surgical patients is the risk of life-threatening bleeding and thus thrombolysis is almost always contraindicated in PMI. Aggressive use of antiplatelet agents and anticoagulants may also increase bleeding. Therefore, a more conservative approach is recommended in the perioperative period. Urgent angiography and percutaneous coronary interventions (PCI) are reserved for patients with STEMI or NSTEMI who are hemodynamically unstable.

Treatment should be individualized according to the following: (1) age, comorbidity, and life expectancy of the patient; (2) hemodynamic status; (3) type of PMI (STEMI, NSTEMI) or MINS; and (4) the balance between the risks of death and bleeding.

### Patients in Unstable Condition

PMI complicated by severe ischemic LV dysfunction presents as hemodynamic instability. Hypotension in patients with critical coronary artery stenosis dramatically reduces coronary blood flow, whereas tachycardia increases $mVO_2$, creating a vicious cycle that can lead to cardiogenic shock.

Hemodynamically unstable patients require a rapid and aggressive diagnostic and therapeutic approach. Immediate coronary angiography and PCI are recommended following the administration of dual antiplatelet therapy (DAPT) [Figure 3]. PCI in these patients may be inherently limited by phenomenon of the no-reflow scenario, as well the greater risk of stent thrombosis in background of a sluggish-flow state, although in some cases the improvement in 6-month survival rate is significant in comparison to the isolated medical therapy.

The supportive treatment for patients with ongoing ischemia, cardiac dysfunction, and hypotension is particularly difficult as catecholamine surge may increase the infarct size and produce atrial or ventricular arrhythmias which are poorly tolerated.

Intra-aortic balloon pump (IABP) counter pulsation is used in order to increase both myocardial perfusion and cardiac output. However, fewer data support an improved survival in the non-cardiac surgical setting. The risk-benefit ratio of IABP use should be carefully evaluated in patients with aortic aneurysms or peripheral vascular disease.[45]

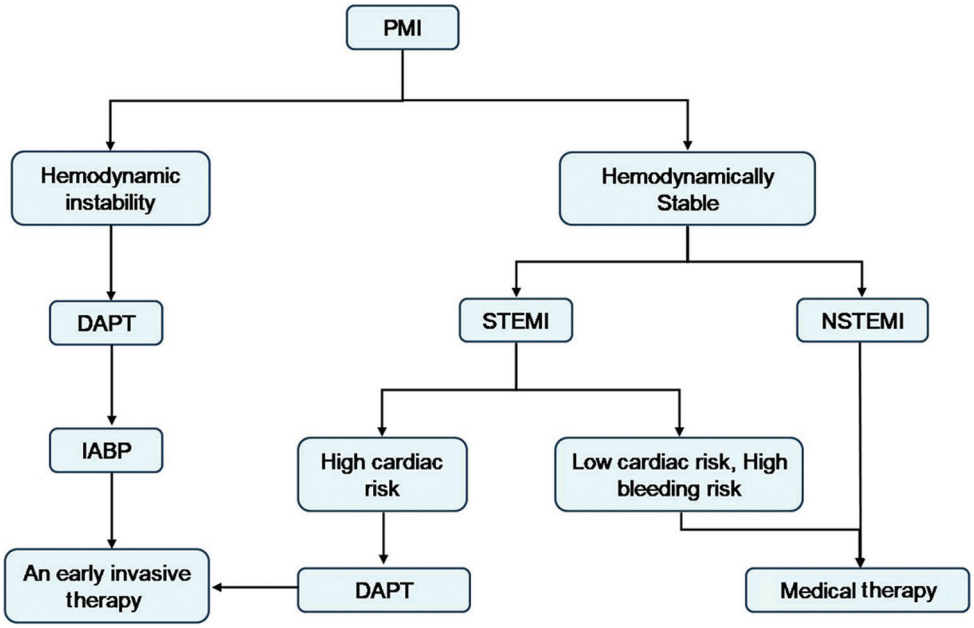


**Figure 3: The approach to PMI management. (DAPT: Dual antiplatelet therapy; IABP: Intra-aortic balloon pump; PMI: Perioperative myocardial infarction; NSTEMI: Non-ST elevation myocardial infarction; STEMI: ST segment elevation myocardial infarction)**

## Patients in Stable Condition

In hemodynamically stable patients, the best therapeutic strategy is largely dictated by accounting for the tenuous balance between the risk of death from PMI and the peri-operative major bleeding. Risk of death can be estimated by employing the TIMI (Thrombolysis in Myocardial Infarction) for STEMI or GRACE (Global Registry of Acute Cardiac Events) risk scores in NSTEMI situation.[46,47] Both the TIMI [Table 4] and GRACE [Table 5] scores recognize patients at high risk of cardiac death who would benefit from an aggressive invasive therapy despite high risk of bleeding [Figure 3], On the other hand, the low-risk patients may be managed with medical therapy.

ST segment elevation usually results from an acute coronary thrombotic occlusion and mandates urgent coronary angiography and PCI in order to reduce mortality rate. A loading dose of aspirin (162-325 mg) and a P2Y12 inhibitor (clopidogrel 600 mg, prasugrel 60 mg, ticagrelor 180 mg), should be administered prior to PCI.

NSTEMI management distinguishes from STEMI in certain aspects. First, NSTEMI emanates as a result of myocardial oxygen supply-demand mismatch owing to the extra-cardiac causes. An effective treatment of such factors presents the potential of reversing the ischemic changes. Second, no complete occlusion of a coronary artery is accountable in most of the cases. Accordingly, the need for an urgent PCI is comparatively less compelling in contrast to STEMI, particularly relevant in the face of an elevated hemorrhagic risk in the perioperative period. However, the 1-year follow-up adverse event incidence is higher in NSTEMI as compared to STEMI. Therefore, a management regime incorporating a routine invasive therapy prior to hospital discharge has been demonstrated to be superior to an isolated medical therapy.

**Table 4: TIMI (Thrombolysis in myocardial infarction) score**

| Factors | Points |
|---|---|
| Age 65-74 years; ≥75 years | 2;3 |
| SBP <100 mm Hg | 3 |
| Heart rate >100 bpm | 2 |
| Killip class 2-4 | 2 |
| Anterior STEMI or LBBB | 1 |
| Diabetes, hypertension or angina | 1 |
| Weight <67 kg | 1 |
| Time to treatment initiation >4 h | 1 |

30 day mortality according to the score: 0: <1%; 1:1.6%; 2:2.2%; 3:4.4%; 4:7.3%; 5:12.4%; 6:16.1%; 7:23.4%; 8:26.8%; >8:35.9%) (SBP: Systolic blood pressure; LBBB: Left bundle branch block

**Table 5: GRACE (Global registry of acute cardiac events) score and the subsequent mortality rates**

| Risk Categorization | GRACE Score | Mortality |
|---|---|---|
| Low risk | <108 | <1% (in hospital) |
| | <88 | <3% (6 months after discharge) |
| Intermediate risk | 109-140 | 1-3% (in hospital) |
| | 89-118 | 3-8% (6 months after discharge) |
| High risk | >140 | >3% (in hospital) |
| | >118 | >8% (6 months after discharge) |

## Conclusion and Future Directions

The perioperative period induces elaborate changes in sympathetic tone, cardiovascular performance, coagulation and inflammatory response inducing spontaneous alterations in plaque morphology. Simultaneous alterations in homeostasis trigger an ischemic-imbalance which begets PMI. PMI is often silent and ECG changes are transient leading to underestimation of the clinical burden. MINS should be studied meticulously as a discrete clinical entity in various perioperative scenarios while formulating robust, scientific and universally applicable definition of a prognostically relevant cardiac troponin elevation. An ischemia-sensitive perioperative monitoring in conjunction with the close titration of physiological goals, helps prevent fatal outcome. It is often easy to put across that an emergency coronary intervention is indicated for hemodynamically unstable patients and medical management for the stable cohort. However, the practical approach and decision-making is essentially an individualized and a multi-disciplinary effort, balancing the risks involved with the cardiac disease on one hand and the perioperative bleeding on the other.

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### Conflicts of interest

There are no conflicts of interest.

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