Perioperative Myocardial Injury After Elective Neurosurgery: Incidence, Risk Factors and Effects on Mortality.

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Abstract

Background

Perioperative myocardial injury is an important reason of mortality and morbidity after neurosurgery. It usually is missed due to asymptomatic character. In the present study, we investigated myocardial injury after noncardiac surgery (MINS) incidence, the risk factor for MINS and association of MINS with 30-day mortality in neurosurgery patients.

Methods

Patients with cardiac risk who underwent elective neurosurgery were enrolled to the study. The patients' demographics, comorbidities, medications used, medical history, and type of operation were recorded. The high-sensitivity cardiac troponin (hs-cTn) levels of the patients were measured 12, 24, and 48 hours after surgery. The patients were considered as MINS-positive if at least one of their postoperative hs-cTn measurement values was ≥14 ng/l. All the patients were followed up for 30 days after surgery for evaluation of their outcomes, including total mortality, mortality due to cardiovascular cause, and major cardiac events.

Results

Total 312 patients completed the study and 64 (20.5%) of them was MINS positive. Long antiplatelet or anticoagulant drug cessation time (OR: 4.9, 95%CI: 2.1-9.4) was found the most prominent risk factor for MINS occurrence. Total mortality rate was 2.4% and 6.2% in patients MINS negative and positive respectively (p = 0.112). The mortality rate due to cardiovascular reasons (0.8% for without MINS, 4.7for with MINS, and p=0.026) and incidence of the major cardiac event (4% for without MINS, 10.9 for with MINS, and p=0.026) were significantly higher in patients with MINS.

Conclusions

MINS is a common problem after neurosurgery and, high postoperative hs-cTn level is associated with mortality and morbidity.

Introduction

Previous studies showed that the mortality rate of patients undergoing noncardiac surgery was notable and cardiovascular complications are one of the leading causes of postoperative mortality [6, 16, 21, 24]. Myocardial injury after noncardiac surgery (MINS) is a relatively new clinical perception characterized by an increase in the serum concentration of cardiac troponin, with or without clinical symptoms and electrocardiographic changes [3,10,22,]. MINS includes all perioperative myocardial injuries with or without myocardial infarction (MI), and previous large studies have shown that MINS is an independent predictor of short-term mortality after noncardiac surgery [3, 10, 14, 22, 24].

Neurosurgical patients require special attention as compared with patients undergoing other surgeries in terms of preventing MINS and postoperative mortality. Most neurosurgical procedures are of the moderate or high-risk category. Unlike in other types of surgeries, antiplatelet drugs (even low-dose acetylsalicylic acid) are usually discontinued before the operation [2, 9, 15]. In addition, the restart time of antiplatelet therapy is usually delayed as compared with that in other surgeries. In the literature, studies that focused on the incidence and risk factors of MINS and cardiac mortality after neurosurgery are lacking. In our institute, we have used high-sensitivity cardiac troponin (hs-cTn) screening in neurosurgical patients with cardiac risk (age ≥ 65 years or history of coronary artery disease, congestive heart failure, serious cardiac arrhythmia, pulmonary embolism, peripheral artery disease, or stroke).

In the present study, we primarily investigated the incidence and risk factors of MINS, and the association of MINS with 30-day mortality. Secondarily, we conducted a research on the impact of prolonged antiplatelet or anticoagulant drug withdrawal time on the outcome of patients undergoing neurosurgery.

Materials And Methods

Study design and patients

The present study was a single-center prospective cohort study approved by the ethics committee of Istanbul Medical Faculty, Turkey (2019/580), and conducted in accordance with the guidelines of the Declaration of Helsinki. We screened all the patients who underwent neurosurgery between December 2018 and January 2020 and were aged ≥ 65 years or had any of the following comorbidities: history of coronary artery disease, congestive heart failure, valvular heart disease, atrial fibrillation, pulmonary embolism, peripheral artery disease, or stroke without age limitation. The patients who met the inclusion criteria were enrolled in the study (definition of comorbidities in Supplement File 1). The patients eligible for participation in the study received general anesthesia or sedation, underwent elective surgery, stayed at least 48 hours in the hospital after surgery, and provided consent to participate. Patients who were pregnant, had an active pulmonary embolism, had MI or stroke, had undergone vascular neurosurgery, had chronic renal failure (glomerular filtration rate < 60 mL/dk/1.73 m2), and had sepsis were excluded. The additional exclusion criteria during the study period were as follows: patients who did not have at least two hs-cTn measurements at the postoperative period and those with incomplete outcome data during the 30-day follow-up.

Study Procedure

Two of the researchers interviewed and examined the patients before operation. The patients' demographics, comorbidities, medications used, medical history, and type of operation were recorded (definition of comorbidities in Supplement File 1). The operations were classified as minor (spine surgeries involving ≤ 2 levels of the spine and cranial surgeries without craniotomy) or major (spine surgeries involving > 2 levels of the spine and cranial surgeries with craniotomy) neurosurgeries. The antiplatelet or anticoagulant drug withdrawal time (duration between medication cessation and operation) was determined. The patients were classified according to their antiplatelet or anticoagulant drug withdrawal times. If the drug therapy cessation duration before the operation was shorter than the recommended duration, it was considered a short cessation time. If the drug therapy cessation duration before the operation was longer than the recommended duration, it was considered a long cessation time. For example, if the recommended preoperative withdrawal duration for acetylsalicylic acid was 7 days and the aspirin withdrawal duration was ≤ 7 day, this means a short cessation time. If the withdrawal duration was > 7 day, this means a long cessation time.

The researchers who collected the study data did not intervene in the anesthesia and hemodynamic management of the patients during the intraoperative period. The preoperative heart rate (HR), amount of blood product transfusion, and vasopressor or inotrope use due to hypotension were recorded. The preoperative HR was recorded at the pre-anesthesia care unit or surgical ward just before the patient was transferred to the operating room. The patients were classified according to their preoperative HRs as follows: low HR (< 90 beats per minute [bpm]) or high HR (≥ 90 bpm). A transfusion of ≥ 2 units of packed red blood cells intraoperatively was considered a major transfusion. Patients were considered vasoactive drug users if they received dopamine, dobutamine, noradrenaline, or adrenaline infusion for > 5 minutes intraoperatively. The high-sensitivity cardiac troponin (hs-cTn) levels of the patients were measured 12, 24, and 48 hours after surgery and later if clinically indicated. The Hs-cTn level was measured using an Elecsys System with Modular Analytics E170 (Roche Diagnostics). The patients were considered as MINS-positive if at least one of their postoperative hs-cTn measurement values was ≥ 14 ng/l, with or without ischemic features. These patients were then assessed for ischemic symptoms and underwent 12-lead electrocardiography (ECG) and a cardiology consultation request if necessary. We informed the primary physician or surgeon of the patient and recorded possible ischemic features when the patient was MINS-positive. Ischemic features included ischemic symptoms such as chest discomfort, arm discomfort, neck discomfort, jaw discomfort, shortness of breath, or pulmonary edema and any of the following electrocardiography findings: I) development of pathologic Q waves in any two contiguous leads that were ≥ 30 milliseconds, and II) development of left bundle branch block and III) ST segment elevation (≥ 2 mm in leads V1, V2, or V3, or ≥ 1 mm in the other leads), ST segment depression (≥ 1 mm), or symmetric inversion of T waves ≥ 1 mm in at least two contiguous leads [25].

Outcomes

All the patients were followed up for 30 days after surgery for evaluation of their outcomes, including total mortality, mortality due to cardiovascular cause, and major cardiac events. Major cardiac events included mortality, nonfatal cardiac arrest, new onset and symptomatic right or left congestive heart failure, MI, and new onset or progression of cardiac arrhythmia that causes severe hemodynamic instability. These follow-up findings were based on the hospital information system, medical records, telephone calls, and interviews with the patients.

Statistical analyses

Categorical values are presented as a percentage and were compared using the chi-square test. Continuous variables are presented as mean ± standard deviation and compared with the Student t test.

The risk factors of MINS were assessed with a multivariable logistic regression analysis. The occurrence of MINS was the dependent variable, and the patients' demographics, comorbidities, and perioperative features were the independent variables. The results of multivariable logistic regression analyses are presented as odds ratio with 95% confidence interval. A Kaplan–Meier plot was constructed to compare the cumulative incidence rates of total mortality, mortality due to cardiovascular causes, and major cardiac events between the patients with and patients without MINS. A Cox proportional hazards model was constructed with total mortality, mortality due to cardiovascular causes, and major cardiac events up to 30 days after surgery as the dependent variables and the categorically classified peak postoperative serum hs-cTnT value as the independent variable. A p value < 0.05 was considered statistically significant. All the statistical analyses were performed using SPSS version 15.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

Characteristics of the cohort and MINS incidence

A total of 353 patients were recruited in the present study. Among these patients, 312 completed the 30-day follow-up (Fig. 1). MINS was diagnosed in 64 patients (20.5%). The demographics, comorbidities, and perioperative features of the patients with and without MINS are presented in Table 1.

Table 1
Baseline characteristics of cohort

Characteristics	All patients (n = 312)	No-MINS (n = 248)	MINS (n = 64)	p value
Age (years)	65.8 ± 11.1	64.9 ± 11.2	69.3 ± 10.7	0.005*
Age groups < 65 years 65–80 years ≥ 80 years	112 (36%) 161 (52%) 39 (12%)	94 (38%) 126 (51%) 28 (11%)	18 (28%) 35 (55%) 11 (17%)	0.232
Gender, male	174 (56%)	135 (54%)	39 (61 %)	0.350
Type of surgery Cranial Spinal Other	163 (52%) 141 (45%) 8 (3%)	131 (53%) 110 (44%) 7 (3%)	32 (50%) 31 (48%) 1 (2%)	0.748
Major surgery	103 (33%)	67 (27%)	36 (56%)	0.019*
Long drug stopping time	39 (13%)	21 (9%)	15 (23%)	0.003*
Coronary artery disease	91 (29%)	64 (26%)	27 (42%)	0.010*
Prior myocardial infarction	37 (12%)	24 (10%)	13 (20%)	0.019*
Chronic heart failure	35 (11%)	23 (9%)	12 (19%)	0.032*
Atrial fibrillation	30 (10%)	19 (8%)	11 (17%)	0.021*
Valvular heart disease	21 (7%)	16 (7%)	5 (8%)	0.698
Prior SVA	43 (14%)	34 (14%)	9 (14%)	0.942
Hypertension	187 (60%)	141 (57%)	46 (72%)	0.029*
Diabetes mellitus	64 (20%)	46 (19%)	18 (28%)	0.091
Lung disease	69 (22%)	50 (20%)	19 (29%)	0.058

MINS: myocardial injury after noncardiac surgery, SVA: cerebrovascular accident, ND: not defined. Quantitative values are presented as mean ± SD and compared with unpaired *t* test. Qualitative data are presented as number and percentage of cases and compared with X^2 test. P value is state comparison between MINS positive and negative patients. *:p < 0.05

Characteristics	All patients (n = 312)	No-MINS (n = 248)	MINS (n = 64)	p value
Heart rate < 90 bpm ≥ 90 bpm ND	256 (82%) 49 (16%) 7 (2%)	211 (85%) 31 (13%) 6 (2%)	45 (70%) 18 (28%) 1 (2%)	0.002*
Vasopressor need	25 (8%)	16 (7%)	9 (14%)	0.046*
Major transfusion	31 (10%)	21 (9%)	10 (16%)	0.088

MINS: myocardial injury after noncardiac surgery, SVA: cerebrovascular accident, ND: not defined. Quantitative values are presented as mean ± SD and compared with unpaired *t* test. Qualitative data are presented as number and percentage of cases and compared with X^2 test. P value is state comparison between MINS positive and negative patients. *:p < 0.05

Risk factors of MINS

A multivariate logistic regression analysis was performed to determine the association between the occurrence of MINS and each independent variable (demographics, comorbidities, and perioperative features of patients). Among all the variables, undergoing a major surgery, long antiplatelet or anticoagulant drug cessation time, history of atrial fibrillation, and high preoperative HR were found to be the significant risk factors of MINS (Table 2).

Table 2
Risk factors of MINS

Variables	Odd ratio (95% CI)	*p* value
Age Groups	1 (reference)	-
< 65 years	1.6 (0.6–4.4)	0.288
65–80 years	2.5 (0.9–7.5)	0.084
≥ 80 years		
Gender (male)	1.1 (0.6–2.1)	0.853
Undergoing major surgery	3.3 (1.7–6.6)	0.001*
Anticoagulant or antiplatelet drug stopping time	1 (reference)	-
None	2.5 (1.6–10.9)	0.014*
Short	4.9 (2.1–9.4)	0.001*
Long		
Coronary artery disease	1 (0.4–2.6)	0.941
Prior myocardial infarction	1.4 (0.5–4.3)	0.562
Chronic heart failure	2 (0.8–5.6)	0.181
Atrial fibrillation	4.2 (1.5–11.4)	0.010*
Valvular heart disease	0.2 (0.1–0.8)	0.067
Prior SVA	1.4 (0.6–3.4)	0.554
Hypertension	1.6 (0.8–3.4)	0.261
Diabetes mellitus	2 (0.8–4.3)	0.076
Lung disease	2.3 (1-5.1)	0.074
Heart rate ≥ 90 bpm	3.8 (1.7–8.2)	0.003*
Vasopressor need	1.7 (0.6–5.5)	0.374
Major transfusion	2.4 (0.9–6.2)	0.074

Multivariate logistic regression analyze was used. Results presented as odd ratio (95% confidence interval) and p value. SVA: cerebrovascular accident.

Clinical findings in the patients with MINS

Of the patients with MINS, 15 (23%) had at least one ischemic symptom and 17 (27%) had new ECG findings suggestive of myocardial ischemia within 3 days after surgery (Supplement File 2). Among the

MINS-positive patients, one who died of a cardiovascular cause and 4 who had major cardiac events did not have any ischemic symptoms or new ECG findings within 3 days after surgery.

Outcome measures

In the whole cohort, the rates of total mortality, mortality due to cardiovascular causes, and major cardiac events were 3.2% (10 patients), 1.6% (5 patients), and 5.4% (17 patients), respectively. The characteristics of the deceased patients are presented in Supplement File 3. We grouped all the patients according to their postoperative peak serum hs-cTnT levels and found that increased serum hs-cTnT level (hs-cTnT ≥ 14 ng/l) was associated with total mortality, mortality due to cardiovascular causes, and major cardiac events as compared with the reference value (hs-cTnT < 14 ng/l; Table 3).

Table 3
Association of peak hs-TnT level with outcome measures

	Postoperative peak serum hs-TnT level		
Variables	**< 14 ng/l**	**14 to < 65 ng/l**	**≥ 65 ng/l**
Patients No.	248 (79.5%)	57 (18.3%)	7 (2.2%)
Total deaths No.	6 (2.4%)	3 (5.3%)	1 (14.3%)
Hazard ratio (95% CI)	1 (reference)	2.2 (0.6–8.9)	6.8 (1.8–55.9)
p value	-	0.257	0.048*
Cardiovascular deaths No.	2 (0.8%)	2 (3.5%)	1 (14.3%)
Hazard ratio (95% CI)	1 (reference)	4.4 (1.6–31.3)	19.9 (2.8-220.5)
p value	-	0.038*	0.014*
Major cardiac event No.	10 (4%)	5 (8.8%)	2 (28.6%)
Hazard ratio (95% CI)	1 (reference)	2.3 (1.7–6.5)	9.3 (3.1–42.7)
p value	-	0.044*	0.004*

Cox regression analyses was used. Results presented as hazard ratio (95% confidence interval) and p value. *: p < 0.05

The total mortality rate was 2.4% (6 patients) in the patients without MINS and 6.2% (4 patients) in those with MINS, with no significant difference between the groups in the Kaplan–Meier curve analyses (log rank test: $\chi2 = 2.52$, $p = 0.112$; Fig. 2A). The rate of mortality due to cardiovascular reasons was 0.8% (2 patients) in the patients without MINS and 4.7% (3 patients) in those with MINS, with a significant difference between the groups in the Kaplan–Meier curve analyses (log rank test: $\chi2 = 4.94$, $p = 0.026$; Fig. 2B). The incidence rate of major cardiac events was 4% (10 patients) in the patients without MINS and 10.9% (7 patients) in those with MINS, with no significant difference between the groups in the Kaplan–Meier curve analyses (log rank test: $\chi2 = 4.95$, $p = 0.026$; Fig. 2C).

Analyses of the patients who were using antiplatelet or anticoagulant drugs

A total of 173 patients (55% of the cohort) were using antiplatelet and/or anticoagulant drugs before surgery. Of these patients, 118 were using only antiplatelet drugs, 39 were using only anticoagulant drugs, and 16 were using both drugs, and 134 (77%) and 39 (23%) had short and long drug therapy cessation times before surgery. The rates of total mortality and mortality due to cardiovascular causes were similar between the groups with short and long drug therapy cessation times. However, the incidence rates of MINS and major cardiac events were higher in the patients with long drug therapy cessation times (Table 4).

Table 4
Comparison of patients with short or long drug stopping time.

Variables	Short drug stopping	Long drug stopping	*p*
Total Mortality	3 (2.2%)	2 (5.1%)	0.343
Mortality due to cardiovascular reason	2 (1.5%)	2 (5.1%)	0.184
Major cardiac event	7 (5.2%)	6 (15.4%)	0.034*
MINS	27 (20.1%)	15 (38.5%)	0.015*

Data are presented as number and percentage of cases and compared with X^2 test. *: $p < 0.05$

Discussion

Myocardial injury after noncardiac surgery was evaluated using the 2014 American College of Cardiology/American Heart Association Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery [9, 25]. This guideline stated that the usefulness of postoperative screening for MINS with troponin level measurements is uncertain, but several studies have shown the relationship between MINS and postoperative adverse outcomes after the guideline was published. In this single-center prospective cohort study, which included 312 patients who underwent elective neurosurgery, we evaluated the incidence of MINS among patients at risk and the risk factors related with MINS and their effects on postoperative mortality and the development of major cardiac events. We determined that the incidence rate of MINS was 20.5% and found that history of atrial fibrillation, undergoing a major surgery, high preoperative HR, and long antiplatelet or anticoagulant drug cessation time before surgery were the risk factors of MINS. In addition, postoperative high serum hs-cTnT levels were associated with mortality and the occurrence of major cardiac events within 30 days after surgery.

The study population has a similar demographic distribution based on age and sex with those in previous studies but differs from other studies in that it focused on a special patient group comprised of patients who underwent neurosurgery [5, 7, 22]. The incidence of MINS ranged from 8–18% in the literature, and this difference is probably related with the population recruited in the studies, the reference definition of MINS, and the laboratory methodology [3, 6, 10, 22]. In the present study, a peak hs-cTnT level ≥ 14 ng/l after surgery was considered as MINS, and the incidence rate of MINS was 20.5%. Our study demonstrates that MINS is not rare in patients at risk who underwent neurosurgery. In the second part of the VISION study, a postoperative serum hs-cTnT concentration ≥ 20 ng/L was chosen as a criterion for MINS, and the incidence of MINS was 17.9% [5]. In the study of Puelacher et al, an absolute increase in hs-cTnT level of ≥ 14 ng/L higher than the preoperative value was defined as a MINS criterion, and the incidence of MINS according to this criterion was 16% [22]. These findings were comparable with those observed in the present study.

Most of the existing preoperative comorbidities were more frequent in patients with MINS as mentioned in previous studies [3, 10, 22]. Although statistically significant differences were found between the MINS-positive and MINS-negative patient groups regarding age, undergoing a major surgery, long anticoagulant or antiaggregant drug therapy cessation time, prior MI, history of atrial fibrillation, and hypertension, we only identified history of atrial fibrillation and undergoing a major surgery as risk factors of MINS in the multivariate logistic regression analysis. The VISION study group also examined the relationship between preoperative HR and postoperative adverse outcomes and found that preoperative a HR > 96 bpm is associated with MINS, MI, and mortality after noncardiac surgery [1]. Similarly, our results indicate that high preoperative HR (> 90 bpm) was an important risk factor of MINS. The VISION study group also evaluated the relationship between the Revised Cardiac Risk Index (RCRI) and myocardial injury, and found that the RCRI alone is not sufficient to predict perioperative cardiac complications [23]. Park et al. observed a relationship between intraoperative blood loss and MINS in their study, but in our study, we found no significant difference between the MINS-positive and MINS-negative patient groups in terms of intraoperative blood loss and no relationship was found to establish a risk factor [19].

Previous studies showed that high hs-cTnT levels during the first 3 days after surgery were significantly associated with short- and long-term mortality [5, 22]. By contrast, no significant relationship was found between MINS and mortality on the basis of our findings, but the incidence rates of mortality due to cardiovascular causes and major cardiovascular events were significantly higher in the MINS-positive group. We think that the important underlying reasons for these differences are that unlike other studies, we did not include different surgical operations in our study and only examined neurosurgical cases and included patients who would undergo elective surgery, excluding emergency surgical interventions. In the VISION study, a relationship was found between elevated hs-cTnT levels and increased mortality rates [5]. Similarly, in our study, we found that the incidence rates of mortality, cardiovascular death, and major cardiac events increased in direct proportion to the increases in hs-cTnT level. Troponin levels > 65 ng/l were associated with 6.8-, 19.9-, and 9.3-fold increases in the incidence rates of mortality, cardiovascular death, and major cardiac events, respectively.

Ischemic symptoms were found in only 23% of the patients, and changes in ECG for suggesting ischemia were found in 27% of the patients who were found to be MINS-positive as a result of hs-cTnT follow-up.

Confirming these data, in the VISION study, 93% of the patients with MINS did not have ischemic symptoms [5]. From these data, we could infer that pathologies that may cause important cardiac consequences such as MINS can be missed in patients who are followed up for symptoms or ECG changes.

Neurosurgical practice is different from other types of surgeries in terms of preoperative antiplatelet and/or anticoagulant drug use. In patients undergoing neurosurgery, cessation of warfarin use as an anticoagulant at least 5 days before surgery and Xa inhibitor use at least 2–3 days before, and use of antiplatelet drugs such as aspirin and clopidogrel should be discontinued at least 7–10 days before surgery [4, 8, 11, 13, 17, 18, 20]. Considering that there is usually no absolute contraindication for surgeries other than neurosurgery in patients using aspirin, patients undergoing neurosurgery should be deprived of anticoagulant-antiplatelet therapy for a longer period [12]. In our institute, like in other centers, neurosurgeons prefer to stop administration of all antiplatelet and anticoagulant drugs that increase the risk of postoperative myocardial injury before surgery. In the present cohort, 55% of the patients were using antiplatelet and/or anticoagulant drugs, and these were discontinued before surgery. Drug cessation duration was not always optimal because of postponed surgery and unexpectedly prolonged preoperative examination. In the multivariate regression analysis, we found that cessation of antiplatelet and anticoagulant drugs before surgery was a risk factor of the occurrence of MINS. In addition, prolonged drug cessation time doubled the risk. In another study, non-initiation of treatment for patients who developed MINS but could not receive anticoagulant-antiplatelet therapy for surgical reasons was considered as an independent risk factor in terms of mortality [10].

The strengths of our study are that the patients who underwent a specialized surgery such as neurosurgery were examined in detail, and the use of anticoagulant-antiplatelet drugs and the relationship between drug discontinuation time and the occurrence of MINS were evaluated unlike in other larger studies related to MINS. However, the present study also has some limitations. First, the preoperative hs-cTnT values were not evaluated, so the basal hs-cTnT levels of patients were not obtained. Second, the relationship between the scales used in the preoperative period, such as RCRI, and the postoperative problems was not examined. For this reason, our study did not show a scale that predicts the risk of MINS and postoperative cardiac events in patients undergoing neurosurgery. Third, although it has a smaller sample size than other studies, it is meaningful in that it was aimed at a specific patient population.

In conclusion, diagnosing MINS with hs-cTnT follow-up in neurosurgery, which is a specialized surgery, appears to be an effective approach for identifying patients with risk factors. In our study, although many risk factors were found to be significant in terms of identifying MINS-positive and MINS-negative patients, the presence of an atrial fibrillation diagnosis, major surgery, and cessation period of anticoagulant-antiplatelet drug use were determined as risk factors of MINS. Unlike in other surgeries, neurosurgery has stricter rules for anticoagulant-antiplatelet drug use. In our study, we showed that the incidence of MINS increased as the time elapsed between drug discontinuation and surgery. The accuracy of our data should be reevaluated in multicenter studies with larger samples.

Declarations

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Conflict of interest: The authors have no conflicts of interest to declare.

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Availability of data and material: Our case series are *well-documented*, we will be able to share all the detailed documents with pleasure if needed.

Code availability: Not aplicable

Ethics approval: The present study was a single-center prospective cohort study approved by the ethics committee of Istanbul Medical Faculty, Turkey (2019/580), and conducted in accordance with the guidelines of the Declaration of Helsinki.

Consent to participate : informed consent was obtained from all patients.

Consent for publication: We declare that all authors give permission to the journal

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Figures

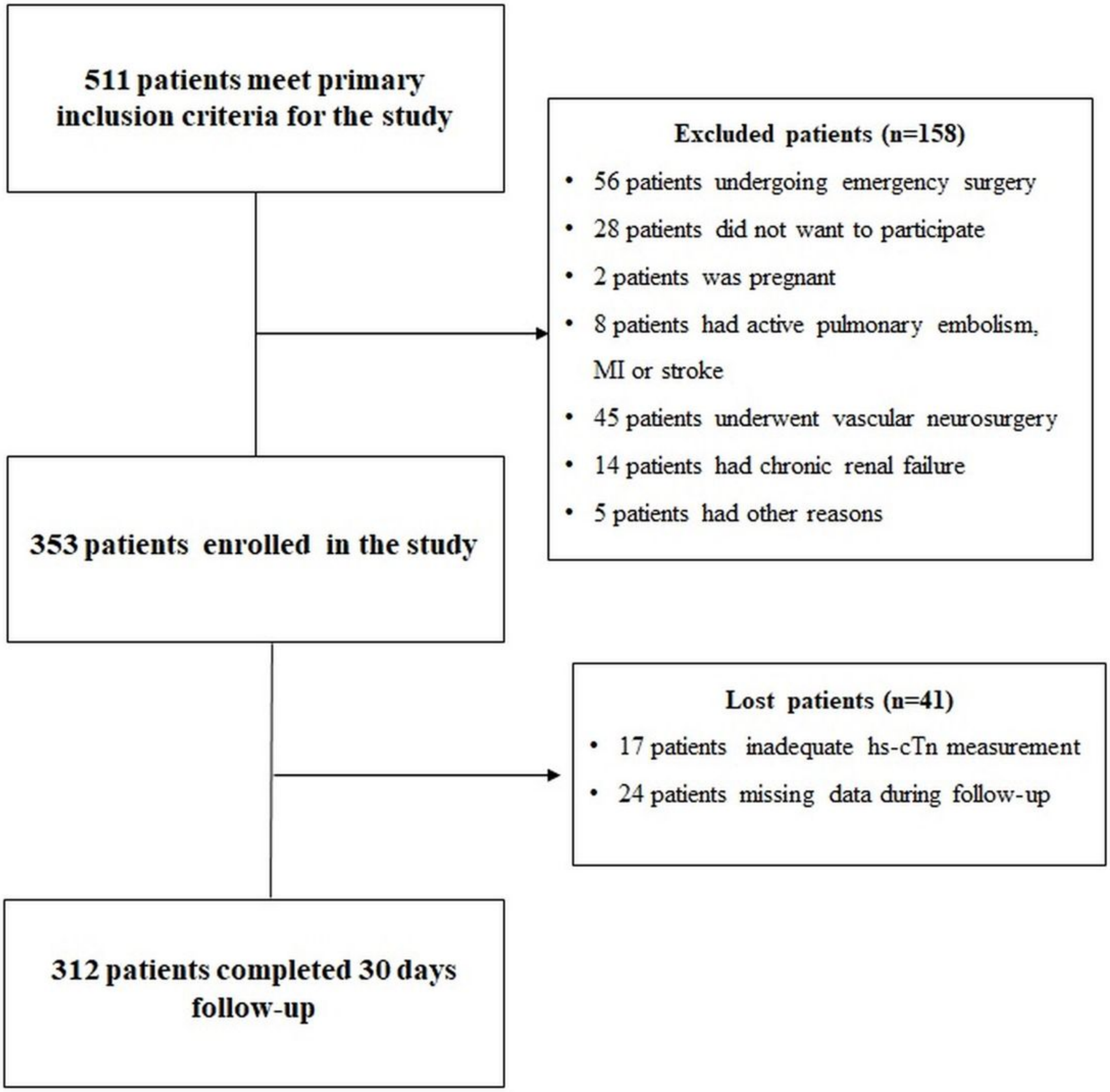

Figure 1

A total of 353 patients were recruited in the present study. Among these patients, 312 completed the 30-day follow-up.

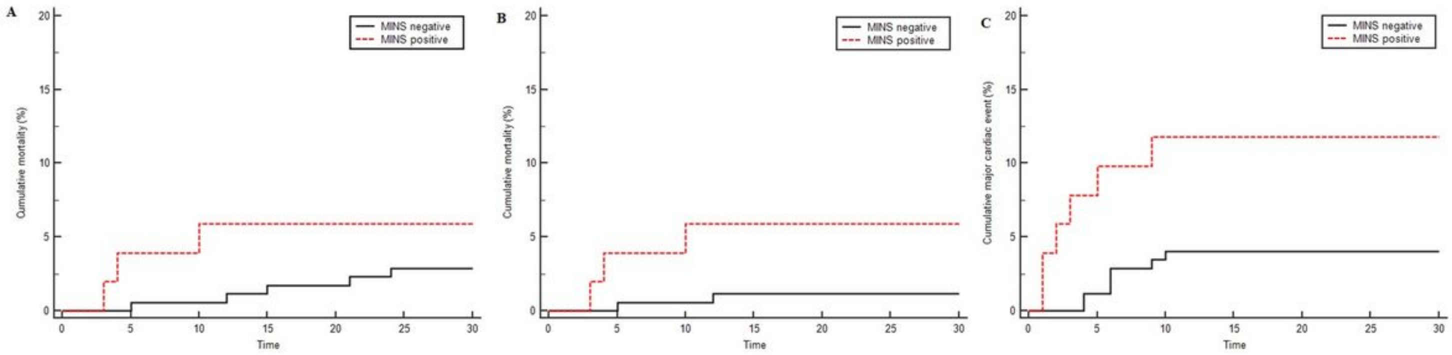

Figure 2

The rate of mortality due to cardiovascular reasons was 0.8% (2 patients) in the patients without MINS and 4.7% (3 patients) in those with MINS, with a significant difference between the groups in the Kaplan–Meier curve analyses.

Supplementary Files

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