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***Original Article** / Özgün Makale*

Myocardial injury after aortoiliac revascularization for extensive disease: A survival analysis

Yaygın hastalıkta aortoiliyak revaskülarizasyon sonrasında miyokard hasarı: Sağkalım analizi

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ABSTRACT

Background: This study aims to evaluate the incidence of myocardial injury after non-cardiac surgery for an extensive disease pattern (TASC II type D) and to examine its prognostic value.

Methods: This prospective study included a total of 66 consecutive patients (62 males, 4 females; mean age 62.5±8.2 years) who underwent elective revascularization for aortoiliac TASC II type D lesions in the tertiary setting between January 2013 and March 2019. The patients were scheduled for revascularization either by open surgery or endovascular approach. Cardiac troponins were routinely measured in the postoperative period. Myocardial injury after non-cardiac surgery was defined as the elevation of cardiac troponin for at least one value above the 99th percentile upper reference limit. Myocardial infarction, acute heart failure, stroke, major adverse cardiovascular events, major adverse limb events, and all-cause mortality were assessed both postoperatively and during follow-up.

Results: The incidence of myocardial injury after non-cardiac surgery was 25.8%. In the multivariate analysis, chronic heart failure was found to be a significant risk factor for myocardial injury after non-cardiac surgery (odds ratio: 10.3; 95% confidence interval 1.00-106.8, p=0.018). At 12 months after revascularization, the diagnosis of myocardial injury after non-cardiac surgery was significantly associated with myocardial infarction, stroke, major adverse cardiovascular events, major adverse limb events, and all-cause mortality. At 12 months after revascularization, the diagnosis of myocardial injury after non-cardiac surgery was significantly associated with myocardial infarction (log-rank p=0.002), stroke (log-rank p=0.007), major adverse cardiovascular events (log-rank p=0.000), major adverse limb events (log-rank p=0.007), and all-causemortality (log-rank p=0.000).

Conclusion: Our study results suggest that myocardial injury after non-cardiac surgery plays a role as a predictor of significant cardiovascular comorbidities and mortality after complex aortoiliac revascularization. The presence of chronic heart failure is also associated with a higher incidence of myocardial injury after aortoiliac TASC II type D revascularization. Therefore, preemptive strategies should be adopted to identify and treat these patients.

Keywords: Aortoiliac revascularization, major adverse cardiovascular events, major adverse limb events, myocardial injury after non-cardiac surgery.

ÖZ

Amaç: Bu çalışmada yaygın hastalık paterni (TASC II tip D) nedeni ile non-kardiyak cerrahi sonrası miyokard hasarının insidansı değerlendirildi ve prognostik değeri araştırıldı.

Çalışma planı: Bu prospektif çalışmaya Ocak 2013 ve Mart 2019 tarihleri arasında üçüncü basamak hastanede aortoiliyak TASC II tip D lezyonları nedeni ile elektif revaskülarizasyon yapılan toplam 66 ardışık hasta (62 erkek, 4 kadın; ort. yaş 62.5±8.2 yıl) alındı. Hastalarda açık cerrahi veya endovasküler yaklaşım ile revaskülarizasyon planlandı. Ameliyat sonrası dönemde kardiyak troponinler rutin olarak çalışıldı. Non-kardiyak cerrahi sonrası miyokard hasarı, üst referans sınırın 99. yüzdeliğinin üzerinde en az bir değerde kardiyak troponin artışı olarak tanımlandı. Ameliyat sonrasında ve takip sırasında miyokard hasarı, akut kalp yetmezliği, inme, majör advers kardiyovasküler olaylar, majör advers ekstremite olayları ve tüm nedenlere bağlı mortalite değerlendirildi.

Bulgular: Non-kardiyak cerrahi sonrası miyokard hasarı insidansı %25.8 idi. Çok değişkenli analizde, kronik kalp yetmezliği, non-kardiyak cerrahi sonrası miyokard hasarında anlamlı bir risk faktörü olarak bulundu (olasılık oranı: 10.3; %95 güven aralığı 1.00-106.8, p=0.018). Revaskülarizasyondan 12 ay sonra, non-kardiyak cerrahi sonrası miyokard hasarı tanısı, miyokard enfarktüsü, inme, majör advers kardiyovasküler olaylar, majör advers ekstremite olayları ve tüm nedenlere bağlı mortalite ile anlamlı düzeyde ilişkili bulundu. Revaskülarizasyondan 12 ay sonra, non-kardiyak cerrahi sonrası miyokard hasarı tanısı, miyokard infarktüsü (log-rank p=0.002), inme (log-rank p=0.007), majör advers kardiyovasküler olaylar (log-rank p=0.000), majör advers ekstremite olayları (log-rank p=0.007) ve tüm nedenlere bağlı mortalite (log-rank p=0.000) ile anlamlı düzeyde ilişkili bulundu.

Sonuç: Çalışma sonuçlarımız, non-kardiyak cerrahi sonrası miyokard hasarının, kompleks aortoiliyak revaskülarizasyonu takiben kardiyovasküler komorbiditeler ve mortalitenin anlamlı bir öngördürücüsü olarak bir rol oynadığını göstermektedir. Kronik kalp yetmezliği varlığı da, aortoiliyak TASC II tip D lezyonların revaskülarizasyonu sonrasında yüksek miyokard hasarı ile ilişkilidir. Bu nedenle, bu hastaları tespit ve tedavi etmek üzere öncelikli stratejiler belirlenmelidir.

Anahtar sözcükler: Aortoiliyak revaskülarizasyon, majör advers kardiyovasküler olaylar, majör advers ekstremite olayları, non-kardiyak cerrahi sonrası miyokard hasarı.

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Myocardial injury after non-cardiac surgery (MINS) has gained significant attention as a risk factor for cardiovascular morbidity and mortality in the postoperative period. Troponin I and T are considered the standard biomarkers to detect myocardial injury with high sensitivity and specificity.[1,2] Due to sedation, anesthesia, or analgesic medication, most patients do not experience ischemic symptoms.[3,4] Therefore, more than 90% of MINS and almost 70% of myocardial infarctions are asymptomatic and may go undiagnosed in the postoperative period without routine troponin monitoring.[4] The incidence of MINS is approximately 8% among patients undergoing non-cardiac surgery, and it is an independent predictor of 30-day mortality with a 10% mortality rate, a hazard ratio (HR) of 3.87, and 95% confidence interval (CI) of 2.96-5.98.[5] In patients with a baseline cardiovascular risk superior to 5%, routinely measurement of cardiac troponin (cTn) is recommended during 48 to 72 h after non-cardiac surgery.[3,6]

The reported incidence of MINS after vascular surgery is almost 10-fold higher than the incidence of deep venous thrombosis,[7] and beyond the association mentioned above with short-term mortality, MINS is also associated with prolonged hospital stay.[8] Myocardial injury after vascular surgery has a reported incidence ranging from 12 to 25%.[7-11] Moreover, troponin elevation after major vascular surgery was found to have a two-fold increased risk of mortality in the long-term.[9]

In an international prospective vascular cohort, 51% of patients who developed MINS had peripheral artery revascularization.[8] In this study, among 15,102 non-cardiac surgery patients, in which 502 of these underwent vascular surgery, the incidence of MINS in the vascular surgery patients was 19.1% and 30-day all-cause mortality significantly increased in patients with MINS versus patients without MINS (12.5% vs. 1.5%, respectively). Scientific evidence concerning MINS prognosis and management are still scarce among extensive Trans-Atlantic Inter-Society Consensus (TASC) II type D aortoiliac disease.[12]

In the present study, we aimed to evaluate the incidence of MINS after open and endovascular aortoiliac revascularization for extensive disease patterns (TASC II type D) and to examine its prognostic value.

PATIENTS AND METHODS

This prospective study included a total of 66 consecutive patients (62 males, 4 females; mean age 62.5±8.2 years) who underwent elective revascularization for aortoiliac TASC II type D lesions[12] in the tertiary setting between January 2013 and March 2019. Demographic and clinical characteristics of the patients, cardiovascular risk factors, procedural, and lesion-specific details were obtained from a detailed review of the clinical records of the patients using the vascular registry.[13] Preoperative arteriogram and computed tomography angiography images were retrieved and reviewed by two independent and experienced observers to assess TASC classification. The TASC II classification was used to categorize disease patterns.[12,14] Only type D aortoiliac lesions were included. Patients with concomitant aortoiliac aneurysmal disease were excluded. Patients with missing troponin values or without an immediately postoperative assessment were also excluded. Sensitivity analysis was performed. A written informed consent was obtained from each patient. The study protocol was approved by the Centro Hospitalar Universitário São João Health Ethics Committee (No. 246-18). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Measurements of troponins

Cardiac troponin I (cTn I) before year 2014, or high-sensitivity troponin I (hsTnI) values after year 2015 (adoption of hsTnI in clinical practice in the hospital) were measured and the highest value was registered systematically during the following 48 h. Troponin measurements were performed immediately after the revascularization and during the two following postoperative days, at 24 and 48 h, after surgery.

The reference value of cTn I chemiluminescent microparticle immunoassay (Architect Stat Troponin I, Abbott Laboratories Inc., Wiesbaden, Germany) for MINS, regardless of sex, was 0.032 µg/mL. A fourth-generation assay, hsTnI (Abbott Laboratories Inc., Wiesbaden, Germany), defined a value of 27 ng/mL for males and 11.4 ng/mL for females. The biochemistry laboratory of the hospital confirmed these reference values for our study population.

The aforementioned cTn I is considered a reliable biomarker for myocardial injury.[1,2] The fourth-generation hsTnI assay is in agreement with the criteria of the International Federation for Clinical Chemistry to be classified as a highly sensitive assay as a cardiac biomarker. The assay has less than 10% of total imprecision at the 99th percentile of reference (upper reference limits) for men and women. It detects cTn in at least 50% of the healthy individuals included in the general population.[3]

Surgical technique

Revascularization technique, either endovascular or open surgical, was made according to the surgeon and the institution experience and preferences. Cases of open bail-out surgery, after technical failure of a first endovascular approach, were also included in the final analysis. Cases with reduced physiological reserve or demonstrated frailty would be less likely to have an open surgical procedure.

Technical success was defined as patency at 24 h after the procedure. Postoperative surveillance consisted of clinical evaluation, Doppler ultrasound, and non-invasive Doppler arterial study with ankle-brachial index (ABI) measurements. The ABI measurements were usually performed at one, six, and 12 months, followed by biannual or annual follow-up.[13] Patency was defined according to reporting standards.[14]

All endovascular procedures were performed by a vascular surgeon under local anesthesia, either in an angiography suite or a C-arm equipped operative room. Only four cases had covered stents. Concerning the remaining patients, non-covered stents were employed, as explained elsewhere.[13] After stent implantation, acetylsalicylic acid (100 mg/day) and clopidogrel (75 mg/day) were prescribed for one month. At the end of one month, acetylsalicylic acid (100 mg/day) was recommended for lifelong use.

Transperitoneal aortobifemoral bypass surgery was performed in an operating room under general anesthesia. A double woven graft was used for all the bilateral aortoiliac surgical reconstructions. After synthetic vascular graft implantation, acetylsalicylic acid (100 mg/day) was also prescribed for long-term use.

All patients went through regular thromboembolic prophylaxis with low-molecular-weight heparin. In the postoperative period, if the patient had an independent indication for anticoagulation, simultaneous anti-aggregation would be selected. In the long-term, anticoagulation was privileged. All open procedures were at least 24 h under continuous monitoring in the intensive care unit. Endovascular procedures seldomly needed intensive care.

Other definitions

All data regarding patients and procedures were defined according to the Society for Vascular Surgery reporting standard for lower extremity ischemia. Symptoms of chronic lower extremity ischemia were classified according to the Rutherford classification.[12]

Myocardial injury after non-cardiac surgery was defined as the elevation of cTn at least one value above the 99th percentile upper reference limit which for the study population was >0.032 μg/mL for cTnI and 11.4 ng/mL (female) and 27 ng/mL (male) for hsTnI. Myocardial infarction (MI) was defined according to the fourth Universal Definition of Myocardial Infarction.[3]

A major adverse cardiovascular event (MACE) was defined as a composite outcome, including MI, acute heart failure (AHF), and all-cause mortality.[3] A major adverse limb event (MALE) was defined as the merged events of reintervention and subsequent major amputation of the revascularized artery segment or acute ischemia.[15]

Since postoperative anemia may be associated with troponin elevation and higher mortality, the hemoglobin (Hb) threshold for cardiac ischemia risk was set to 10 g/dL.[16] The final Hb measurement before surgery was considered.[16]

Statistical analysis

The necessary sample for a survival test was calculated resorting to WinPepi® version 11.65 (Brixton Health, United Kingdom), aiming for a statistical power (β) of 80% and an alpha (α) value of <0.05. The sample size was estimated (n=52) for an event rate difference of 30% between groups, although higher event rate differences were described previously.[5,10]

Statistical analysis was performed using the IBM SPSS for Windows version 25.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard error (SE), median (min-max) or number and frequency. For univariate purposes, chi-square (χ^2) and Fisher's exact tests were used to measure the association between categorical variables and Student's t-test for the continuous variables. Binary logistic regression was performed for the multivariate analysis, resorting to the dimension reduction method to exclude confounding factors. Survival analysis was also done using the Kaplan-Meier estimator and lifetable method. The log-rank estimator was applied to compare time-dependent variables. The evaluation of troponin measurement as a screening test was performed and sensitivity and specificity were analyzed based on the receiver operating characteristic (ROC) curve. Calculation of likelihood ratios (LR) for each associated complication to evaluate the value of troponin monitoring was also performed. A *p* value of <0.05 was considered statistically significant.

RESULTS

Of the patients, 17 (26%) were diagnosed with MINS. In the univariate analysis, the MINS group

was significantly older than the patients without MINS (65±8.7 vs. 61±7.7 years, respectively; p=0.05). However, only the sex association was confirmed in the multivariate analysis (adjusted odds ratio [OR]: 0.05, 95% CI: 0.004-0.590, p=0.018). The median follow-up was 51 (range, 40.6 to 61.4) months. There was no statistically significant difference in the demographic characteristics between the groups. Demographic and clinical characteristics are shown in Table 1.

Regarding the differences between the groups concerning the variables measured preoperatively, smoking was less prevalent in the MINS group (76.5% vs. 100%, respectively; p=0.001), and chronic heart failure (CHF) was more prevalent in patients with MINS (17.60% vs. 2.00%, respectively; p=0.02). Additionally, troponin elevation was significantly associated with percutaneous iliac stenting in 52.9% (n=9) of the patients compared to those without MINS (18.4%) (p=0.006).

Only CHF and aortoiliac stenting were confirmed in the multivariate analysis as potentially risk factors for MINS (OR: 10.3; 95% CI: 1.00-106.8 and OR: 5.00; 95% CI: 1.512-16.531; respectively). However, the aOR for CHF was 14.67 (95% CI: 1.253-171.7, p=0.032), whereas aortoiliac stenting had an aOR of 5.954 (95% CI: 1.673-21.189, p=0.006).

The length of stay in the hospital or intensive care unit did not significantly prolong in MINS patients (p=0.454 and p=0.659, respectively).

Prognostic impact of MINS in short and one-year follow-up

At 30-days after the procedure, troponin elevation in the immediate postoperative period showed a positive association with mortality (n=4, 23.5% vs. n=1, 2.0%, respectively; p=0.004), MACE (n=7, 41.2% vs. n=1, 2.0%, respectively; p<0.000), and MALE (n=8, 47.10% vs. n=5, 10.2%, respectively; p=0.001) (Table 2).

At one-year follow-up, in the MINS group, the mean freedom from MALE was 45.8±13.7% (p= 0.007) and the mean freedom from MACE was 47.1±12.1% (p≤0.001). At 12 months after revascularization, postoperative MINS was significantly associated with MI, stroke, AHF, MALE, MACE, and all-cause mortality (Figure 1).

Table 1. Baseline demographic and clinical characteristics of patients

Variables	No MINS (n=49)			MINS (n=17)			*p*	Adjusted odds ratio (95% CI)	*p**
	n	%	Mean±SD	n	%	Mean±SD			
Age (year)			60.9±7.7			65.4±8.7	0.05		
Sex Male	48	98.0		14	82.4		0.02	0.05 (0.004-0.590)	0.018
Hypertension	31	63.3		14	82.4		0.145		
Smoking	49	100		13	76.5		0.000		
CKD	4	8.2		4	23.5		0.094		
Diabetes mellitus	19	38.8		5	29.4		0.489		
Dyslipidemia	28	57.1		12	70.6		0.328		
Coronary arterial disease	10	20.4		6	35.3		0.217		
Chronic heart failure	1	2		3	17.6		0.02	10.3 (1.00-106.8)	0.018
COPD	5	10.2		2	11.8		0.857		
Hemoglobin (g/dL)			13.4±1.7			13.2±2.2	0.555		
SFA disease	30	62.5		11	73.3		0.442		
Limb threatening ischemia	30	61.2		14	82.4		0.111		
Rutherford classification			4.08±0.862			4.0±0.816	0.74		
Iliac stenting vs ABF	9	18.4		9	52.9		0.006	5.00 (1.512-16.531)	0.04

* Multivariable analysis using binary logistic regression; MINS: Myocardial injury after non-cardiac surgery; SD: Standard deviation; CI: Confidence interval; CKD: Chronic kidney disease (creatinine >1.5 mg/dL); COPD: Chronic obstructive pulmonary disease; SFA: Hemodynamically significant disease of the superficial femoral artery; ABF: Aortobifemoral bypass grafting.

Table 2. MINS - 30-day results

	Death			MACE			MALE		
	n	%	*p*	n	%	*p*	n	%	*p*
No MINS	1	2	0.004	1	2	<0.001	5	10.2	0.001
MINS	4	23.5		7	41.2		8	47.1	

MACE: Major adverse cardiovascular events; MALE: Major adverse limb events; MINS: Myocardial injury after non-cardiac surgery.

Troponin measurement test value

Assessment of cTn I or hsTnI was performed in all included patients. Regarding sensitivity and specificity, analysis of troponin monitoring, specificity for all-cause mortality was 85.71% (true negatives). In addition, MINS demonstrated an acceptable specificity and sensitivity performance regarding individual and combined cardiovascular outcomes (Table 3).

A LR above 5 for a positive MINS test was determined for MACE (Table 3). Concerning patients without MINS, only those who experienced MALE had a negative LR above 0.5 (0.72). The patients who died or experienced MI, stroke, AHF or MACE had a calculated negative LR of 0.48, 0.25, 0.32, 0, and 0.45, respectively.

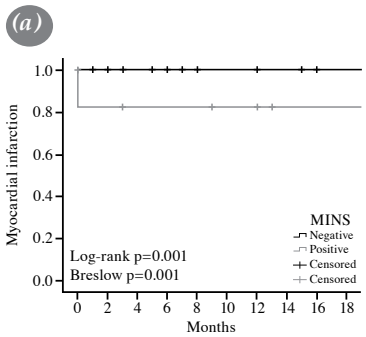
DISCUSSION

This study reported an incidence of postoperative MINS after aortoiliac TASC II D revascularization of 17 patients (25.8%). Chronic heart failure and endovascular revascularization were found to be significant risk factors. Troponin elevation in these patients confirmed a risk of worse prognosis in the short-term and after one-year follow-up. All-cause mortality, MI, stroke, AHF, MALE, and MACE occurred more frequently in the patients with MINS.

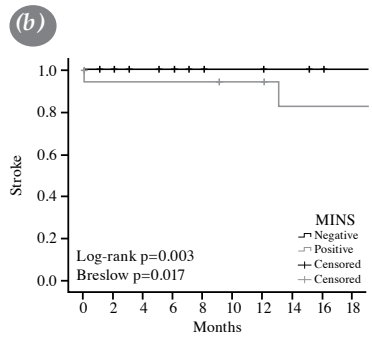
Myocardial injury after non-cardiac surgery is most common in patients with cardiovascular disease and associated risk factors.[17] However, no significant differences were found between the patients with and without MINS in terms of cardiovascular risk factors in our study. In addition, CHF was confirmed as a significant independent predictor of troponin elevation in the multivariate analysis. Heart failure is a well-established risk factor for perioperative cardiac events,[18,19] and severe compromised left ventricle has been shown to be an important determinant of MACE in vascular surgery.[20] Troponin elevation could be explained by an oxygen supply-demand mismatch enhanced by acute and chronic heart failure.[3,21] This mechanism would increase cardiac stress and endothelial dysfunction together with potential myocardial necrosis, proteolysis, and direct toxicity related to inflammation, neurohormones, or infiltrative processes triggering troponin release to the bloodstream.[21] These results are supported by a large cohort study which found that 17.7% of MINS patients had previous congestive heart failure.[8] Other studies also reported that patients with critical lower limb ischemia who underwent endovascular revascularization and presented MINS had a significant association with previous CHF (p=0.006).[7,11]

In this cohort, MINS appeared to be more likely to happen under endovascular therapy for AI-TASC II D lesions. These results can be explained by selection bias, since patients with fewer comorbidities are suitable for open repair, whereas more frail patients with poor health status are aimed for endovascular therapy.[13] Additionally, patients scheduled for endovascular treatment might be at a prohibitive risk for open surgery due to their poor cardiopulmonary status, which would alter and potentially undermine the conclusion that endovascular intervention was associated with MINS. Other prospective studies regarding surgical treatment of peripheral artery disease (PAD) found similar results. Linnemann et al.[10] also found an increased incidence for the endovascular approach (open repair 1.8% vs. endovascular therapy 54.1%, respectively), although only artery stenting was significant for troponin elevation.

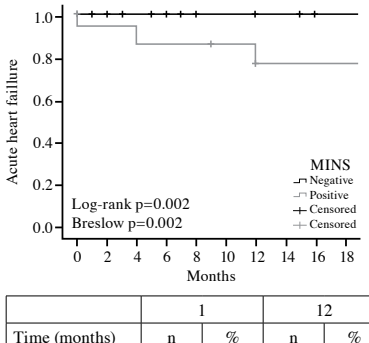
The occurrence of MINS in this patient cohort was an independent determinant of MI, AHF, death, and MACE after a one-year follow-up. Similar results were attained for MINS patients revascularized for critical limb ischemia (MACE, MI and death) in another study at one-year follow-up (p=0.003, p=0.007, and p=0.011, respectively). The HR was 2.89 (95% CI: 1.41-5.92) for MACE and 2.44 (95% CI: 1.18-5.06) for death.[11] Comparable to this and to reinforce this association, MINS predicted MACE after PAD endovascular revascularization with an aHR=2.14 (95% CI: 1.42-3.23, p=0.0003) at long-term follow-up.[22] Myocardial infarction was a frequent adverse outcome



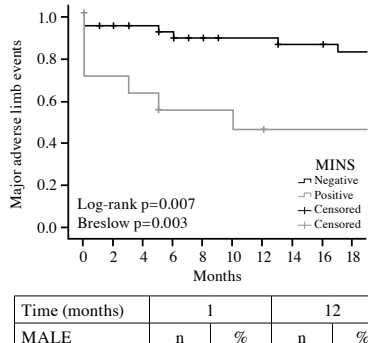
	1		12	
Time (months)	n	%	n	%
No MINS (n=49)	48	100	32	100
SE		0		0
MINS (n=17)	14	82.4	7	82.4
SE		9.2		9.2



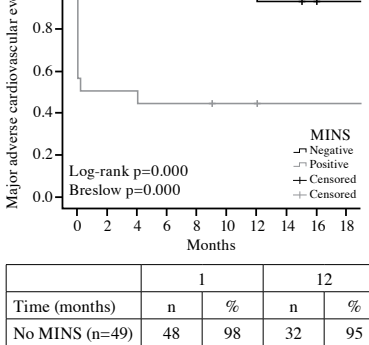
	1		12	
Time (months)	n	%	n	%
No MINS (n=49)	48	100	32	100
SE		0		0
MINS (n=17)	16	94.1	9	94.1
SE		5.7		5.7



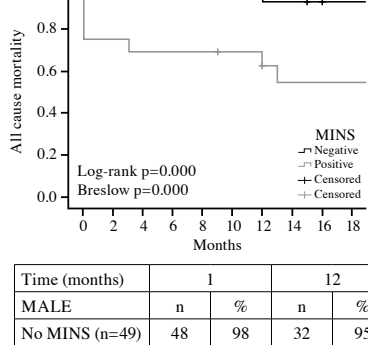
	1		12	
Time (months)	n	%	n	%
No MINS (n=49)	48	100	32	100
SE		0		0
MINS (n=17)	12	94.1	8	82.4
SE		5.7		9.2



Time (months)	1		12	
MALE	n	%	n	%
No MINS (n=49)	45	93.9	28	88.4
SE		3.4		4.9
MINS (n=17)	9	70.6	4	45.8
SE		11.1		13.7



	1		12	
Time (months)	n	%	n	%
No MINS (n=49)	48	98	32	95
SE		2		3.5
MINS (n=17)	10	58.8	6	47.1
SE		11.9		12.1



Time (months)	1		12	
MALE	n	%	n	%
No MINS (n=49)	48	98	32	95
SE		2		3.5
MINS (n=17)	13	76.5	9	63.5
SE		10.3		12

Figure 1. Survival plots. 18-month follow-up Kaplan Meier survival plots for different clinical events in patients with and without MINS. **(a)** Myocardial Infarction; **(b)** Stroke; **(c)** Acute Heart Failure; **(d)** Major Adverse Limb Event; **(e)** Major Adverse Cardiovascular Event; **(f)** All-cause mortality.

MINS: Myocardial Injury after non-cardiac surgery; SE: Standard Error.

Table 3. Diagnostic test evaluation

	MI	No MI	Stroke	No stroke	AHF	No AHF	MACE	No MACE	MALE	No MALE	Death	Alive
	n	n	n	n	n	n	n	n	n	n	n	n
No MINS	1	48	1	48	0	48	8	41	11	38	7	42
MINS	4	13	3	14	3	14	12	5	8	9	10	7
Sensitivity (%)	80.00		75.00		100		60.00		42.11		58.82	
Specificity (%)	78.69		77.42		77.42		89.13		80.85		85.71	
LR+	3.75		3.32		4.43		5.52		2.20		4.12	
LR-	0.25		0.32		0		0.45		0.72		0.48	

MI: Myocardial infarction; AHF: Acute heart failure; MACE: Major adverse cardiovascular events; MALE: Major adverse limb events; MINS: Myocardial injury after non-cardiac surgery; LR: Likelihood ratio.

at one-year follow-up following revascularization for PAD and critical limb ischemia with established MINS.[10,11] Linnemann et al.[10] similarly described higher mortality rates at one-year follow-up in patients undergoing revascularization for PAD lesions with MINS (HR, 8.14, 95% CI: 3.77-17.6, p<0.001). Congestive heart failure at 30-days after MINS was described by Biccard et al.[8] in patients undergoing vascular surgery.

In our study, patients with MINS were more likely to suffer MALE in the postoperative period (n=8, 47.10% vs. n=5, 10.2%, respectively; p=0.001). Linnemann et al.[10] found a significant association at one-year in patients with MINS undergoing revascularization for PAD (HR, 3.71, 95% CI: 1.33-10.3, p=0.012). Additionally, even with lower troponin elevations, current evidence suggests that patients surgically treated for acute lower limb ischemia have a longer length of stay in the hospital (17 days vs. 6 days, respectively; p>0.001), suggesting MINS as a potential predictor of morbidity.[23]

In this study, the presence of MINS as a screening test for cardiovascular complications demonstrated high sensitivity (100%) only for AHF, remaining significantly lower for other outcomes. A high sensitivity (100%) was only demonstrated for AHF. For the other adverse outcomes, specificity showed higher rates than sensitivity, with specificity near 80% for all adverse outcomes. The best value for specificity was 89.13% for MACE. However, since the event rates were low between the patients with and without MINS to assess positive and negative predictive values, LR was the best approach to evaluate the utility of troponin monitoring. Indeed, patients with a positive test for MINS had an LR of 5.52 for MACE, reflecting a moderately increased risk of approximately 20 to 30%.[24] Considering the remaining outcomes, the value of a negative test for MINS is likely to be more useful, since it reveals a moderate decrease in the risk of MI and stroke (nearly 20 to 30%) and an even higher decrease in the risk for AHF (45%).[24] Biccard et al.[8] reported that 74.1% of vascular patients would have MINS undiagnosed, keeping in mind that these patients potentially had approximately 10-fold increased risk of death at 30-days. Given with the fact that troponin elevation is associated with increased morbidity and mortality rates in patients undergoing revascularization for AI-TASC II D lesions and as undiagnosed MINS may carry severe outcomes, monitoring of hsTn I in the following 48 h after revascularization in selected patients is recommended for improved clinical follow-up.[6,19] Patients should be also risk-stratified according to the Revised Cardiac Risk Index (RCRI) due to cost-effectivity purposes.[6,18,19,25] If RCRI has at least 1 point attributed (risk estimate 6%, 95% CI: 4.9-7.4), plus minimal age of 65 years old (or age 45-64 with significant cardiovascular comorbidity), the Canadian Cardiovascular Society guidelines recommend ordering N-terminal pro-brain natriuretic peptide/brain natriuretic peptide (NT-proBNP/BNP) monitoring and, if positive, troponin assessment should be performed.[6] However, troponin measurement seems to be more cost-effective due to its reliability and lower cost.

The current management of MINS is still unclear. A recent international, randomized, placebo-controlled trial, the Dabigatran in Patients with Myocardial Injury after Non-Cardiac Surgery (MANAGE) trial, showed that the use of dabigatran 110 mg twice daily in patients with postoperative troponin elevation after non-cardiac surgery had a significant advantage in reducing combined adverse outcomes including vascular mortality, non-fatal MI, stroke, peripheral artery thrombosis, amputation and symptomatic venous thromboembolism (HR, 0.72, 95% CI: 0.55-0.93,

p=0.0115) without an increased risk of additional bleeding.[25]

The strengths of the current study are the longitudinal surveillance of the patients on a prospective basis and the fact that the diagnosed TASC II lesions had similar degrees among patients. On the other hand, some limitations need to be considered. A small sample limits the external validity for difficult conclusions. The low prevalence of female patients in the sample could also mask a potential role as a determinant of the incidence of MINS. The lack of randomization of treatment modalities limits the considerations concerning endovascular versus surgical treatment in terms of MINS incidence and cardiovascular events in the postoperative period. A selection bias is likely to interfere in the results. The preoperative infection status could lower the threshold for MINS, although not available in this report. Data regarding the pharmacological treatment of these patients was also not available; therefore, beta-blockers and statins intakes were not considered in the analysis.

In conclusion, our study results showed that the incidence of myocardial injury after non-cardiac surgery was 25.8% after revascularization of aortoiliac Trans-Atlantic Inter-Society Consensus II type D lesions and chronic heart failure was associated with the presence of myocardial injury after non-cardiac surgery. In addition, myocardial injury after aortoiliac type D lesions revascularization was a strong predictor of further myocardial infarction, stroke, acute heart failure, major adverse cardiovascular events, major adverse limb events, and all-cause mortality at a one-year follow-up. Based on these findings, we suggest that screening for myocardial injury after non-cardiac surgery in high-risk vascular patients may improve the management of outcomes. However, further large-scale, long-term, prospective studies are needed to confirm these findings and to develop preventive and management methods of myocardial injury after non-cardiac surgery after revascularization of aortoiliac-Trans-Atlantic Inter-Society Consensus II type D lesions.

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