Original Article

The Effect of High-Dose Atorvastatin on Postoperative Troponin in Patients Undergoing Non-Cardiac Surgery: A Triple-Blind Randomized Clinical Trial

Mohammad Javad Aminizadeh [1], Seyyed Hosein Mousavi [1], Reza Mosaed [2], Mehran Khoshfetrat [1], Reza Arefizdeh [1], Mohsen Askari [3], Seyed Abolfazl Mohsenizade [1]*

[1] Trauma and Surgery Research Center, AJA University of Medical Sciences, Tehran, Iran.
[2] Department of Clinical Pharmacy, School of Medicine, AJA University of Medical Sciences, Tehran, Iran.
[3] Department of Internal Medicine, School of Medicine, AJA University of Medical Sciences, Tehran, Iran.

Citation: Aminizadeh MJ, Mousavi SH, Mosaed R, Khoshfetrat M, Arefizdeh R, Askari M, et al. The Effect of High-Dose Atorvastatin on Postoperative Troponin in Patients Undergoing Non-Cardiac Surgery: A Triple-Blind Randomized Clinical Trial. Res Heart Yield Transl Med 2025; 20(4):276-284.

Highlights

- Preoperative administration of high-dose statins in patients undergoing non-cardiac surgery reduced postoperative troponin.

Article info:

Received: 20 Sep. 2025
Revised: 21 Sep. 2025
Accepted: 26 Sep. 2025

*** Corresponding Author:**
Seyed Abolfazl Mohsenizade
Trauma and Surgery Research Center, AJA University of Medical Sciences, Tehran, Iran.
E-mail: dr.mohseni959@gmail.com

ABSTRACT

Background: Cardiovascular complications account for a substantial proportion of perioperative complications. This study aimed to evaluate whether preoperative high-dose atorvastatin reduces postoperative changes in serum high-sensitivity cardiac troponin (hs-cTn) concentrations in patients at elevated cardiac risk undergoing noncardiac surgery.

Methods: In this triple-blind, parallel-group, randomized controlled trial, adults with a Revised Cardiac Risk Index (RCRI) of 1 or greater scheduled for noncardiac surgery were randomized (1:1) to receive atorvastatin 80 mg 24 hours preoperatively or placebo. The primary outcome was the change in serum hs-cTn concentrations 24 hours after surgery. Secondary outcomes included the incidence of major adverse cardiovascular events (MACE) within 7 days after surgery, as well as cardiovascular death, myocardial infarction, stroke, heart failure, arrhythmia, or transient ischemic attack.

Results: A total of 112 patients with similar baseline characteristics were randomized and completed a 7-day follow-up. Postoperative hs-cTn levels increased significantly in the placebo group (P<0.001) but decreased in the statin group (P<0.001), with a significant between-group difference favoring statin therapy (P<0.001). Subgroup analyses by anesthesia type and prior statin use showed consistent findings. MACE occurred in three patients (5.4%) in the statin group and two patients (3.6%) in the placebo group (P=1.00).

Conclusion: Preoperative high-dose atorvastatin significantly reduced postoperative hs-cTn levels, indicating a biochemical cardioprotective effect, but it did not translate into a reduction of short-term clinical cardiovascular events. Larger multicenter trials with longer follow-up are required to determine whether troponin reduction translates into improved clinical outcomes.

Keywords: Major Adverse Cardiovascular Events (MACE); High-Sensitivity Cardiac Troponin (hs-cTn); Statins; Randomized Controlled Trial (RCT)

Introduction

Approximately 5% of patients undergoing noncardiac surgery experience cardiovascular complications, independent of preexisting comorbidities.[1]

This risk is substantially higher among individuals with elevated baseline cardiac risk, accounting for up to 35% of perioperative deaths.[2] Given this burden, accurate preoperative risk stratification and effective preventive strategies are critical to improving outcomes.[3]

Validated tools such as the Revised Cardiac Risk Index (RCRI) are widely used to identify patients at increased risk of major cardiac complications during noncardiac surgery, with demonstrated high sensitivity.[4] According to the 2024 American College of Cardiology/American Heart Association Joint Committee guideline,[5] an RCRI score of greater than 1 denotes elevated perioperative cardiac risk. Accordingly, strategies aimed at reducing their perioperative cardiovascular burden are of particular interest.

Statins have established benefits in both primary and secondary prevention of atherosclerotic cardiovascular disease, mediated not only through lipid-lowering effects but also via pleiotropic mechanisms.[6] Several studies have suggested the potential benefit of perioperative statin therapy in vascular and endovascular surgery.[7,9] Nonetheless, current evidence remains insufficient to support firm recommendations for their use in noncardiac surgery.[3,10] These uncertainties underscore the need for further well-designed randomized controlled trials to clarify the balance of benefits and risks.

This randomized clinical trial investigated whether a single high dose of atorvastatin reduces perioperative cardiovascular complications in Iranian patients undergoing noncardiac surgery with an elevated cardiac risk (RCRI≥1). The objective was to assess the impact on the postoperative cardiac troponin levels at 24 hours and the incidence of major adverse cardiovascular events (MACE) within 7 days after surgery.

Methods

Trial Design and Setting

This study was conducted as a triple-blind, parallel-group randomized controlled trial with a 1:1 allocation ratio. Participants, health care providers, and members of the research team were blinded until completion of data collection. The trial framework was designed to evaluate the superiority of high-dose statin therapy compared with placebo. No major changes to the study protocol, outcomes, or analyses occurred after trial commencement. The study was conducted at Imam Reza Hospital, affiliated with AJA University of Medical Sciences in Tehran, Iran. The study complies with the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of AJA University of Medical Sciences (IR.AJAUMS.REC.1403.070), and the trial was prospectively registered in the Iranian Registry of Clinical Trials (IRCT20240825062861N1). The trial was reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines.

Eligibility

Eligible participants were adults aged 40 to 90 years scheduled for noncardiac surgery and considered to have moderate to high cardiovascular risk. Preoperative risk was assessed using the RCRI.[11] This index assigns one point for each risk factor, and a total score of one or greater was classified as indicating moderate to high risk. All RCRI scores were calculated by an independent specialist who was not involved in the conduct of the trial. Written informed consent was obtained before enrollment. Exclusion criteria included cancellation of surgery for any reason, routine use of high-dose statins before allocation, and end-stage renal disease (ESRD).

Variables

Baseline demographic and clinical variables were defined using standardized criteria. Diabetes mellitus was considered present if patients had a prior diagnosis of type 1 or type 2 diabetes, were receiving oral hypoglycemic agents or insulin, or, in the absence of a known history, demonstrated fasting blood glucose levels of 126 mg/dL or greater on two separate occasions. Hypertension was defined as a prior diagnosis or current use of antihypertensive therapy, or by blood pressure readings of systolic 140 mm Hg or greater or diastolic 90 mm Hg or greater on at least two

measurements. Smoking status was recorded as any lifetime history of regular or intermittent tobacco use, as well as current daily or weekly use at the time of data collection. Concomitant medication use was recorded for statins, antiplatelets, β-blockers, nitrates, antihypertensives (including angiotensin-converting enzyme [ACE] inhibitors and angiotensin II receptor blockers [ARBs]), sodium-glucose cotransporter 2 (SGLT2) inhibitors, and insulin when taken regularly during the week preceding surgery. Left ventricular ejection fraction (LVEF) was assessed from the most recent preoperative echocardiogram performed by a cardiologist. Surgical time was recorded in minutes, defined as the interval from the first incision to the completion of skin closure, based on operative records.

Interventions and Comparator

Patients in the intervention group received a single oral dose of atorvastatin 80 mg administered 24 hours before surgery. Those in the control group received a placebo capsule that was visually indistinguishable from the study drug. All medications were prepared and dispensed by an independent pharmacist who was not otherwise involved in the study, and the capsules were packaged sequentially to maintain concealment.

Outcomes

The primary outcome was the change in serum concentrations of high-sensitivity cardiac troponin (hs-cTn). Secondary outcomes included MACE, defined as a composite of cardiovascular death, myocardial infarction (MI), heart failure, arrhythmia, stroke, and transient ischemic attack (TIA).

hs-cTn was measured in nanograms per milliliter using a radioimmunoassay method. Because the hospital laboratory could not perform hs-cTn assays, all measurements were conducted in an external certified laboratory. Serum concentrations were obtained preoperatively and repeated 24 hours postoperatively; both absolute values and changes from baseline were analyzed, with results summarized as mean (SD) or median (IQR), as appropriate.

The incidence of MACE within 7 days after surgery was defined according to International Classification of Diseases, Clinical Modification, Tenth Revision (ICD-10-CM) codes. MI was defined as an elevation in troponin above the 99th percentile (cutoff: 52 ng/L), accompanied by clinical or electrocardiographic (ECG) evidence of infarction, in accordance with the specifications of the assay kit. Heart failure was defined as the new onset of clinical signs or symptoms (eg, dyspnea, peripheral edema, or pulmonary rales) confirmed by the treating physician, in conjunction with ischemic changes resulting in reduced LVEF. Arrhythmias were defined as new atrial or ventricular rhythm disturbances detected on postoperative monitoring or ECGy, including atrial fibrillation, ventricular tachycardia, or complete heart block. Stroke was defined as a new, sudden-onset focal neurological deficit lasting more than 24 hours, confirmed by neuroimaging or clinical assessment and attributed to a vascular cause. TIA was defined as an acute episode of focal neurological dysfunction lasting less than 24 hours, without evidence of acute infarction on neuroimaging. All secondary outcomes were analyzed as binary incidence variables and reported as the proportion of patients affected within 7 days of surgery.[13]

Harms

Adverse events were monitored by blinded physicians throughout hospitalization and for up to 7 days postoperatively. In cases of postoperative cardiovascular complications (MI, heart failure, and arrhythmia), patients were followed up for 1 to 2 months through outpatient visits.

Sample Size

The required sample size was calculated using G*Power software, assuming an effect size of 0.5, a power of 90%, and a 1-tailed type I error of 0.05. Based on these assumptions, 140 patients were required, with 70 allocated to each group.

Randomization

The random allocation sequence was generated by an independent biostatistician using block randomization to ensure balance between groups. A fixed block size of four (kept concealed from the investigators) was used. Allocation concealment was maintained through sequentially

numbered, opaque, sealed envelopes prepared by the biostatistician. Patients were enrolled by research staff, and the assigned intervention was dispensed by an independent pharmacist. Neither the personnel responsible for patient enrollment nor the clinical team assigning interventions had access to the random sequence at any stage.

Blinding

After random assignment, participants, care providers, investigators, outcome assessors, and data analysts were blinded to the allocated interventions. Blinding was achieved by providing atorvastatin and placebo capsules that were identical in appearance, packaging, and labeling, making the interventions indistinguishable to both patients and study personnel.

Statistical Analysis

Categorical outcomes were compared between groups using the χ^2 or Fisher exact test, as appropriate. Continuous outcomes were analyzed with the student t test or the Mann-Whitney U test, depending on distributional assumptions. Normality of continuous variables was assessed using the Kolmogorov-Smirnov test, histograms, and quantile-quantile (Q-Q) plots. All randomized patients were analyzed according to the intention-to-treat principle. Missing data were handled by complete-case analysis, and no imputation was performed. Exploratory analyses were conducted to assess whether treatment effects differed by type of anesthesia (general vs spinal) and by prior statin exposure (yes vs no).

All statistical analyses were performed using IBM SPSS Statistics, version 26 (IBM Corp, Armonk, NY). A 2-sided P value of less than 0.05 was considered statistically significant.

Results

Participant Flow

Of the 140 patients initially enrolled, 112 were included in the final analysis. Twenty-eight patients were excluded because of surgery cancellation (n=8) and incomplete clinical data (n=20). All participants included in the final cohort received their assigned intervention and were analyzed for the primary outcome. No additional exclusions occurred after randomization (Figure 1).

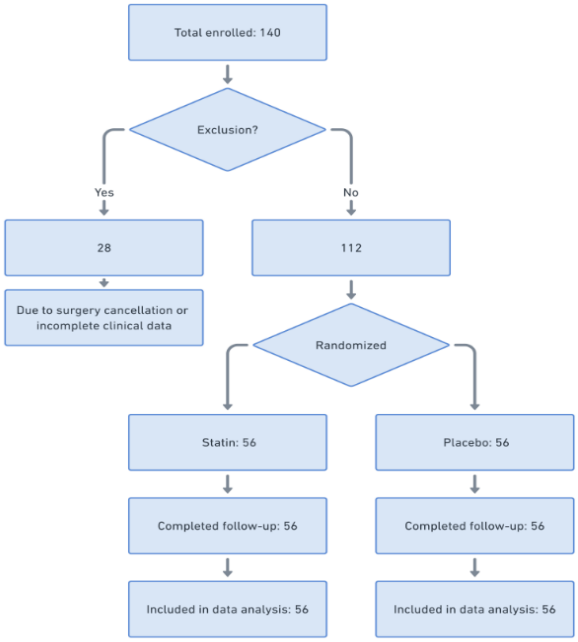

Figure 1. CONSORT flow diagram for two-group randomized clinical trial (statin vs placebo).

Recruitment

Patients were recruited between September 2024 and April 2025. Follow-up for all outcomes was conducted for 7 days postoperatively. The trial was terminated after the allocation of 56 patients to each group.

Intervention Delivery and Concomitant Care

Patients in the intervention group received a single oral dose of atorvastatin 80 mg administered 24 hours before surgery, whereas those in the control group received a visually identical placebo capsule. Both interventions were delivered according to the study protocol, and adherence was complete. No protocol deviations occurred in either group; therefore, all randomized patients were included in the analysis according to the intention-to-treat principle. Concomitant medication uses at baseline, including statins, antiplatelets, β-blockers, nitrates, antihypertensives, SGLT2 inhibitors, and insulin, did not differ significantly between the groups (Table 1). Similarly, perioperative variables such as type of anesthesia (general vs spinal), surgical category (intraperitoneal, neurological, orthopedic, urological, head and neck, thoracotomy), and surgery duration were comparable between the two groups (Table 1).

Baseline Data

Demographic and clinical baseline characteristics were comparable between the groups. The mean age was 67.9 (12.4) years in the placebo group and 63.9 (12.0) years in the statin group (P=0.576). The proportion of male participants was 50.0% and 46.4%, respectively (P=0.705). Mean body mass index (BMI), LVEF, RCRI scores, and the prevalence of comorbidities, including diabetes, hypertension, and smoking, were not significantly different between the groups (Table 1). Preoperative laboratory values, including white blood cell count, hemoglobin concentration, platelet count, and serum creatinine, did not differ significantly between the groups (Table 1). Surgical characteristics were also comparable, with no meaningful differences in type of anesthesia, type of surgery, or duration of operation (Table 1).

Table 1. Baseline characteristics of patients in the placebo and statin groups

Characteristics	Placebo (n=56)	Statin (n=56)	P
Demographics			
Age, mean (SD), y	67.9 (12.4)	63.9 (12.0)	0.576 [a]
Male sex	28 (50.0)	26 (46.4)	0.705 [b]
BMI, mean (SD), kg/m ^{2}	21.6 (3.3)	21.8 (3.3)	0.638 [a]
LVEF, mean (SD), %	53.5 (4.5)	53.5 (5.2)	0.747 [a]
EF <50%	2 (3.6)	2 (3.6)	1.000 [c]
RCRI score, mean (SD)	1.1 (0.5)	1.1 (0.3)	0.569 [a]
Comorbidities			
Diabetes mellitus	19 (33.9)	15 (26.8)	0.411 [b]
Hypertension	27 (48.2)	20 (35.7)	0.180 [b]
Smoking	9 (16.1)	11 (19.6)	0.622 [b]
Medications			
Statin use	23 (41.1)	14 (25.0)	0.071 [b]
Antiplatelets	19 (33.9)	11 (19.6)	0.088 [b]
β-blockers	16 (28.6)	10 (17.9)	0.179 [b]
Nitrates	7 (12.5)	3 (5.4)	0.185 [b]
Antihypertensives	26 (46.4)	18 (32.1)	0.122 [b]
SGLT2 inhibitors	6 (10.7)	2 (3.6)	0.271 [c]
Insulin	3 (5.4)	2 (3.6)	1.000 [c]
Laboratory Values			
WBC count, mean (SD), ×103/μL×103/μL	8.2 (2.9)	8.29 (3.1)	0.835 [a]
Hemoglobin, mean (SD), g/dL	12.8 (2.0)	12.8 (2.1)	0.932 [a]
Platelet count, mean (SD),	205.0 (73.1)	226.6 (145.9)	0.718 [a]
Creatinine, mean (SD), mg/dL	1.1 (0.3)	1.0 (0.3)	0.360 [a]
Surgical Variables			
Anesthesia type			
General	48 (85.7)	47 (83.9)	1.000 [b]
Spinal	8 (14.3)	9 (16.1)	
Type of Surgery			
Intraperitoneal	27 (48.2)	28 (50.0)	0.760 [c]
Neurological	11 (19.6)	15 (26.8)	
Orthopedic	9 (16.1)	6 (10.7)	
Urological	7 (12.5)	5 (8.9)	
Head and neck	1 (1.8)	2 (3.6)	
Thoracotomy	1 (1.8)	0 (0.0)	
Duration of surgery, mean (SD), min	119.2 (63.4)	113.1 (58.6)	0.569 [a]

BMI: body mass index; LVEF: left ventricular ejection fraction; RCRI: Revised Cardiac Risk Index; SGLT2: sodium-glucose cotransporter 2; WBC: white blood cell.
Data are presented as No. (%) unless otherwise indicated.
[a]Calculated using an independent samples t test.
[b]Calculated using the Pearson χ^2 test.
[c]Calculated using the Fisher exact test.

Outcomes

Preoperative hs-cTn concentrations were similar between the placebo and statin groups (P=0.484). At 24 hours postoperatively, hs-cTn levels increased significantly in the placebo group (P<0.001), whereas they decreased significantly in the statin group (P<0.001) (Table 2 and Figure 2). The median absolute and percentage changes in hs-cTn were markedly higher in the placebo group than in the statin group (both P<0.001) (Table 2).

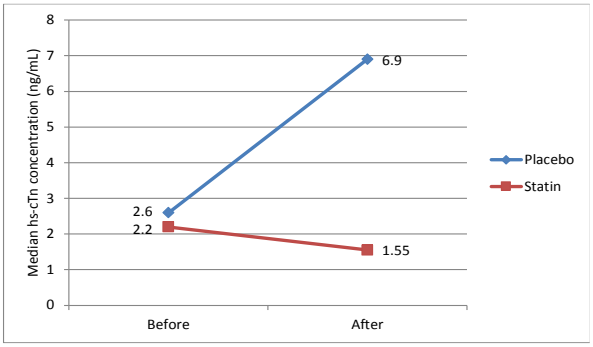

Figure 2. Preoperative and postoperative high-sensitivity cardiac troponin (hs-cTn) levels in the placebo and statin groups

Within 7 days, MACE occurred in two patients (3.6%) in the placebo group and three patients (5.4%) in the statin group (P=1.00) (Table 3). Cardiovascular death occurred in two patients (3.6%) in the placebo group and two patients (3.6%) in the statin group (P=1.00); all deaths were cardiovascular in origin. Postoperative MI and heart failure each occurred in one patient (1.8%) in the statin group and did not occur in the placebo group (P=1.00 for both). Arrhythmia was diagnosed in two patients (3.6%) in the placebo group and one patient (1.8%) in the statin group (P=1.00); all cases were atrial fibrillation (Table 3). No patient in either group experienced stroke or transient ischemic attack (Table 3).

Harms

No unexpected harms or serious adverse events attributable to the intervention were observed. The trial medication was well tolerated in all participants.

Additional Analysis

Subgroup analysis by type of anesthesia revealed no significant differences in preoperative or postoperative troponin concentrations between patients receiving general or spinal anesthesia (P=0.417 and P=0.868, respectively) (Table 4). In addition, subgroup analysis among patients without prior statin use revealed that postoperative troponin levels increased significantly in the placebo group but decreased in the statin group (P<0.001 and P=0.004, respectively) (Table 4).

Table 2. Comparison of preoperative and postoperative hs-cTn levels between the placebo and statin groups

Variables	**Placebo (n=56)** Median (IQR)	**Statin (n=56)** Median (IQR)	**P*** (between groups)
Absolute change, ng/mL	3.9 (9.0)	-0.45 (2.6)	<0.001
Percentage change, %	164.5 (640.3)	-9.2 (51.6)	<0.001
Time point (ng/mL)			
Before surgery	2.6 (6.2)	2.2 (7.4)	0.484
After surgery	6.9 (15.1)	1.6 (5.5)	<0.001
P** (within group)	<0.001	<0.001	

* Mann-Whitney U test
** Wilcoxon signed rank test

Table 3. Secondary outcomes within 7 days after surgery

Outcomes	**Placebo (n = 56)**	**Statin (n = 56)**	**P***
MACE, n (%)	2 (3.6)	3 (5.4)	1.00
Cardiovascular death, n (%)	2 (3.6)	2 (3.6)	1.00
Myocardial infarction, n (%)	0 (0.0)	1 (1.8)	1.00
Stroke, n (%)	0 (0.0)	0 (0.0)	–
Heart failure, n (%)	0 (0.0)	1 (1.8)	1.00
Arrhythmia, n (%)	2 (3.6)	1 (1.8)	1.00
Transient ischemic attack, n (%)	0 (0.0)	0 (0.0)	–

MACE: major adverse cardiac events
*Fisher exact test
Cardiovascular death, myocardial infarction, and stroke were considered MACE.

Table 4. Subgroup analysis of hs-cTn changes according to anesthesia type and statin use

Subgroup Analysis	**Before Median** (IQR)	**After Median** (IQR)	**P*** (within group)
Type of Anesthesia			
General (n=95)	2.2 (6.4)	3.6 (7.5)	
Spinal (n=17)	2.8 (10.2)	4.1 (11.75)	
P** (between groups)	0.417	0.868	
Patients Without Prior Statin Use			
Placebo (n=33)	3.1 (7.9)	7.1 (18.5)	<0.001
Statin (n=42)	1.8 (6.525)	0.85 (5.675)	0.004

* Wilcoxon signed rank test
** Mann-Whitney U test

Discussion

Our trial demonstrated that high-dose statin therapy in patients undergoing noncardiac surgery significantly reduced postoperative hs-cTn levels, despite no differences in baseline or preoperative characteristics between the groups. This effect was also evident in the categorical distribution of hs-cTn, with a higher proportion of patients in the statin group maintaining normal levels and fewer showing borderline or elevated values compared with placebo. Nevertheless, this biochemical improvement did not translate into a significant difference in cardiovascular complications such as MI, arrhythmia, heart failure, stroke, or MACE.

Our findings are consistent with Almansob et al,[12] who also reported reductions in markers of myocardial injury after statin therapy, although their study focused on noncoronary cardiac surgery with simvastatin and explored molecular mechanisms (Akt-eNOS activation, reduced p38 signaling). Similarly, they partially align with observational data by Berwanger et al,[13] who found preoperative statin use reduced 30-day cardiovascular risk, although in our trial, the effect was limited to biochemical endpoints rather than clinical outcomes and had a shorter follow-up period of 7 days. In contrast, the randomized trial by Berwanger et al[14] of preoperative atorvastatin loading found no significant effect on either MACE or biochemical markers, possibly reflecting differences in patient populations, surgical types, or treatment regimens.

Our results are also in line with Neilipovitz et al,[15] who found that preoperative statins did not significantly reduce C-reactive protein levels or yield major clinical benefits, suggesting the predominant effect is biochemical rather than clinical. At the evidence synthesis level, a meta-analysis by Putzu et al[16] indicated statins might reduce perioperative MI in noncardiac surgery but had no impact on mortality or stroke, consistent with our findings. In contrast, Xia et al[17] reported that atorvastatin reloading in patients with stable coronary artery disease undergoing urgent noncardiac surgery significantly reduced MACE and atrial fibrillation, which is likely explained by differences in patient population, urgency of surgery, and baseline risk.

The present trial has several notable strengths. The randomized design with equal allocation to high-dose statin and placebo minimized selection bias, and balanced baseline characteristics (including age, sex, BMI, EF, and comorbidities) enhanced internal validity. The use of hs-cTn, a highly sensitive biomarker of myocardial injury, as the primary endpoint increased the ability to detect subtle perioperative effects of statin therapy.

Several limitations should also be acknowledged. First, the relatively small, single-center sample may restrict generalizability. Still, the homogeneity of the study population and standardized perioperative management protocols reduced variability, thereby strengthening internal consistency. Because the hospital laboratory could not perform hs-cTn assays, all measurements were conducted in an external certified laboratory, which resulted in some cases of loss to follow-up. Second, follow-up was limited to the short-term postoperative period (7 days postoperatively). This limitation was intentional to focus on the immediate perioperative risk period, when statin therapy is most likely to exert measurable biological effects. However, studies with longer follow-up remain warranted. Third, the trial was underpowered to detect differences in infrequent hard outcomes such as MACE or mortality. Nevertheless, the observed significant

reduction in hs-cTn levels provides a signal of myocardial protection that may translate into clinical benefit in larger populations.

Conclusion

The present randomized clinical trial demonstrated that preoperative administration of high-dose statins in patients undergoing noncardiac surgery significantly reduced postoperative troponin elevation, indicating a potential biochemical cardioprotective effect. Nonetheless, this reduction did not result in significant improvements in outcomes such as MACE.

Given the observed benefits at the biomarker level, high-dose statin therapy may be considered a potential cardioprotective strategy in high-risk patients. To strengthen the evidence base, larger multicenter randomized controlled trials with longer follow-up are required to determine whether reductions in troponin ultimately lead to meaningful improvements in hard cardiovascular outcomes and mortality.

Declarations:

Ethical Approval

All participants were informed of the study's purpose and provided signed, dated informed consent.

Ethical ap0proval was obtained from the Ethics Committee of AJA University of Medical Sciences in accordance with the principles of the Declaration of Helsinki (IR.AJAUMS.REC.1403.070).

Funding

This article has no financial support.

Conflict of Interest:

The authors report no conflict of interest.

Acknowledgement:

The authors have no acknowledgement to disclose.

References

1. Li P, Lei Y, Li Q, Lakshmipriya T, Gopinath SCB, Gong X. Diagnosing perioperative cardiovascular risks in noncardiac surgery patients. J Anal Methods Chem. 2019;2019:6097375.
2. Furuichi Y, Sakamoto A. [Perioperative cardiovascular evaluation and management for noncardiac surgery]. Masui. 2014;63(3):287-95.
3. Halvorsen S, Mehilli J, Cassese S, Hall TS, Abdelhamid M, Barbato E, et al. 2022 ESC Guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery: Developed by the task force for cardiovascular assessment and management of patients undergoing non-cardiac surgery of the European Society of Cardiology (ESC) Endorsed by the European Society of Anaesthesiology and Intensive Care (ESAIC). Eur Heart J. 2022;43(39):3826-924.
4. Andersson C, Wissenberg M, Jørgensen ME, Hlatky MA, Mérie C, Jensen PF, et al. Age-specific performance of the revised cardiac risk index for predicting cardiovascular risk in elective noncardiac surgery. Circ Cardiovasc Qual Outcomes. 2015;8(1):103-8.
5. Thompson A, Fleischmann KE, Smilowitz NR, de las Fuentes L, Mukherjee D, Aggarwal NR, et al. 2024 AHA/ACC/ACS/ASNC/HRS/SCA/SCCT/SCMR/SVM Guideline for Perioperative Cardiovascular Management for Noncardiac Surgery: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation. 2024;150(19):e351-e442.
6. Chan Y, Cheng S, Irwin M. Perioperative use of statins in noncardiac surgery. Vasc Health Risk Manag. 2008;4(1):75-81.
7. Poldermans D, Bax JJ, Kertai MD, Krenning B, Westerhout CM, Schinkel AF, et al. Statins are associated with a reduced incidence of perioperative mortality in patients undergoing major noncardiac vascular surgery. Circulation. 2003;107(14):1848-51.
8. Winkel T, Schouten O, Voûte M, Hoeks S, Welten G, Bax J, et al. The effect of statins on perioperative events in patients undergoing vascular surgery. Acta Chir Belg. 2010;110(1):28-31.
9. Antoniou GA, Hajibandeh S, Hajibandeh S, Vallabhaneni SR, Brennan JA, Torella F. Meta nalysis of the effects of statins on perioperative outcomes in vascular and endovascular surgery. J Vasc Surg. 2015;61(2):519-32.e1.

10. Ma B, Sun J, Diao S, Zheng B, Li H. Effects of perioperative statins on patient outcomes after noncardiac surgery: a meta-analysis. Ann Med. 2018;50(5):402-9.

11. Lee TH, Marcantonio ER, Mangione CM, Thomas EJ, Polanczyk CA, Cook EF, et al. Derivation and prospective validation of a simple index for prediction of cardiac risk of major noncardiac surgery. Circulation. 1999;100(10):1043-9.

12. Almansob MAS, Xu B, Zhou L, Hu X-X, Chen W, Chang F-J, et al. Simvastatin reduces myocardial injury undergoing noncoronary artery cardiac surgery: a randomized controlled trial. Arterioscler Thromb Vasc Biol. 2012;32(9):2304-13.

13. Berwanger O, Le Manach Y, Suzumura EA, Biccard B, Srinathan SK, Szczeklik W, et al. Association between pre-operative statin use and major cardiovascular complications among patients undergoing non-cardiac surgery: the VISION study. Eur Heart J. 2016;37(2):177-85.

14. Berwanger O, de Silva PGdB, Barbosa RR, Precoma DB, Figueiredo EL, Hajjar LA, et al. Atorvastatin for high-risk statin-naïve patients undergoing noncardiac surgery: The Lowering the Risk of Operative Complications Using Atorvastatin Loading Dose (LOAD) randomized trial. Am Heart J. 2017;184:88-96.

15. Neilipovitz DT, Bryson GL, Taljaard M. STAR VaS-Short Term Atorvastatin Regime for Vasculopathic Subjects: a randomized placebo-controlled trial evaluating perioperative atorvastatin therapy in noncardiac surgery. Can J Anaesth. 2012;59(6):527-37.

16. Putzu A, de Carvalho E Silva CMPD, de Almeida JP, Belletti A, Cassina T, Landoni G, et al. Perioperative statin therapy in cardiac and non-cardiac surgery: a systematic review and meta-analysis of randomized controlled trials. Ann Intensive Care. 2018;8(1):95.

17. Xia J, Qu Y, Shen H, Liu X. Patients with stable coronary artery disease receiving chronic statin treatment who are undergoing noncardiac emergency surgery benefit from acute atorvastatin reload. Cardiology. 2014;128(3):285-92.