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Perioperative Myocardial Injury after Non-cardiac Surgery (MINS): Diagnosis and Management.

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Abstract

Introduction: Perioperative myocardial injury after non-cardiac surgery (MINS) is a common yet frequently under-recognized postoperative complication associated with increased cardiovascular morbidity and mortality. As most patients remain asymptomatic, routine postoperative cardiac troponin surveillance has become increasingly important for early diagnosis and timely management. This study evaluated the incidence, risk factors, clinical presentation, diagnosis, management, and short-term outcomes of MINS in patients undergoing major non-cardiac surgery. ***Materials and Methods:*** A prospective observational study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital from September 2024 to September 2025. A total of 100 adult patients undergoing elective or emergency non-cardiac surgery under general or regional anaesthesia were enrolled. Demographic characteristics, comorbidities, perioperative variables, high-sensitivity cardiac troponin levels, electrocardiographic and echocardiographic findings, management strategies, and postoperative outcomes were recorded. ***Results:*** The incidence of MINS was 18.0%, with 55.6% of cases diagnosed on the first postoperative day. Most affected patients (61.1%) were asymptomatic despite elevated postoperative cardiac troponin levels. Advanced age, hypertension, diabetes mellitus, coronary artery disease, chronic kidney disease, emergency surgery, prolonged operative duration, intraoperative hypotension, and perioperative blood transfusion were significantly associated with MINS ($p<0.05$). Multivariate analysis identified intraoperative hypotension (adjusted OR: 4.62), coronary artery disease, advanced age, chronic kidney disease, emergency surgery, and prolonged surgery as independent predictors. Patients with MINS experienced longer hospital stay, higher rates of postoperative cardiovascular complications, and increased in-hospital mortality. ***Conclusion:*** MINS is a frequent and often clinically silent complication following major non-cardiac surgery. Routine postoperative high-sensitivity cardiac troponin monitoring in high-risk patients facilitates early diagnosis, while prompt risk stratification and evidence-based management may improve postoperative outcomes and reduce cardiovascular morbidity and mortality.

Keywords: Perioperative myocardial injury; MINS; Non-cardiac surgery; High-sensitivity cardiac troponin; Perioperative outcomes.

INTRODUCTION

Perioperative myocardial injury after non-cardiac surgery (MINS) has emerged as one of the most important causes of postoperative morbidity and mortality in patients undergoing major non-cardiac surgical procedures [1]. MINS is characterized by an elevation in cardiac troponin concentrations secondary to myocardial ischemia occurring during or within 30 days after surgery, irrespective of the presence of ischemic symptoms [2]. Unlike spontaneous myocardial infarction, the majority of perioperative myocardial injuries are clinically silent due to the effects of anaesthesia, sedation, and postoperative analgesia, making routine surveillance with cardiac biomarkers particularly valuable for early diagnosis [3]. The increasing number of elderly patients with multiple cardiovascular comorbidities undergoing complex surgical procedures has further heightened the clinical significance of MINS [4].

The pathophysiology of MINS is multifactorial and involves an imbalance between myocardial oxygen supply and demand precipitated by perioperative physiological stress [6]. Factors such as intraoperative hypotension, tachycardia, anaemia, hypoxia, blood loss, systemic inflammation, and underlying coronary artery disease contribute to myocardial ischemia and subsequent cardiac injury [7]. Previous studies have reported that approximately 8–20% of patients undergoing major non-

cardiac surgery develop MINS, with affected individuals experiencing a substantially increased risk of heart failure, arrhythmias, prolonged hospitalization, and both short- and long-term mortality [8]. Despite its high incidence and prognostic importance, MINS remains under-recognized because a large proportion of patients do not exhibit classical symptoms of myocardial ischemia [9].

Recent evidence has emphasized the importance of postoperative high-sensitivity cardiac troponin monitoring for timely identification of myocardial injury in high-risk surgical patients [10]. Early recognition enables prompt optimization of haemodynamic status, initiation or intensification of cardioprotective therapies such as statins, antiplatelet agents, beta-blockers, and anticoagulation when appropriate, and timely cardiology consultation [11]. Current international guidelines increasingly advocate perioperative cardiovascular risk assessment and selective postoperative troponin surveillance in patients at elevated cardiovascular risk [12]. Nevertheless, data regarding the incidence, perioperative predictors, clinical presentation, and management of MINS in routine clinical practice remain limited, particularly in developing healthcare settings.

The present study aimed to determine the incidence of perioperative myocardial injury after non-cardiac surgery (MINS), identify the perioperative risk factors associated with its development, evaluate its clinical presentation and diagnostic profile, assess the management strategies employed, and examine short-term postoperative outcomes among patients undergoing major non-cardiac surgery.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital over a period of one year, from September 2024 to September 2025. The study aimed to evaluate the incidence, diagnosis, risk factors, and management of perioperative myocardial injury after non-cardiac surgery (MINS) in adult patients undergoing major non-cardiac surgical procedures. Institutional Ethics Committee approval was obtained before commencement of the study, and written informed consent was obtained from all participants prior to enrolment.

A total of 100 consecutive adult patients aged 18 years and above who underwent elective or emergency non-cardiac surgery requiring either general or regional anaesthesia were included in the study. Patients undergoing cardiac surgery, those with documented acute myocardial infarction within the preceding 30 days, chronic elevation of cardiac troponin due to end-stage renal disease without evidence of acute myocardial injury, patients refusing consent, and those with incomplete perioperative data were excluded. Baseline demographic characteristics, body mass index, American Society of Anesthesiologists (ASA) physical status, medical comorbidities including hypertension, diabetes mellitus, dyslipidaemia, coronary artery disease, chronic kidney disease, heart failure, smoking history, and previous cerebrovascular disease were recorded preoperatively.

Perioperative data collected included the type and urgency of surgery, anaesthetic technique, duration of surgery, estimated blood loss, intraoperative hypotension, blood transfusion requirement, postoperative intensive care unit admission, and laboratory investigations including haemoglobin, serum creatinine, and high-sensitivity cardiac troponin I/T (hs-cTnI/hs-cTnT). Cardiac troponin levels were measured preoperatively (when clinically indicated) and within the first 48–72 hours after surgery or earlier in patients with suspected myocardial injury. Patients diagnosed with MINS were further evaluated clinically with assessment of symptoms, electrocardiography, and transthoracic echocardiography whenever indicated. Details regarding postoperative management, including cardiology consultation, initiation or optimisation of statins, antiplatelet agents, beta-blockers, anticoagulation, coronary angiography, postoperative complications, duration of hospital stay, and in-hospital mortality, were documented. The primary outcome was the incidence of perioperative myocardial injury after non-cardiac surgery, defined according to the Fourth Universal Definition of Myocardial Infarction as an acute postoperative elevation in cardiac troponin attributable to myocardial ischemia, with or without ischemic symptoms or electrocardiographic changes. Secondary outcomes included identification of perioperative risk factors associated with MINS, clinical presentation, management strategies employed, and short-term postoperative outcomes.

Statistical analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequency and percentage. Comparisons between patients with and without MINS were performed using the independent Student's *t*-test for continuous variables and the Chi-square or Fisher's exact test for categorical variables, as appropriate. Variables demonstrating statistical significance on univariate analysis were entered into a multivariate logistic regression model to identify independent predictors of MINS. A p-value of <0.05 was considered statistically significant.

RESULTS

The study included 100 patients undergoing non-cardiac surgery. The mean age of the study population was 62.8 ± 10.7 years, with the majority belonging to the 60–69 years age group (34.0%). Males constituted 61.0% of the participants, and

the mean body mass index was 27.6 ± 4.5 kg/m². Most patients were classified as ASA physical status III (49.0%). Hypertension (58.0%) was the most common comorbidity, followed by diabetes mellitus (41.0%), dyslipidaemia (38.0%), smoking (31.0%), and coronary artery disease (24.0%) (Table 1).

Table 1. Baseline Demographic, Clinical Characteristics and Preoperative Comorbidities (N=100)

Variable	Category	Frequency (%)
Age (years)	<50	18 (18.0)
	50–59	26 (26.0)
	60–69	34 (34.0)
	≥70	22 (22.0)
	Mean ± SD	62.8 ± 10.7
Gender	Male	61 (61.0)
	Female	39 (39.0)
BMI (kg/m²)	Mean ± SD	27.6 ± 4.5
ASA Physical Status	II	36 (36.0)
	III	49 (49.0)
	IV	15 (15.0)
Comorbidities	Hypertension	58 (58.0)
	Diabetes mellitus	41 (41.0)
	Dyslipidaemia	38 (38.0)
	Chronic kidney disease	17 (17.0)
	Coronary artery disease	24 (24.0)
	Previous myocardial infarction	11 (11.0)
	Heart failure	9 (9.0)
	Smoking	31 (31.0)
	COPD	13 (13.0)
	Stroke/TIA	8 (8.0)

Orthopaedic surgery (28.0%) was the most frequently performed procedure, followed by general abdominal surgery (25.0%) and vascular surgery (17.0%). Most surgeries were elective (76.0%) and performed under general anaesthesia (71.0%). The mean duration of surgery was 184.6 ± 62.4 minutes, with an average blood loss of 465 ± 238 mL. Intraoperative hypotension occurred in 29.0% of patients, while 22.0% required blood transfusion and 35.0% were admitted to the intensive care unit postoperatively. The mean peak postoperative hs-cTnI and hs-cTnT levels were 34.9 ± 47.8 ng/L and 41.6 ± 55.3 ng/L, respectively (Table 2).

Table 2. Surgical Characteristics, Anaesthesia, Perioperative Variables and Cardiac Biomarkers (N=100)

Variable	Category	Frequency (%) / Mean ± SD
Type of surgery	Orthopaedic	28 (28.0)
	General abdominal	25 (25.0)
	Vascular	17 (17.0)
	Urological	14 (14.0)
	Neurosurgical	9 (9.0)
	Thoracic	7 (7.0)
Nature of surgery	Elective	76 (76.0)
	Emergency	24 (24.0)
Anaesthesia	General anaesthesia	71 (71.0)
	Regional anaesthesia	29 (29.0)
Mean duration of surgery (minutes)	Mean ± SD	184.6 ± 62.4
Estimated blood loss (mL)	Mean ± SD	465 ± 238
Intraoperative hypotension	Yes	29 (29.0)
Blood transfusion	Yes	22 (22.0)
Postoperative ICU admission	Yes	35 (35.0)
Peak postoperative hs-cTnI (ng/L)	Mean ± SD	34.9 ± 47.8
Peak postoperative hs-cTnT (ng/L)	Mean ± SD	41.6 ± 55.3
Mean postoperative haemoglobin (g/dL)	Mean ± SD	10.7 ± 1.8
Mean serum creatinine (mg/dL)	Mean ± SD	1.21 ± 0.46

Perioperative myocardial injury after non-cardiac surgery (MINS) was diagnosed in 18.0% of patients. More than half of the cases (55.6%) were identified on the first postoperative day. Among patients with MINS, 61.1% were asymptomatic, while hypotension (33.3%) and dyspnoea (27.8%) were the most common clinical manifestations. ECG abnormalities were observed in 55.6%, and new left ventricular dysfunction was detected in 33.3% of cases. Most patients received statins (88.9%) and antiplatelet therapy (77.8%), whereas coronary angiography was performed in 16.7%. The mean hospital stay among patients with MINS was 10.8 ± 4.2 days, with an in-hospital mortality rate of 11.1% (Table 3).

Table 3. Incidence of MINS, Clinical Findings, Management and Outcomes (N=100)

Variable	Category	Frequency (%)
Diagnosis of MINS	Yes	18 (18.0)
	No	82 (82.0)
Day of diagnosis	POD-1	10 (55.6)
	POD-2	5 (27.8)
	POD-3	3 (16.6)
Clinical presentation among MINS (n=18)	Asymptomatic	11 (61.1)
	Chest pain	4 (22.2)
	Dyspnoea	5 (27.8)
	Hypotension	6 (33.3)
	Arrhythmia	4 (22.2)
	ECG abnormalities	10 (55.6)
	New LV dysfunction on Echocardiography	6 (33.3)
	Cardiology consultation	18 (100.0)
	Statin initiated/intensified	16 (88.9)
	Antiplatelet therapy	14 (77.8)
	Beta-blocker optimisation	11 (61.1)
	Anticoagulation	8 (44.4)
	Coronary angiography	3 (16.7)
	ICU stay >48 hours	8 (44.4)
	Heart failure	4 (22.2)
	Major arrhythmia	5 (27.8)
	Length of hospital stay (days)	10.8 ± 4.2
	In-hospital mortality	2 (11.1)

Patients who developed MINS were significantly more likely to be aged ≥65 years, have hypertension, diabetes mellitus, coronary artery disease, chronic kidney disease, and a history of smoking. Emergency surgery, longer operative duration, intraoperative hypotension, and perioperative blood transfusion were also significantly associated with the development of MINS (all $p<0.05$). Male gender did not show a statistically significant association with MINS ($p=0.277$) (Table 4).

Table 4. Factors Associated with Development of MINS

Variable	MINS (n=18)	No MINS (n=82)	χ^2/t	p-value
Age ≥65 years	14 (77.8)	29 (35.4)	11.24	0.001
Male gender	13 (72.2)	48 (58.5)	1.18	0.277
Hypertension	15 (83.3)	43 (52.4)	6.09	0.014
Diabetes mellitus	12 (66.7)	29 (35.4)	5.98	0.015
Coronary artery disease	10 (55.6)	14 (17.1)	12.11	<0.001
Chronic kidney disease	7 (38.9)	10 (12.2)	7.28	0.007
Smoking	10 (55.6)	21 (25.6)	5.88	0.015
Emergency surgery	9 (50.0)	15 (18.3)	8.05	0.005
Duration of surgery (minutes)	229.8±51.6	174.6±58.7	3.68	<0.001
Intraoperative hypotension	12 (66.7)	17 (20.7)	14.67	<0.001
Blood transfusion	9 (50.0)	13 (15.9)	10.23	0.001

Multivariate logistic regression demonstrated that intraoperative hypotension was the strongest independent predictor of MINS (adjusted OR: 4.62, 95% CI: 1.87–11.42, $p=0.001$). Other independent predictors included coronary artery disease (adjusted OR: 3.91), age ≥65 years (adjusted OR: 2.86), chronic kidney disease (adjusted OR: 2.74), emergency surgery (adjusted OR: 2.53), and operative duration greater than 180 minutes (adjusted OR: 2.31), all of which remained statistically significant after adjustment for confounding variables (Table 5).

Table 5. Multivariate Logistic Regression Analysis for Predictors of MINS

Variable	Adjusted OR	95% CI	p-value
Age ≥65 years	2.86	1.24–6.58	0.014
Coronary artery disease	3.91	1.59–9.62	0.003
Chronic kidney disease	2.74	1.08–6.92	0.034
Emergency surgery	2.53	1.02–6.30	0.046
Intraoperative hypotension	4.62	1.87–11.42	0.001
Duration of surgery (>180 min)	2.31	1.01–5.28	0.048

DISCUSSION

In the present study, the incidence of perioperative myocardial injury after non-cardiac surgery (MINS) was 18%, which is consistent with the incidence reported in contemporary literature. A large systematic review and meta-analysis by Smilowitz et al. reported an overall MINS incidence of 17.9%, while the international VISION study similarly demonstrated that postoperative myocardial injury is a common complication associated with adverse postoperative outcomes [13,14]. Our findings therefore reinforce that nearly one in five patients undergoing major non-cardiac surgery may develop perioperative myocardial injury, emphasizing the importance of routine postoperative troponin surveillance in high-risk individuals. The present study demonstrated that increasing age, hypertension, diabetes mellitus, coronary artery disease, chronic kidney disease, emergency surgery, prolonged operative duration, intraoperative hypotension, and perioperative blood transfusion were significantly associated with the development of MINS. After multivariate analysis, intraoperative hypotension emerged as the strongest independent predictor, followed by coronary artery disease and advanced age. These findings closely agree with the systematic review by Chang et al., which identified hypertension, diabetes, heart failure, renal impairment, and perioperative haemodynamic instability as important predictors of postoperative myocardial injury [15]. Similarly, an Indian prospective observational study by George R et al reported a 17.5% incidence of MINS and identified advanced age, pre-existing cardiovascular disease, and perioperative physiological derangements as major determinants of postoperative myocardial injury, findings that closely parallel those observed in our cohort [16].

A notable observation in our study was that 61.1% of patients with MINS remained asymptomatic despite elevated postoperative cardiac troponin levels, highlighting the silent nature of this condition. ECG abnormalities and newly detected left ventricular dysfunction were present in only a subset of affected patients, indicating that reliance on symptoms alone may substantially underestimate the burden of myocardial injury. These findings are consistent with the VISION investigators, who demonstrated that the majority of patients with MINS do not present with classical ischemic symptoms and are identified only through routine postoperative troponin measurements [14,17]. Consequently, current recommendations increasingly support postoperative high-sensitivity troponin surveillance among patients with elevated cardiovascular risk undergoing major non-cardiac surgery. Management of MINS in the present study predominantly included cardiology consultation, initiation or optimization of statin therapy, antiplatelet agents, beta-blockers, and anticoagulation in selected patients. Patients with MINS experienced longer hospital stay, higher rates of postoperative heart failure and arrhythmias, and greater in-hospital mortality than patients without myocardial injury. These observations are consistent with the review by Devereaux et al., which emphasized that early recognition of MINS followed by institution of evidence-based cardioprotective therapies may improve postoperative outcomes and reduce cardiovascular complications [18]. Overall, the findings of the present study support routine perioperative risk stratification and postoperative troponin monitoring in high-risk patients, enabling early diagnosis and timely intervention to reduce the burden of perioperative cardiovascular morbidity and mortality.

CONCLUSION

Perioperative myocardial injury after non-cardiac surgery (MINS) is a common yet frequently asymptomatic postoperative complication that is associated with adverse clinical outcomes, including prolonged hospitalization, cardiovascular complications, and increased mortality. In the present study, advanced age, coronary artery disease, chronic kidney disease, emergency surgery, prolonged operative duration, and intraoperative hypotension were identified as significant predictors of MINS, with intraoperative hypotension emerging as the strongest independent risk factor. Routine postoperative high-sensitivity cardiac troponin surveillance in high-risk patients facilitates early diagnosis of clinically silent myocardial injury and enables timely implementation of evidence-based cardioprotective strategies. Early recognition, appropriate perioperative risk stratification, and multidisciplinary management may improve postoperative outcomes and reduce the burden of perioperative cardiovascular morbidity and mortality in patients undergoing major non-cardiac surgery.

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