Turkish Journal of Geriatrics
2025; 28(4):534–544

DOI: 10.29400/tjgeri.2025.470

İsmail DUYMAZ
Hacer Şebnem TÜRK
Pınar SAYIN
Leyla KILINÇ
Mustafa Bilgehan AYIK
Ayşe SURHAN ÇINAR
Sibel OBA

Sisli Hamidiye Etfal Training And Research Hospital, Anesthesiology And Reanimation, Istanbul, Türkiye

ORIGINAL ARTICLE

THE EFFECT OF INCREASED FRAILTY ON MYOCARDIAL INJURY AFTER NON-CARDIAC SURGERY (MINS) IN ELDERLY PATIENTS UNDERGOING ORTHOPEDIC SURGERY: A PROSPECTIVE, COHORT STUDY

Abstract

Introduction: The objective of this study was to assess the association between elevated frailty levels and the risk of postoperative myocardial injury in elderly patients undergoing orthopedic procedures.

Materials and Method: All patients aged 65 years and older who underwent surgery at the Orthopedics Department of our hospital between May 1, 2023, and May 1, 2024, were included. Demographic data such as age, sex, comorbidities, and surgical indications were documented preoperatively. Frailty status was assessed using the FRAIL Index and categorized into three groups. Pre-anesthetic baseline measurements of heart rate and mean arterial pressure were obtained before the initiation of anesthesia and subsequently monitored every 10 minutes intraoperatively. Data regarding perioperative blood transfusion, intravenous fluid administration, vasopressor requirement, and anesthesia technique were collected. Troponin T levels were measured at 0, 6, 12, 24, 48, and 72 hours postoperatively. Outcomes assessed included intensive care unit and hospital length of stay, incidence of postoperative complications, and all-cause mortality within 30 days following surgery.

Results: A total of 206 patients were included in the final analysis. Among them, 56.7% were classified as frail, 33.5% as pre-frail, and 9.7% as non-frail. The overall incidence of myocardial injury after non-cardiac surgery was 44.4%, occurring in 63.2% of frail patients, 23.2% of pre-frail patients, and 5.3% of non-frail patients. Thirty-day adverse outcomes and mortality were significantly higher in frail patients, who also demonstrated longer intensive care and hospital stays.

Conclusion: In elderly individuals undergoing orthopedic procedures, greater degrees of frailty are strongly associated with an increased risk of postoperative myocardial injury following non-cardiac surgery.

Keywords: Troponin; Frailty, Aged; Orthopedic Procedures.

Correspondence

Hacer Şebnem TÜRK
Phone : +905324432544
e-mail : hacersebnem@yahoo.com.tr

Received : Nov 09, 2025
Accepted: Nov 11, 2025

Cite this article as:
Duymaz İ, Türk HŞ, Sayın P. et al. The Effect of Increased Frailty on Myocardial Injury After Non-Cardiac Surgery (Mins) in Elderly Patients Undergoing Orthopedic Surgery: A Prospective, Cohort Study. Turkish Journal of Geriatrics 2025; 28(4):534–544.doi:10.29400/tjgeri.2025.470

INTRODUCTION

With the worldwide rise in life expectancy and the proportion of elderly individuals, the demand for surgical interventions in this population has been steadily increasing. Among these, orthopedic procedures represent one of the most common surgical needs. However, postoperative morbidity and mortality rates are considerably higher in older patients compared to younger groups. The American Society of Anesthesiologists (ASA) classification has long been used for preoperative risk assessment, yet it has notable limitations in the evaluation of geriatric patients.

Frailty, characterized by reduced physiological reserves and impaired ability to respond to stress due to neuromuscular, metabolic, and immune system decline, has emerged as a key determinant in evaluating surgical risk in older adults. Although it may be observed across all age groups, frailty is particularly valuable in assessing physiological resilience in the elderly (1, 2). Patients with orthopedic hip fractures often present with higher frailty levels, which correlates with increased rates of postoperative complications, prolonged hospitalization, and elevated mortality. Therefore, incorporating frailty assessment into the preoperative evaluation process plays an essential role in predicting outcomes and optimizing perioperative management (3, 4).

Despite advances in perioperative care, cardiovascular complications remain the predominant contributors to postoperative morbidity and mortality in patients undergoing non-cardiac surgery. Myocardial injury after non-cardiac surgery (MINS) is characterized by asymptomatic myocardial damage, diagnosed solely based on postoperative elevations in cardiac troponin levels in the absence of overt clinical signs. Unlike myocardial infarction, MINS does not typically present symptoms or ECG changes, yet it has a strong association with early postoperative mortality. Detecting MINS requires routine monitoring of troponin levels from the preoperative period through the first 72 postoperative hours (5). Despite the growing recognition of MINS as a critical postoperative complication, limited research has specifically examined its association with frailty.

This study primarily aimed to evaluate the effect of elevated frailty levels on the occurrence of postoperative myocardial injury in elderly individuals undergoing orthopedic procedures. Additionally, the study sought to determine the prevalence of frailty in this specific patient cohort.

MATERIALS AND METHOD

This study was designed as a prospective, single-center cohort study. Ethical clearance for the research was secured from our hospital's institutional review board (Approval date: April 18, 2023; Decision No: 2297). All patients aged 65 years and older who underwent surgery at the Orthopedics Department between May 1, 2023, and May 1, 2024, were considered eligible. Informed consent, both written and verbal, was secured from all participants or, when necessary, from their legally authorized representatives. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patients were excluded from the study if they had a preoperative diagnosis of sepsis, pulmonary embolism, or myocardial infarction within the preceding month, underwent another surgical procedure within the last month, necessitated preoperative tracheal intubation within the intensive care unit or had a postoperative hospital stay shorter than three days.

Demographic variables such as ASA scores, along with comorbidities were recorded. Surgical indications were also documented.

Frailty was evaluated using the FRAIL Index, a brief five-item tool assessing fatigue, resistance, ambulation, comorbid illnesses, and unintentional weight loss. Based on the total score, patients were categorized as follows:

0: Non-frail

1-2: Pre-frail

3-5: Frail and divided into groups

Electrocardiography (ECG) and baseline Troponin T measurements were obtained within 24 hours before surgery. In the operating room, ECG, non-invasive or invasive blood pressure, arterial pressure, and peripheral oxygen saturation (SpO_2) were continuously monitored. Heart rate (HR), mean arterial pressure (MAP), and SpO_2 values were recorded before anesthesia induction and subsequently at 10-minute intervals throughout surgery.

The choice of anesthesia (general or spinal) was determined by an anesthesiologist independent of the study, according to surgical requirements and patient factors. Intraoperative use of blood products, crystalloid administration, and vasopressor requirements were documented. Anesthesia duration was defined as the interval from induction to recovery room transfer, while surgical duration was measured from the initial incision to wound closure.

High-sensitivity Troponin T was measured using the "Elecsys Troponin T hs" assay. Troponin levels were assessed immediately postoperatively (0 h) and at 6, 12, 24, 48, and 72 hours thereafter. Patients with normal baseline values and postoperative hsTnT levels between 20–65 ng/L with an absolute increase of ≥5 ng/L, or any hsTnT ≥65 ng/L, were diagnosed with MINS. ECG was performed in patients with elevated troponin, and cardiology consultation was requested for new ST-segment changes or left bundle branch block.

The length of intensive care stay, total hospitalization period, 30-day postoperative complications, and mortality were documented for all patients.

Statistical Analysis

Statistical analyses were conducted using SPSS version 15.0 (SPSS Inc., Chicago, IL, USA). Categorical variables were expressed as numbers and percentages, while continuous variables were reported as mean ± standard deviation, minimum–maximum, and median values. Group comparisons of categorical variables were performed using the Chi-square test. As numerical variables did not meet normality assumptions, the Kruskal–Wallis test was applied for comparisons among more than two groups. Post-hoc subgroup analyses were conducted using the Mann–Whitney U test with Bonferroni correction. Results with a p-value <0.05 were considered statistically significant.

To determine whether frailty was an independent predictor of MINS, a multivariable logistic regression analysis was performed. Variables entered into the model included age, sex, ASA classification, major comorbidities, intraoperative vasopressor requirement, intraoperative hypotension, and frailty category. Both ENTER and backward stepwise (Backward LR) methods were applied. Model fit was assessed using –2LL, Cox–Snell R^2, and Nagelkerke R^2 statistics, and results were reported as odds ratios (ORs) with 95% confidence intervals (CIs). A *p* value <0.05 was considered statistically significant.

Power Analysis

Sample size was calculated using G*Power version 3.1.9.7 (Franz Faul, Germany). Based on an estimated effect size of d=0.267 derived from the study by Berkay Demiriş, "Evaluation of the Relationship Between Frailty Index and Fracture Risk in Patients 65 Years and Older," a minimum of 147 participants was required to achieve 80% power with a 10% margin of error.

RESULTS

Between April 1, 2023, and April 1, 2024, a total of 672 patients aged 65 years and older underwent orthopedic surgery at our institution. Of these, 285 did not meet the inclusion criteria: 272 patients were expected to have a postoperative hospital stay of less than three days (e.g., day surgery, hand surgery), 11 had undergone another surgical procedure within the preceding month (revision surgery, repeated debridement), and 2 were intubated and monitored in the intensive care unit preoperatively.

Additionally, 45 patients were excluded due to invalid troponin samples, 40 due to incomplete clinical data, and 96 due to premature postoperative discharge, which prevented completion of the 72-hour troponin monitoring protocol. Ultimately, 206 patients fulfilled all eligibility requirements and were included in the final analysis.

When the distribution of the groups is analyzed, there were 69 pre-frail (33.5%), 117 frail (56.7%) and 20 non-frail patients (9.7%) (Table 1). Female gender was predominant in total, frail and pre-frail patients (Table 1). The age distribution differed significantly between the groups. (Table 1) ($p<0.001$).

Table 1. Demographic Data, Anesthesia Duration, Surgical Duration, Length of Stay in Hospital and ICU, Amount of Bleeding

		Frailty				
		Total	**Pre-Frail**	**Frail**	**Not Frail**	
		Mean±SD (Min-Max) (Median)	**Mean±SD (Min-Max) (Median)**	**Mean±SD (Min-Max) (Median)**	**Mean±SD (Min-Max) (Median)**	**P**
Age (years)		78.2±8.0 65-104 (78)	74.8±6.6 65-94 (75)	81.6±7.6 65-104 (82)	70.0±2.6 65-75 (69.5)	**<0.001**
Sex	Female	141(68.4%)	42 (60.9%)	89 (76.1%)	10 (50.0%)	**0.017**
	Male	65(31.6%)	27 (39.1%)	28 (23.9%)	10 (50.0%)	
Weight		71.4±13.9 45-130 (70)	73.2±14.1 50-130 (70)	69.7±14.1 45-130 (68)	75.6±11.1 55-98 (77)	**0.037**
BMI		27.0±5.4 16.3-50.8 (26.0)	27.2±5.3 20-50.8 (25.8)	26.8±5.6 16.3-50.8 (26.0)	27.1±4.4 19.2-34.7 (26.9)	0.698
Anesthesia Duration (min)		137.4±47.6 60-300 (130)	145.4±48.0 60-300 (150)	134.3±47.7 0-300 (130)	127.8±43.5 70-210 (130)	0.140
Surgical Duration (min)		119.0±42.8 50-280 (120)	124.9±42.6 50-270 (120)	116.8±43.3 60-280 (110)	111.8±39.8 60-180 (120)	0.266
Bleeding Amount (cc)		315.2±158 4 100-750 (300)	292.1±149 1 100-750 (300)	331.5±167 1 100-700 (300)	340.0±151 7 200-500 (300)	0.509
ICU Stay Duration (days)		2.3±4.1 0-30 (1)	1.9±4.2 0-30 (1)	2.9±4.3 0-26 (2)	0.2±0.7 0-3 (0)	**<0.001**
Hospital Stay Duration (days)		11.2±9.4 3-82 (9)	10.7±9.4 3-60 (9)	12.4±9.8 4-82 (11)	5.3±2.6 4-14(4)	**<0.001**

Chi-square Test, Kruskal-Wallis Test, ICU: Intensive Care Unit

Frail patients were statistically significantly older than pre-frail and non-frail patients (Table 2) (p<0,001). Pre-frail patients were statistically significantly older than non-frail patients (Table 2) (p=0.002).

The groups differed significantly in terms of weight distribution (Table 1) (p=0.037). Frail patients were statistically significantly thinner than non-frail patients (Table 2) (p=0,024). There was a statistically significant difference between the duration of intensive care and hospitalization of the groups (Table 1) (p=0.001). The intensive care unit duration of stay of frail patients was statistically significantly longer than that of pre-frail and non-frail patients (Table 2) (p=0.002, p<0,001). The duration of intensive care hospitalization of pre-frail patients was statistically significantly longer than non-frail patients (Table 2) (p=0,002). The duration of hospitalization of frail and pre-frail patients was statistically significantly longer than that of non-frail patients (Table 1b) (p<0,001).

Comorbid conditions were present in 95.1% of patients, with hypertension being the most common (68.9%). The prevalence of comorbidities was significantly higher in frail and pre-frail groups (p<0.001). Hip surgery represented the leading surgical indication (65%). Hip and knee surgeries were more common in frail and pre-frail patients, while tibial surgeries were more frequent in non-frail patients (p<0.001).

A statistically significant difference was found between the crystalloid consumption of the groups (Table 3) (p=0.019). A statistically significant difference was found between the vasopressor needs of the groups (Table 3) (p=0,012).

A statistically significant difference was found between the incidences of MINS of the groups (Table 3) (p<0,001). The incidence of MINS in the total number of patients was 44.4%, with 23.2% in pre-frail patients, 63.2% in frail patients and 5.3% in non-frail patients. A statistically significant difference was found between the 30-day adverse event frequencies of the groups (Table 3) (p<0,001). The incidence of 30-day adverse events in the total number of patients was 16.1%, with 4.3% in pre-frail patients, 25.6% in frail patients and 0.0% in non-frail patients. A statistically significant difference was found between the 30-day mortality rates of the groups (Table 3) (p=0.001). The rate of 30-day mortality rates in the total number of patients was 9.8%, with 1.4% in pre-frail patients, 16.4% in frail patients and 0.0% in non-frail patients.

A statistically significant difference was found between the groups at 30 and 40 minutes (p=0.038, p=0.026). With the increase in frailty, MAP values

Table 2. Demographic Data, Anesthesia Duration, Surgical Duration, Duration of Hospitalization and Intensive Care Unit Stay, Amount of Bleeding Subgroup Analyses

	Pre-frail vs. Frail	Pre-frail vs. Non-Frail	Frail vs. Non-Frail
	p	p	p
Age	**<0.001**	**0.002**	**<0.001**
Weight	0.094	0.220	**0.024**
BMI	0.626	0.579	0.453
Anesthesia Duration	0.072	0.155	0.668
Surgical Duration	0.148	0.203	0.771
Amount of Bleeding	0.288	0.473	0.810
Duration of ICU Stay	**0.002**	**0.002**	**<0.001**
Duration of Hospitalization	0.032	**<0.001**	**<0.001**

Mann Whitney U Test Bonferroni correction p<0.017, BMI: Body Mass Index, ICU: Intensive Care Unit

decreased. A statistically significant difference was found between the HR distributions of the groups before and after induction at 20.-120 minutes (p=0.002, p=0.045, p=0.036, p=0.004, p=0.020,

Table 3. Anesthesia Method, Crystalloid and Blood Product Use, Vasopressor Requirement, Presence of MINS, 30-Day Adverse Events and Mortality

		Total		Frailty						p
				Pre-frail		Frail		Non-Frail		
		n	%	n	%	n	%	n	%	
Type of Anesthesia	General	77	37.4%	25	36.2%	46	39.3%	6	30.0%	0.708
	Spinal	129	62.6%	44	63.7%	71	60.7%	14	70.0%	
Crystalloid Consumption (cc)		1560.0±1105.3 500-15000 (1500)		1844.9±1732.3 500-15000 (1500)		1411.1±511.5 500-3000 (1500)		1447.5±632.3 750-3500 (1500)		**0.019**
Blood Product Use (n)		47	23.5%	16	23.9%	29	25.7%	2	10.0%	0.312
Vasopressor Requirement (n)		91	44.2%	26	37.7%	61	52.1%	4	20.0%	**0.012**
MINS (n)		91	44.4%	16	23.2%	74	63.2%	1	5.3%	**<0.001**
30-Day Adverse Events (n)		33	16.1%	3	4.3%	30	25.6%	0	0.0%	**<0.001**
30-Day Mortality		20	9.8%	1	1.4%	19	16.4%	0	0.0%	**0.001**

Chi-square test, Kruskal -Wallis test, MINS: Myocardial Injury After Non-Cardiac Surgery

Table 4. Troponin Levels

	Total	Frailty			p
		Pre-frail	Frail	None	
	Mean±SD Min-Max (Median)	Mean±SD Min-Max (Median)	Mean±SD Min-Max (Median)	Mean±SD Min-Max (Median)	
Troponin Monitoring					
Pre-op	17.4±15.0 0.04-153.4 (13.7)	12.1±7.3 3-32.5 (10.74)	22.4±17.4 0.04-153.4 (19.7)	6.5±4.2 2.3-15.6 (4.8)	**<0.001**
Post-op 0.	27.9±50.5 2.3-599 (17.55)	16.1±18.3 2.5-125 (12.27)	38.4±63.6 3.6-599 (26.8)	7.2±4.5 2.3-17.1 (5.45)	**<0.001**
6th hour	28.4±35.3 2.19-341 (19)	18.6±25.8 2.3-195 (13.22)	37.9±39.8 2.2-341 (28.6)	7.1±4.5 2.3-18.1 (4.9)	**<0.001**
12th hour	31.7±37.4 2.45-313 (19.76)	19.5±27.1 2.5-205 (12.7)	43.1±41.5 3.5-313 (33)	7.5±4.4 2.5-16.2 (5.1)	**<0.001**
24th hour	41.0±83.0 2.56-782 (22.15)	30.5±94.2 2.7-782 (13.6)	53.0±81.0 3.6-732 (32.1)	7.6±4.4 2.6-18 (5.9)	**<0.001**
48th hour	49.0±104.1 2.4-971 (20.85)	35.5±119.9 2.4-971 (13.7)	64.0±100.4 3.5-584 (29.1)	7.4±4.3 2.9-18.3 (6.3)	**<0.001**
72nd hour	49.8±136.6 2-1392 (20.56)	30.4±97.5 2-793 (12.5)	68.7±163.1 3.3-1392 (30.4)	6.9±4.1 3-19.1 (5.3)	**<0.001**

Kruskal Wallis Test, Pre-op: Preoperative

Table 5. Subgroup Analysis of Troponin

	Pre-Frail vs.Frail	Pre-Frail vs.None	Frail vs.None
TROPONİN Monitoring	**p**	**p**	**p**
Preop	<0.001	<0.001	<0.001
Postop 0.	<0.001	<0.001	<0.001
6th hour	<0.001	<0.001	<0.001
12th hour	<0.001	<0.001	<0.001
24th hour	<0.001	<0.001	<0.001
48th hour	<0.001	<0.001	<0.001
72th hour	<0.001	<0.001	<0.001

Mann Whitney U Test with Bonferroni correction, p<0.017, Pre-op: Preoperative

p=0.001, p=0.003, p=0.003, p=0.009), p=0.006). HR values increased with the increase in frailty. A statistically significant difference was found between the SPO2 distributions of the groups before induction (p=0,024). SPO 2 values of frail patients before induction were statistically significantly lower than non-frail patients (p=0,013).

A statistically significant difference was found between the Troponin distributions of the groups at Pre-op, post-op 0, 6, 12, 24, 48 and 72 hours (Table 4) (p<0,001).

Troponin values of frail patients were statistically significantly higher than those of pre-frail and non-frail patients (Table 5) (p<0,001). Troponin values of pre-frail patients were statistically significantly higher than those of non-frail patients (Table 5) (p<0,001).

A multivariate logistic regression analysis was performed to identify variables associated with MINS, including age, gender, ASA score, comorbidities (DM, HT, CAD, HF, dementia, COPD, CKD), vasopressor requirement, hypotension, and frailty status. In the ENTER model, ASA score (OR= 3.445; 95% CI: 1.287–9.222; p= 0.014), hypertension (OR= 2.726; 95% CI: 1.108–6.707; p= 0.029), dementia (OR= 4.414; 95% CI: 1.040–18.734; p= 0.044), and frailty (OR= 2.492; 95% CI: 1.019–6.098; p= 0.045) were significantly associated with MINS. No other variables reached statistical significance (Table 6).

Table 6. Logistic Regression Analysis Using ENTER Method to Determine Predictors of MINS

		OR	%95 GA	p
Age		1.038	0.985 – 1.094	0.160
Sex	Male	–	–	–
	Female	1.434	0.632 – 3.254	0.388
ASA		**3.445**	1.287 – 9.222	**0.014**
Comorbidities		0.157	0.014 – 1.760	0.133
DM		1.065	0.490 – 2.313	0.874
HT		**2.726**	1.108 – 6.707	**0.029**
CVD		1.031	0.331 – 3.207	0.959
CAD		0.668	0.300 – 1.488	0.323
HF		3.938	0.858 – 18.065	0.078
AF		1.914	0.297 – 12.341	0.495
Alzheimer		1.146	0.199 – 6.611	0.878
Dementia		**4.414**	1.040 – 18.734	**0.044**
Asthma		3.391	0.629 – 18.291	0.156
COPD		0.753	0.177 – 3.195	0.700
CKD		1.197	0.159 – 9.007	0.861
Hypothyroidism		0.773	0.201 – 2.976	0.708
Malignancy		0.424	0.058 – 3.071	0.395
Vasopressor requirement		1.488	0.675 – 3.280	0.324
Hypotension		1.101	0.486 – 2.494	0.818
Frailty status Pre-Frail		–	–	–
Frail		**2.492**	1.019 – 6.098	**0.045**
Non-Frail		0.386	0.039 – 3.859	0.418

OR= Odds ratio; CI= Confidence interval; ASA= American Society of Anesthesiologists; DM= Diabetes mellitus; HT= Hypertension; CVD= Cerebrovascular disease; CAD= Coronary artery disease; HF= Heart failure; AF= Atrial fibrillation; COPD= Chronic obstructive pulmonary disease; CKD= Chronic kidney disease. p<0.05

In the final Backward LR model, ASA score (OR= 2.892; 95% CI: 1.234–6.779; p= 0.015) and frailty (OR= 2.720; 95% CI: 1.215–6.090; p= 0.015) remained independently associated with MINS (Table 7).

Table 7. Multivariable Logistic Regression Model for Predictors of MINS (Backward LR Method)

	OR	%95 GA	p
Age	1.044	0.996 – 1.095	0.072
ASA	2.892	1.234 – 6.779	0.015
HT	1.990	0.918 – 4.318	0.081
HF	3.505	0.843 – 14.567	0.084
Dementia	3.563	0.922 – 13.773	0.065
Frailty	1.000	–	–
Frail	2.720	1.215 – 6.090	0.015
Non-Frail	0.514	0.058 – 4.539	0.549

OR= Odds ratio; CI= Confidence interval; ASA= American Society of Anesthesiologists; HT= Hypertension; HF= Heart failure. p<0.05

DISCUSSION

In this prospective cohort study evaluating the association between frailty and postoperative myocardial injury in elderly patients undergoing orthopedic surgery, we found that the incidence of MINS significantly increased with higher frailty levels. Frail patients were predominantly older, of female sex, and had a greater burden of comorbidities. Moreover, increased frailty was associated with longer hospitalization and ICU stays, as well as higher 30-day morbidity and mortality.

Previous research has reported frailty rates of approximately 23% among patients undergoing orthopedic surgery, while studies focusing on hip fracture surgery have demonstrated rates as high as 53% (6,7). In our study, the prevalence of frailty and pre-frailty was higher—56.7% and 33.5%, respectively. This may be explained by the inclusion of patients aged 65 years and above, combined with the high proportion of hip fracture cases (65%). Hip fractures often require urgent surgical intervention in elderly individuals with multiple comorbidities, which likely contributed to the higher frailty prevalence in our sample.

Frailty has consistently been shown to increase postoperative morbidity, prolong hospital stays, and worsen functional outcomes (8, 9). In line with these findings, our results demonstrated that frail patients required longer ICU and hospital care compared to their pre-frail and non-frail counterparts. The mean hospital stay was 12.4 days in frail patients, 10.7 days in pre-frail patients, and 5.3 days in non-frail patients, while ICU stays averaged 2.9, 1.9, and 0.2 days, respectively.

Thirty-day outcomes were also adversely affected by frailty. We observed a 30-day complication rate of 25.6% in frail patients compared to 4.3% in pre-frail patients, with no adverse events in the non-frail group. Similarly, 30-day mortality was 16.4% in frail patients and 1.4% in pre-frail patients, while no deaths occurred among non-frail patients. These findings are consistent with prior evidence showing increased short- and long-term mortality in frail surgical patients, independent of frailty measurement tools or type of surgery (3, 4, 8, 9).

When the risk factors associated with frailty are examined, it is pointed out that there are many environmental, epigenetic and biological factors, and especially, that frailty increases with age. Our study also found that frailty increased with age. Epidemiological data consistently demonstrate that frailty is more prevalent among women than men, highlighting a critical sex-specific vulnerability. (10,11). In our study, female gender was more common with a rate of 68.4%. It was also observed

that female gender was more common in frail (76.9%) and pre-frail patients (60.1%).

Although frailty has been widely recognized as a critical determinant of surgical outcomes, no universally accepted standard exists for its measurement. Several assessment tools have been proposed, yet none have been universally adopted for routine clinical practice. The FRAIL questionnaire, which evaluates fatigue, resistance, ambulation, illnesses, and weight loss, offers a simple and practical method, especially in immobile patients, and has been validated in Turkish populations (12-14). This tool allowed us to categorize patients effectively into frail, pre-frail, and non-frail groups.

Cardiovascular dysfunction is a major concern in frail populations. Subclinical structural and functional changes in the heart, combined with the presence of comorbidities, increase susceptibility to perioperative cardiovascular events (15, 16). In our study, nearly all frail patients (99.1%) and most pre-frail patients (94.2%) had additional systemic illnesses, supporting this association.

Although MINS is asymptomatic, it is distinguished from other cardiac pathologies by its significant contribution to postoperative morbidity and mortality. Existing literature predominantly addresses the development of MINS, as well as its incidence and associated risk factors, primarily in adult populations aged 45 years and older (17). However, there is a notable absence of studies specifically investigating clinical characteristics, predisposing factors, and 30-day outcomes of MINS in frail geriatric patients.

In the VISION study, 15103 patients over the age of 45 who underwent non-cardiac surgery were evaluated, of whom 3092 underwent orthopedic procedures. The incidence of MINS in this orthopedic subgroup was reported as 11.9%, which is notably higher than in non-orthopedic surgeries. These findings highlight the importance of postoperative troponin surveillance in patients with risk factors for MINS (17, 18).

In our study, the overall incidence of MINS was 44.4%. Notably, this rate increased substantially with frailty status: MINS was observed in 63.2% of frail patients, 23.2% of pre-frail patients, and only 5.3% of non-frail patients. The higher incidence of MINS compared to the VISION study may be attributed to our study population consisting exclusively of patients aged 65 years and older. However, the markedly elevated rate of MINS among frail individuals underscores the need to reassess existing risk models and incorporate frailty as a significant and independent predictor of MINS.

Even after adjusting for potential confounding factors such as age, sex, ASA classification, comorbidity burden, vasopressor use, and intraoperative hypotension, frailty remained an independent predictor of MINS in our cohort. Frail patients had more than a twofold higher likelihood of developing MINS compared with pre-frail individuals. These findings demonstrate that the association between frailty and myocardial injury cannot be attributed solely to chronological aging or comorbidity clustering, but rather reflects a distinct physiological vulnerability inherent to frailty itself. Given that both ASA classification and frailty consistently emerged as significant predictors across all models, incorporating systematic frailty assessment into perioperative risk stratification frameworks may enhance clinical decision-making for geriatric orthopedic patients.

The VISION Study Group defined a high-sensitivity troponin value between 20 and 65ng/L and an absolute change of at least 5ng/L, or an absolute change of 65ng/L or more as MINS (19). Therefore, we accepted the reference values of this study as the diagnosis of MINS in our study.

Severe hypotension or anemia, both recognized causes of oxygen supply-demand imbalance, have been associated with 72% of perioperative myocardial ischemic events. The primary risk factor for MINS is perioperative and postoperative

hypotension. Within a subgroup analysis of the VISION Study, tachycardia and systolic hypotension were identified as significant predictors of increased MINS risk (17).

In our study, mean arterial pressure (MAP) was found to be statistically significantly lower in frail patients only at 30 and 40 minutes intraoperatively. However, given that the overall intraoperative vasopressor requirement was 52.1% in frail patients compared to 37.7% in pre-frail patients, it is plausible that the actual incidence of intraoperative hypotension is substantially higher among the frail population. Despite efforts to mitigate the most critical known risk factor for MINS by maintaining target heart rate (HR) and MAP, the incidence of MINS remained notably high in frail patients.

The impact of anesthesia technique on outcomes in frail patients remains unclear. The 2020 guideline for the management of hip fractures reported no significant differences between general and regional anesthesia, emphasizing that optimal perioperative care is paramount (20). In our study, the choice of anesthesia technique was made by the anesthesiologist independently of the study protocol. Spinal anesthesia was administered in 60.7% of frail patients, 63.7% of pre-frail patients, and 70% of non-frail patients. Although no statistically significant differences were detected among the groups regarding anesthesia technique, the reduced preference for spinal anesthesia in frail patients was primarily attributed to concerns over hypotension and the prevalent use of oral anticoagulants in this population.

Our study is limited by a smaller sample size compared to similar research and exclusion of MINS events after 72 hours. Nevertheless, we found that MINS incidence increases in frail geriatric patients undergoing orthopedic surgery.

Conflict of Interest: The authors report no conflicts of interest.

REFERENCES

1. Panayi AC, Orkaby AR, Sakthivel D, et al. Impact of frailty on outcomes in surgical patients: A systematic review and meta-analysis. Am J Surg 2019;218(2):393-400. doi: 10.1016/j.amjsurg.2018.11.020.
2. Lin HS, Watts JN, Peel NM, Hubbard RE. Frailty and post-operative outcomes in older surgical patients: A systematic review. BMC Geriatr 2016;16(1):157. doi:10.1186/s12877-016-0329-8.
3. Chan S, Wong EKC, Ward SE, Kuan D, Wong CL. The predictive value of the Clinical Frailty Scale on discharge destination and complications in older hip fracture patients. J Orthop Trauma 2019;33(10):497-502. doi:10.1097/BOT.0000000000001518.
4. Pizzonia M, Giannotti C, Carmisciano L, et al. Frailty assessment, hip fracture and long-term clinical outcomes in older adults. Eur J Clin Invest 2021;51(4): e13445. doi:10.1111/eci.13445.
5. Ruetzler K, Khanna AK, Sessler DI. Myocardial Injury After Noncardiac Surgery: Preoperative, Intraoperative, and Postoperative Aspects, Implications, and Directions. Anesth Analg 2020;131(1):173-86. doi:10.1213/ANE.0000000000004567.
6. van de Ree CLP, Landers MJF, Kruithof N, et al. Effect of frailty on quality of life in elderly patients after hip fracture: a longitudinal study. BMJ Open 2019;9(7): e025941. doi:10.1136/bmjopen-2018-025941.
7. Johnson RL, Abdel MP, Frank RD, et al. Impact of Frailty on Outcomes After Primary and Revision Total Hip Arthroplasty. J Arthroplasty 2019;34(1):56-64.e5. doi: 10.1016/j.arth.2018.09.078.
8. Beggs T, Sepehri A, Szwajcer A, Tangri N, Arora RC. Frailty and perioperative outcomes: a narrative review. Canadian Journal of Anesthesia/Journal Canadien d'anesthésie 2015;62(2):143-57. doi:10.1007/s12630-014-0273-z.
9. Lin H-S, McBride R, Hubbard R. Frailty and anesthesia – risks during and post-surgery. Local Reg Anesth 2018; 11:61-73. doi:10.2147/LRA.S142996.
10. O'Caoimh R, Sezgin D, O'Donovan MR, et al. Prevalence of frailty in 62 countries across the world: a systematic review and meta-analysis of population-level studies. Age Ageing 2021;50(1):96-104. doi:10.1093/ageing/afaa219.
11. Park C, Ko FC. The Science of Frailty. Clin Geriatr Med 2021;37(4):625-38. doi:10.1016/j.cger.2021.05.008.

12. Gleason LJ, Benton EA, Alvarez-Nebreda ML,et al. FRAIL Questionnaire Screening Tool and Short-Term Outcomes in Geriatric Fracture Patients. J Am Med Dir Assoc 2017;18(12):1082-6. doi:10.1016/j.jamda.2017.07.005.

13. Kitamura K, van Hooff M, Jacobs W, Watanabe K, de Kleuver M. Which frailty scales for patients with adult spinal deformity are feasible and adequate? A systematic review. Spine Journal 2022;22 (7):1191-204. doi:10.1016/j.spinee.2022.01.017.

14. Hymabaccus BAB, Dogrul RT, Balcı C, et al. An effective and practical tool to assess physical frailty in older adults: Turkish validation of the FRAIL Scale. Marmara Medical Journal 2023;36(2):149-56. doi:10.5472/marumj.1297696.

15. Kusunose K, Okushi Y, Yamada H, et al. Prognostic Value of Frailty and Diastolic Dysfunction in Elderly Patients. Circulation Journal 2018;82(8):2103-10. doi:10.1253/circj. CJ-18- 0017.

16. Singh M, Stewart R, White H. Importance of frailty in patients with cardiovascular disease. Eur Heart J 2014;35(26):1726-31. doi:10.1093/eurheartj/ehu197.

17. Abbott TEF, Pearse RM, Archbold RA, et al. A Prospective International Multicentre Cohort Study of Intraoperative Heart Rate and Systolic Blood Pressure and Myocardial Injury After Noncardiac Surgery: Results of the VISION Study. Anesth Analg 2018;126(6):1936-45. doi:10.1213/ANE.0000000000002560.

18. Thomas S, Borges F, Bhandari M, et al. Association between myocardial injury and cardiovascular outcomes of orthopaedic surgery: A vascular events in noncardiac surgery patients cohort evaluation (VISION) substudy. J Bone Joint Surg Am 2020;102(10):880-8. doi: 10.2106/JBJS.18.01305.

19. Devereaux PJ, Biccard BM, Sigamani A, et al. Association of Postoperative High-Sensitivity Troponin Levels With Myocardial Injury and 30-Day Mortality Among Patients Undergoing Noncardiac Surgery. JAMA 2017;317(16):1642-51. doi:10.1001/jama.2017.4360.

20. Griffiths R, Babu S, Dixon P, et al. Guideline for the management of hip fractures 2020. Anaesthesia 2021;76(2):225-37. doi:10.1111/anae.15291.