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ABSTRACT

Objective: To determine the prognostic relevance, clinical characteristics, and 30-day outcomes associated with myocardial injury after noncardiac surgery (MINS) in vascular surgical patients.

Summary background data: MINS has been independently associated with 30 day mortality after noncardiac surgery. The characteristics and prognostic importance of MINS in vascular surgery patients are poorly described.

Methods: This was an international prospective cohort study of 15,102 noncardiac surgery patients ≥45 years of age, of whom 502 patients underwent vascular surgery. All patients had fourth-generation plasma Troponin T concentrations (TnT) measured during the first three postoperative days. MINS was defined as a TnT ≥0.03 ng/mL secondary to ischemia. The objectives of this study were to determine; i) if MINS is prognostically important in vascular surgical patients, ii) the clinical characteristics of vascular surgery patients with and without MINS, iii) the 30-day outcomes for vascular surgery patients with and without MINS, and iv) the proportion of MINS that probably would have gone undetected without routine troponin monitoring.

Results: The incidence of MINS in the vascular surgery patients was 19.1% (95% confidence interval (CI), 15.7-22.6%). 30-day all-cause mortality in the vascular cohort was 12.5% (95% CI 7.3-20.6%) in patients with MINS compared with 1.5% (95% CI 0.7-3.2%) in patients without MINS (p<0.001). MINS was independently associated with 30-day mortality in vascular patients (odds ratio [OR], 9.48; 95% CI, 3.46-25.96). The 30-day mortality was similar in MINS patients with (15.0%; 95% CI, 7.1-29.1) and without an ischemic feature (12.2%; 95% CI, 5.3-25.5, p=0.76). The proportion of vascular surgery patients who suffered MINS without overt evidence of myocardial ischemia was 74.1% (95% CI, 63.6-82.4).

Conclusions Approximately 1 in 5 patients experienced MINS following vascular surgery. MINS was independently associated with 30 day mortality. The majority of patients with MINS were asymptomatic and would have gone undetected without routine postoperative troponin measurement.

Myocardial Injury after Noncardiac Surgery (MINS) in vascular surgical patients: a prospective observational cohort study

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Short running title: Myocardial injury after vascular surgery

Mini-abstract: This prospective observational cohort study showed that myocardial injury after noncardiac surgery (MINS) independently impacts 30-day mortality (odds ratio, 9.48; 95% CI, 3.46-25.96); with an associated 30-day mortality of 12.5% (95% CI, 7.3-20.6) in vascular surgical patients. The 30-day mortality was similar between patients with and without ischemic features. Approximately 1 in 5 vascular surgery patients sustained MINS, most of whom are asymptomatic and would have been missed without routine postoperative troponin screening.

ABSTRACT

Objective To determine the prognostic relevance, clinical characteristics, and 30-day outcomes associated with myocardial injury after noncardiac surgery (MINS) in vascular surgical patients.

Summary background data: MINS has been independently associated with 30 day mortality after noncardiac surgery. The characteristics and prognostic importance of MINS in vascular surgery patients are poorly described.

Methods This was an international prospective cohort study of 15,102 noncardiac surgery patients ≥45 years of age, of whom 502 patients underwent vascular surgery. All patients had fourth-generation plasma Troponin T concentrations (TnT) measured during the first three postoperative days. MINS was defined as a TnT ≥0.03 ng/mL secondary to ischemia. The objectives of this study were to determine; i) if MINS is prognostically important in vascular surgical patients, ii) the clinical characteristics of vascular surgery patients with and without MINS, iii) the 30-day outcomes for vascular surgery patients with and without MINS, and iv) the proportion of MINS that probably would have gone undetected without routine troponin monitoring.

Results: The incidence of MINS in the vascular surgery patients was 19.1% (95% confidence interval (CI), 15.7-22.6%). 30-day all-cause mortality in the vascular cohort was 12.5% (95% CI 7.3-20.6%) in patients with MINS compared with 1.5% (95% CI 0.7-3.2%) in patients without MINS ($p<0.001$). MINS was independently associated with 30-day mortality in vascular patients (odds ratio [OR], 9.48; 95% CI, 3.46-25.96). The 30-day mortality was similar in MINS patients with (15.0%; 95% CI, 7.1-29.1) and without an ischemic feature (12.2%; 95% CI, 5.3-25.5, $p=0.76$). The proportion of vascular surgery patients who suffered MINS without overt evidence of myocardial ischemia was 74.1% (95% CI, 63.6-82.4).

Conclusions: Approximately 1 in 5 patients experienced MINS following vascular surgery. MINS was independently associated with 30 day mortality. The majority of patients with MINS were asymptomatic and would have gone undetected without routine postoperative troponin measurement.

Key Words: vascular surgery, diagnosis, myocardial injury, prognosis

INTRODUCTION

The American College of Cardiology/American Heart Association (ACC/AHA) perioperative cardiovascular evaluation guideline classified vascular surgery as high risk surgery, with the exception of carotid endarterectomy in 2007,[1] due to the high incidence of postoperative cardiac complications. In the 2014 update of the guidelines, a validated risk prediction tool that includes vascular surgery has been recommended.[2] The elevated cardiovascular risk associated with vascular surgery is multifactorial in etiology and relates partly to the characteristics of the patients who require vascular surgery and partly to the surgery itself. Peripheral vascular disease represents a significant atherosclerotic burden which requires secondary prevention strategies that are similar to patients with established coronary artery disease.[3-5] Arterial disease shares the same risks factors irrespective of its location so concomitant coronary artery disease and carotid artery disease are common in patients undergoing vascular surgery, predisposing them to myocardial ischemia and cerebral hypoperfusion. Further, perioperative hemodynamic instability associated with blood loss, aortic cross clamping and reperfusion phenomena, as well as arterial embolic complications all contribute to the elevated risk of cardiovascular complications intrinsic to vascular surgery. It is therefore not surprising that the rates of in-hospital myocardial infarction, congestive heart failure and arrhythmias, for example, exceed 6% following vascular surgery and 18% following open abdominal aortic aneurysm repair.[6] Large prospective registries have demonstrated that postoperative plasma troponin elevations are associated with an increased risk of 30-day mortality after noncardiac surgeries.[7-9] Recently, the diagnosis of Myocardial Injury in the setting of Noncardiac Surgery (MINS) was introduced to focus attention on the prognostic relevance of ischemic troponin elevations after noncardiac surgery.[10] The diagnostic criteria for MINS comprise a peak fourth generation troponin T (TnT) plasma

level ≥0.03 ng/ml judged to be due to myocardial ischemia which occurs within 30 days after noncardiac surgery.[10] In the Vascular Events In Noncardiac Surgery Patients Cohort Evaluation (VISION) Study (clinicaltrials.gov, identifier NCT00512109), which included >15,000 patients who underwent noncardiac surgery, MINS was independently associated with a 3 to 4 fold excess 30-day mortality.[10] Whether or not MINS is associated with an adverse prognosis in vascular surgical patients is not known. Their high intrinsic risk of postoperative complications makes vascular surgical patients a group of particular clinical interest. Currently, the ACC/AHA recommends, as a class IIb indication (i.e. a physician may consider) postoperative screening with troponin levels in patients at high risk for perioperative myocardial infarction (MI) without signs or symptoms suggestive of myocardial ischemia or MI.[2] Further analysis of the VISION Study data may help to inform the appropriateness of this recommendation in vascular surgical patients.[7]

The objectives of this study were to determine; i) if the VISION MINS diagnostic criteria are prognostically relevant in vascular surgical patients, ii) the clinical characteristics of vascular surgery patients with and without MINS, iii) the 30-day outcomes for vascular surgery patients with and without MINS, and iv) the proportion of MINS that would have gone undetected without routine troponin measurement.

METHODS

Study design

The VISION Study methodology has been previously described.[7] In summary, VISION was a prospective international cohort study of a representative sample of adults undergoing noncardiac surgery. Eligible patients were ≥45 years of age and underwent elective or urgent/emergency noncardiac surgery that required general or regional anesthesia and at least one night in hospital after surgery. The plasma concentration of TnT was measured using Roche 4th generation Elecsys™ troponin T (TnT) assay at 6 to 12 hours postoperatively and on the first three days following surgery. Some patients who developed ischemic symptoms after the third postoperative day had TnT measurements conducted by their healthcare providers. For these patients, we have also evaluated these TnT measurements. All TnT measurements were analyzed at the participating hospitals, and the TnT results were reported to the attending physicians. Patients with a plasma TnT concentration ≥0.04 ng/mL (laboratory threshold considered abnormal at the time of the study) were assessed for ischemic symptoms and signs, and ischemic electrocardiogram (ECG) findings. If a patient with a TnT ≥0.04 ng/mL had no ischemic symptoms or signs or ischemic ECG findings, centers were encouraged to obtain cardiac imaging. An ischemic feature was defined as any of the following: an ischemic symptom/sign, an ischemic ECG finding, a new or presumed new cardiac wall motion abnormality on echocardiography, or a new or presumed new fixed defect on radionuclide imaging. The full definitions of ischemic symptoms/signs and electrocardiography findings are reported in Supplemental Appendix 1.

The primary outcome of the VISION study was mortality at 30 days after surgery. Data monitoring in VISION included central data consistency checks, statistical monitoring, and on-site monitoring for all centers.[7] Adjudicators evaluated all patients with an elevated plasma TnT measurement to determine the presence of any ischemic features (i.e., whether or not the universal definition of myocardial infarction was fulfilled),[11] the presence of a non-ischemic etiology for the elevated plasma TnT concentration, and that the myocardial injury had occurred during or after surgery (i.e., no evidence to suggest that it was a preoperative event). These decisions were used in the statistical analyses.

Myocardial injury aftervascularsurgerystudy

For patients to be included in the MINS vascular study, they had to fulfil both of the following criteria; i) they underwent a vascular procedure in the VISION Study between August 2007 and January 2011, and ii) they had at least one 4th generation plasma TnT measured after noncardiac surgery. Vascular surgical patients were recruited at 12 centers in 8 countries in North and South America, Australia, Asia, and Europe. Vascular surgical procedures were defined as thoracic aorta reconstruction, aorto-iliac reconstruction, peripheral arterial reconstruction without aortic cross-clamping, extracranial cerebrovascular surgery, or endovascular aortic repair (EVAR). The definitions of the surgical procedures are shown in Supplemental Appendix 2. MINS was defined as a peak plasma TnT concentration $\geq$ 0.03 ng/ml or greater that was judged to be secondary to myocardial ischemia (i.e., no evidence of a non-ischemic etiology causing the TnT elevation, such as sepsis, pulmonary embolism or myocarditis) which occurred during or up to 30 days after surgery.[10]

Statistical analyses

A statistical analysis plan outlining the analyses in this paper was written prior to undertaking the analyses. For all analyses, we only included patients with plasma TnT result in the first 30 days postoperatively, and excluded patients with an elevated plasma TnT due to a non-ischemic etiology or who had missing variables which were predictors in the originally described MINS main model.[10] The characteristics of patients who did and did not develop MINS were compared using the Fisher's exact test for categorical variables and the Student T-test or Mann-Whitney U test for continuous variables, as appropriate. We report the 30-day mortality and other important 30-day outcomes (nonfatal cardiac arrest, congestive heart failure, cardiac revascularization and stroke) for patients with and without MINS. The outcome definitions are reported in Supplemental Appendix 3. To determine if the VISION MINS diagnostic criteria were prognostically important in patients undergoing vascular surgery, we undertook a multivariable logistic regression model and included a test of interaction to assess if there was any difference in the impact of MINS on 30-day mortality between patients who suffered MINS after vascular surgery and non-vascular surgery. In this model the dependent variable was time to 30-day mortality and independent variables included preoperative, surgical, and perioperative complication variables previously shown to impact 30-day mortality (Supplemental Appendix 2 reports the preoperative and surgical variables included in the multivariable analysis). An interaction of $p<0.05$ was considered significant, which would indicate that the diagnostic criteria for MINS after vascular surgery had a different impact on mortality than for patients who underwent a non-vascular noncardiac surgery.

To describe the clinical features of MINS events (e.g., ischemic symptoms, ischemic ECG changes), we restricted the analysis to patients who developed MINS and had a peak plasma TnT ≥0.04 ng/ml because we did not assess patients for ischemic features if their peak TnT was <0.04 ng/ml in the original study.[10] To determine the proportion of patients who developed MINS that would have gone undetected after vascular surgery without troponin monitoring (i.e. asymptomatic patients without chest discomfort or other symptoms or signs suggesting myocardial injury), we also restricted the analysis to include patients with a peak plasma TnT ≥ 0.04 ng/ml, as we did not capture symptoms and signs for patients with a peak troponin <0.04 ng/ml.[10]

For patients with more than one episode of MINS, we only considered the first episode. We reported hazard ratios (HR) for the Cox proportional hazards regression, odds ratios (OR) for other associations, 95% confidence intervals (CIs), and associated p-values to 3 decimal places with p-values less than 0.001 reported as p<0.001. For all tests, an alpha level <0.05 was considered significant. All analyses were performed using SAS version 9.2 (Cary, North Carolina)

Ethical considerations and funding sources

The Research Ethics Board at each site approved the protocol prior to patient recruitment. Funding for VISION and its substudies was obtained from over 50 grants.

RESULTS

Figure 1 shows the patient flow for the 15,102 patients who were included in the VISION study. Complete 30-day follow up was available for 99.7% of the patients. The cohort included 502 patients who underwent vascular surgery. More than 90% of the cohort had more than one troponin measurement postoperatively, with only 1431/15,102 (9.5%) of the entire patient cohort and 42/502 (8.4%) of the vascular surgery patients having had a single postoperative troponin measurement. Of these patients, 96 (19.1%; 95% CI 15.7-22.6%) patients developed MINS at a median of one day (range 0-16 days, IQR 0-2 days) after surgery.

Clinical characteristics associated with myocardial injury after vascular surgery

The baseline characteristics of the vascular patients who did and did not develop MINS are reported in Table 1. Patients with MINS were significantly older and more often had atrial fibrillation, congestive heart failure, coronary artery disease and renal dysfunction, and had a higher mean pre-operative heart rate than patients who did not develop MINS. Non-elective surgery and peripheral arterial reconstruction were more common while extracranial cerebrovascular surgery and EVAR were less common in patients who developed MINS compared to patients who did not develop MINS.

Myocardial injury and clinical outcomes after vascular surgery

Of the 15,102 patients, mortality data was missing in 18 of the patients (two from the vascular cohort, and 16 from the non-vascular cohort). Of the remaining 15, 084 patients, eighteen (3.6%; 95% CI, 2.3-5.6) of 500 vascular patients died within 30 days after surgery compared with 250 (1.7%; 95% CI, 1.5-1.9) of 14,584 non-vascular patients in the VISION cohort (p=0.005). Table

2 and figure 2 show the 30-day mortality for vascular surgical patients with and without MINS. Mortality was significantly higher (12.5% v 1.5%; p<0.001) in patients who developed MINS compared with those who did not develop MINS (OR 9.48; 95% CI, 3.46-25.96). Multivariable regression analysis suggested that the impact of MINS on 30-day mortality was similar after vascular and non-vascular surgery (p=0.573 for test of interaction). Patients with MINS also had higher 30-day rates of nonfatal cardiac arrest, congestive heart failure, stroke, and coronary revascularization than patients without MINS (Table 3). Vascular surgical patients who suffered MINS had a significantly increased length of stay (LOS) (17 days; interquartile range [IQR] 5-31 days) compared to vascular surgical patients who did not suffer MINS (LOS 6 days; IQR 3-10 days), p<0.001.

Among the vascular surgery patients who suffered MINS, 81/96 (84.4%) had a plasma TnT concentration ≥0.04ng/ml. Of these patients, 41 (49.4%) had one or more ischemic features (i.e., they fulfilled the universal definition of myocardial infarction) and 40 (50.6%) did not. Table 4 reports the ischemic features of the 81 vascular patients suffering MINS with a plasma TnT concentration ≥0.04ng/ml. Twenty-one (25.9%) of the MINS patients had clinical ischemic symptoms. The most common ischemic ECG findings were T wave inversion (30.9%) and ST depression (19.8%). Timing of diagnosis of asymptomatic and symptomatic MINS was similar (median 1 day after surgery (IQR 0-1 days) and 1 day after surgery (IQR, 0-2), respectively). 145/ 15,102 (1.0%) of patients had troponin measurements after the third postoperative day for clinical symptoms, of which 45 were diagnosed with MINS. Of the vascular surgery patients, 13/502 (2.6%) had troponin measurements after the third postoperative day for clinical symptoms of which five were diagnosed with MINS. Therefore, 361/406 (89.1%) of all patients,

and 91/96 (94.8%) of vascular patients were diagnosed with MINS within the first three postoperative days.

The 30-day mortality was not significantly different (p=0.76) between MINS patients with (15.0%; 95% CI, 7.1-29.1; OR, 11.71; 95% CI, 3.58-38.27) and without an ischemic feature (12.2%; 95% CI, 5.3-25.5; OR, 9.21; 95% CI, 2.68-31.67).

The proportion of MINS in vascular surgery patients that would have gone undetected without troponin monitoring (i.e. asymptomatic MINS) was 60/81 (74.1%; 95% CI, 63.6-82.4).

DISCUSSION

Main findings

In a cohort of more than 500 patients who underwent vascular surgery, MINS was a common finding, with an incidence of 19.1% (95% CI, 15.7-22.6%). MINS was prognostically important. MINS was associated with an increased risk of 30-day mortality (OR, 9.48; 95% CI, 3.46-25.96) and major adverse cardiac events. The majority of patients who developed MINS were asymptomatic (74.1%; 95% CI, 63.6-82.4), and would therefore have gone undetected without routine measurement of plasma troponin concentrations. The 30-day mortality was similar in vascular patients with MINS with and without clinical features of myocardial ischemia.

Our study in relation to other studies

MINS has been shown to be prognostically important in large cohorts of noncardiac surgical patients.[9, 10] MINS has been associated with significantly increased 30-day mortality[9, 10] and long-term mortality.[12] The current ACC/AHA preoperative cardiovascular evaluation guidelines, however, concluded that routine measurement of postoperative troponin levels in unselected patients without signs or symptoms of myocardial ischemia or MI is not useful for guiding perioperative management.[2] Nor do they recommend postoperative troponin surveillance in patients without symptoms or signs of myocardial ischemia who are at high risk for MI (such as vascular surgical patients).[2] These conclusions arose, at least in part, from the lack of an established management strategy for patients who develop MINS.[2] This should not detract from research such as this aimed at clarifying whether or not there is clinical value in diagnosing MINS. Furthermore, there is data suggesting that interventions in patients who develop MINS may have clinical benefits. A case-control study of vascular surgical patients suggested that

optimization of medical therapy in patients with a postoperative troponin elevation (some of which were asymptomatic) was associated with an improved 12 month survival.[13] The 2015 United Kingdom National Vascular Registry (NVR) highlighted opportunities to improve rates of evidence-based medical therapy in vascular surgical patients with nearly 20% of vascular patients not taking statin or aspirin therapy and over 60% of vascular patients not receiving an angiotensin converting enzyme-inhibitors.[14] Moreover, the recent Canadian Cardiovascular Society guidelines on perioperative cardiac risk assessment and management for patients undergoing noncardiac surgery made a strong recommendation based on moderate-quality evidence to obtain daily troponin measurements for 48 to 72 hours after noncardiac surgery in patients with a baseline risk >5% for cardiovascular death or nonfatal myocardial infarction at 30 days after surgery.[15] This would apply to patients aged >65 years of age, those aged 45-64 years with significant cardiovascular disease, patients who have a revised cardiac risk index score >1, and those who have an elevated preoperative plasma concentration of B-type natriuretic peptides.[15] A pharmaco-economic analysis of routine postoperative troponin screening suggests that such surveillance may be cost-effective.[16]

Strengths and weaknesses of our study

The main strength of this study is that it includes a large sample of surgical patients which allowed us to determine the prognostic importance of the MINS diagnosis in vascular surgical patients. As all patients underwent troponin monitoring after surgery, it was possible to determine the proportion of patients in whom the diagnosis of MINS would have gone undetected without troponin surveillance. This study shares the limitations of all observation studies in the potential for confounding. Patients who developed MINS had different clinical

characteristics to patients who did not develop MINS. We attempted to account for confounding through the use of multivariate statistical analysis and MINS was identified as a marker for adverse clinical outcomes independent of other factors. We systematically monitored plasma troponin concentrations until the third postoperative day; and therefore it is possible that we missed MINS events that occurred after the third postoperative day. At the time of the study, a plasma concentration of TnT ≥0.04 ng/mL was considered clinically important, and thus ischemic symptoms and signs were only assessed in these patients.

Interpretation

MINS is common following vascular surgery. MINS is associated with an adverse prognosis, and this prognosis is similar between patients with and without ischemic features. In this study, 12.5% patients with MINS died within 30 days of surgery, yet approximately three-quarters of the cases of MINS (representing nearly 15% of all postoperative vascular patients) will go undetected without routine troponin surveillance. MINS is a potentially useful marker for adverse postoperative outcomes.

CONCLUSIONS

Troponin surveillance detects MINS in approximately 20% patients after vascular surgery. MINS is independently associated with 30-day mortality. Screening for MINS might provide opportunities to improve clinical outcomes in affected patients.

DISCLOSURES

The VISION Study funding sources had no role in the design and conduct of the study; in collection, management, analysis, and interpretation of the data; or in preparation or approval of the manuscript.

Conflict of interest statement: Roche Diagnostics provided the plasma Troponin T assays and some financial support for the VISION Study.

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Table 1. Clinical characteristics of vascular surgery patients with and without MINS.

	No MINS N=406	MINS N=96	p-value for difference
Age (years)			0.002
45-64	126 (31.0)	15 (15.6)	
65-74	141 (34.7)	32 (33.3)	
≥75	139 (34.2)	49 (51.0)	
Females	94 (23.2)	19 (19.8)	0.587
History of tobacco use	329 (81.0)	80 (83.3)	0.663
Current atrial fibrillation	17 (4.2)	13 (13.5)	0.002
History of diabetes mellitus	122 (30.0)	33 (34.4)	0.461
History of hypertension	304 (74.9)	79 (82.3)	0.143
History of CHF	27 (6.7)	17 (17.7)	0.002
History of CAD	145 (35.7)	47 (49.0)	0.019
Recent high risk CAD	10 (2.5)	4 (4.2)	0.319
Coronary revascularization			
Any time before surgery*	86 (21.2)	23 (24.0)	0.583
Within 6 months before surgery	7 (1.7)	2 (2.1)	0.684
History of cardiac arrest	3 (0.7)	1 (1.0)	0.573
History of PVD	229 (56.4)	62 (64.6)	0.168
History of stroke	46 (11.3)	15 (15.6)	0.296
History of COPD	87 (21.4)	26 (27.1)	0.277

Cancer	17 (4.2)	0 (0.0)	0.053
Pre-operative heart rate, mean (SD)	73.3 (13.8)	78.1 (15.5)	0.003
Pre-operative systolic blood pressure, mean (SD)	147.3 (25.4)	146.7 (31.6)	0.859
Pre-operative eGFR (ml/min)**			<0.001
<30 or on dialysis at baseline	15 (3.9)	16 (16.8)	
30-44	43 (11.2)	20 (21.1)	
45-59	69 (18.0)	21 (22.1)	
> 60	256 (66.8)	38 (40.0)	
Type of vascular surgery:			
Thoracic aorta reconstruction	21 (5.2)	5 (5.2)	1.000
Aorto-iliac reconstruction	107 (26.4)	27 (28.1)	0.703
Peripheral arterial reconstruction without aortic cross-clamping	143 (35.2)	49 (51.0)	0.005
Extracranial cerebrovascular surgery	77 (19.0)	13 (13.5)	0.239
EVAR	65 (16.0)	4 (4.2)	0.002
Urgent/emergent surgery	28 (6.9)	17 (17.7)	0.002
Type of anesthesia:			0.201
General only	198 (48.8)	45 (46.9)	
Neuraxial only	103 (25.4)	32 (33.3)	
General and nitrous oxide only	43 (10.6)	3 (3.1)	
General and thoracic epidural only	38 (9.4)	10 (10.4)	
General and nerve block only	2 (0.5)	0 (0.0)	

Other	22 (5.4)	6 (6.3)	

Number (%), unless specified otherwise.

* n=405 and n=96.

** n=383 and n=95.

CHF, congestive heart failure; CAD, coronary artery disease; PVD, peripheral vascular disease; COPD, chronic obstructive pulmonary disease; EVAR, endovascular aortic aneurysm repair

Table 2. 30-day mortality in patients undergoing vascular surgery.

	Mortality at 30 days	
	n/N	% (95% CI)
All vascular surgery patients	18/500	3.6 (2.3-5.6)
No MINS	6/404	1.5 (0.7-3.2)
MINS	12/96	12.5 (7.3-20.6)
MINS patients with peak plasma troponin concentration ≥0.04 ng/ml*		
MINS with no ischemic feature **	5/41	12.2 (5.3-25.5)
MINS with ≥1 ischemic feature	6/40	15.0 (7.1-29.1)

30-day mortality in vascular surgery patients, N=500. Patients who were lost before their 30 day follow-up are not included in this table (N=2 vascular patients).

* For patients with multiple episodes of MINS with peak plasma troponin concentration ≥0.04 ng/ml, the first episode was used as the endpoint.

** ischemic feature was defined as any 1 or more of the following: chest discomfort, neck/jaw/arm discomfort, dyspnea, pulmonary edema, new Q waves, ST elevation, ST depression, T wave inversion, new left bundle branch block, new or presumed new wall motion abnormality on echocardiography, new or presumed new fixed defect on nuclear imaging.

Table 3 30-day outcomes for vascular surgery patients who did and did not develop myocardial injury after noncardiac surgery (MINS)*

Outcome	No MINS n=404	MINS n=94	
	n (%)	n (%)	Unadjusted OR (95% CI), vs no MINS
Nonfatal Cardiac arrest	1 (0.2)	4 (4.3)	17.91 (1.98-162.16)
Congestive heart failure	8 (2.0)	11 (11.7)	6.56 (2.56-16.81)
Stroke	6 (1.5)	6 (6.4)	4.52 (1.43-14.35)
Coronary revascularization (PCI and/or CABG)	1 (0.2)	6 (6.4)	27.48 (3.27-231.11)
Mortality (n=500)	6/404 (1.5)	12/96 (12.5)	9.48 (3.46-25.96)

* Four patients who were lost to follow up within 30 days of surgery were not included in the individual outcomes (n=498). Two patients who were lost to follow up within 30 days of surgery, were not included in the 30-day mortality figures (n=500)

PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting

Table 4 Ischemic features of myocardial injury after noncardiac surgery (MINS) among the 81 vascular surgery patients with a peak plasma troponin concentration ≥0.04 ng/ml

Ischemic features	Frequency N (%)
Ischemic symptoms:	
chest discomfort	9 (11.1)
neck/jaw/arm discomfort	2 (2.5)
dyspnea	12 (14.8)
pulmonary edema	9 (11.1)
any of the above	21 (25.9)
New Q waves	1 (1.2)
ST elevation	1 (1.2)
ST depression	16 (19.8)
T wave inversion	25 (30.9)
New LBBB	0 (0.0)
New WMA on echocardiography	2 (2.5)
Presumed new WMA on echocardiography	8 (9.9)
New flow defect on nuclear imaging	1 (1.2)
Presumed new flow defect on nuclear imaging	2 (2.5)

For patients with multiple episodes of MINS with peak troponin ≥0.04, we have used the first episode.

LBBB, left bundle branch block; WMA, wall motion abnormality

Figure 1. Patient flow chart

See attached figure

Figure 2. Kaplan-Meier Curves for death within 30 days for vascular patients with and without MINS. $p<0.001$, log rank test