Cukurova Medical Journal
ÇUKUROVA ÜNİVERSİTESİ TIP FAKÜLTESİ

Cukurova Med J 2023;48(3):954-964
DOI: 10.17826/cumj.1329179

RESEARCH

The effect of perioperative cardiac risk factors on postoperative outcomes in the elderly patients undergoing hip replacement surgery

Kalça protezi ameliyatı yapılan yaşlı hastalarda perioperatif kardiyak risk faktörlerinin postoperatif sonuçlara etkisi

Demet Laflı Tunay[1], Murat Türkeün Ilgınel[1]

[1]Department of Anesthesiology and Intensive Care, Çukurova University Faculty of Medicine, Adana, Türkiye

Abstract

Purpose: Cardiac risk factors are among the most important determinants of postoperative outcomes in elderly surgical patients. This study aimed to determine the effect of perioperative cardiac risk factors on postoperative adverse outcomes in elderly patients undergoing total hip replacement surgery.

Materials and Methods: Patients aged 65 and older who underwent total hip replacement surgery at Cukurova University Hospital between 2014 and 2019 were analyzed retrospectively. The primary outcome measures were postoperative adverse outcomes and mortality rate.

Results: Two hundred twenty-three patients with total hip replacement surgery within five years of experience in our hospital were screened. 34.5% had postoperative cardiac, pulmonary, cerebral, and infectious morbidity and systemic inflammatory response syndrome, and the in-hospital mortality rate was 2.2%. On multivariate analysis, perioperative risk factors associated with postoperative adverse outcomes included American Society of Anesthesiologists (ASA) II physical status (aOR 5.63, 95% CI 1.75-18.11), preoperative poor functional capacity (aOR 9.50, 95% CI 3.14-28.79), traumatic fracture (aOR 2.75, 95% CI 1.22-6.24), preoperative anemia (aOR 2.15, 95% CI 1.05-4.37), and prolonged surgery (aOR 1.02, 95% CI 1.01-1.02).

Conclusion: A significant relationship was determined between preoperative poor functional capacity, pre-existing anemia, traumatic hip fracture, ASA II physical status, prolonged case duration and the risk of postoperative complications in elderly patients undergoing total hip replacement surgery.

Keywords:. Cardiac risk factors, hip replacement surgery, mortality, postoperative morbidity.

Öz

Amaç: Kardiyak risk faktörleri, yaşlı cerrahi hastalarda postoperatif sonuçların en önemli belirleyicilerinden biridir. Bu çalışma, total kalça protezi ameliyatı geçiren yaşlı hastalarda perioperatif kardiyak risk faktörlerinin postoperatif olumsuz sonuçlara etkisini belirlemeyi amaçlamıştır.

Gereç ve Yöntem: Bu çalışmada, 2014-2019 yılları arasında Çukurova Üniversitesi Hastanesinde total kalça protezi ameliyatı geçiren 65 yaş ve üstü hastalar retrospektif olarak incelendi. Çalışmanın birincil sonuç ölçütleri postoperatif olumsuz sonuçlar ve mortalite oranıydı.

Bulgular: Hastanemizin beş yıllık tecrübesi dahilinde olan 223 total kalça protezi cerrahisi hastası tarandı. Hastaların %34,5'inde postoperatif kardiyak, pulmoner, serebral ve enfeksiyöz morbidite ile sistemik inflamatuar yanıt sendromu vardı ve hastane içi ölüm oranı %2,2 idi. Çok değişkenli analizde, postoperatif olumsuz sonuçlarla ilişkili perioperatif risk faktörleri arasında Amerikan Anestezistler Topluluğu (ASA)-II fiziksel durumu (aOR 5.63, %95 CI 1.75-18.11), preoperatif zayıf fonksiyonel kapasite (aOR 9,50, 95% GA 3,14-28,79), travmatik kırık (aOR 2,75, %95 GA 1,22-6,24), preoperatif anemi (aOR 2,15, %95 GA 1,05-4,37) ve uzamış cerrahi (aOR 1,02, %95 GA 1,01-1,02) yer almaktaydı.

Sonuç: Bu çalışmada, total kalça protezi ameliyatı geçiren yaşlı hastalarda ameliyat öncesi zayıf fonksiyonel kapasite, önceden var olan anemi, travmatik kalça kırığı, ASA II fiziksel durumu, uzamış vaka süresi ile ameliyat sonrası komplikasyon riski arasında anlamlı ilişki belirlendi.

Anahtar kelimeler: Kardiyak risk faktörleri, kalça protezi cerrahisi, mortalite, postoperatif morbidite

Address for Correspondence: Demet Laflı Tunay, Department of Anesthesiology and Intensive Care, Çukurova University Faculty of Medicine, Adana, Türkiye E-mail: dlafli@yahoo.com
Received: 18.07.2023 Accepted: 20.08.2023

INTRODUCTION

The population of patients aged 65 years or over is increasing rapidly. Surgical and anesthesia practices in geriatric patients will rise gradually with the increase in the elderly population, as well as diseases that require surgical intervention in the future. Although advanced age is a risk factor for perioperative mortality, preoperative comorbidities, frailty, and invasiveness of the surgical procedure are other important determinants in the geriatric age group[1]. Risk factors associated with perioperative cardiac events have always been of major concern for the geriatric patient population undergoing major non-cardiac surgery because these adverse cardiac events lead to postoperative morbidity, mortality and prolonged hospital stay[2]. Currently, the most common surgical procedures in individuals over 65 years old are lens and cataract surgery, knee arthroplasty and hip replacement surgery, respectively[3]. Hip replacement surgery due to osteoarthritis and trauma fractures significantly increases with the increasing elderly population[4]. Factors such as age, timing of surgery, and comorbidities affect the patient outcomes after hip surgery.

On the other hand, perioperative factors associated with perioperative cardiac complications are probably quite important in patients undergoing hip surgery because they result in considerable rates of further complications, prolonged hospitalization and poor quality of life[5]. As a result of various analyses, several risk indexes and models predicting perioperative adverse cardiac events used in preoperative risk assessment have been developed in the last 20 years[6-8]. Risk factors associated with perioperative cardiac complications mentioned in these prediction tools are thought to be potential complication inducers during and after non-cardiac surgery. Although potential risk factors are known to be associated with adverse outcomes in hip surgery, conflicting evidence points to the need for more research in this area[9-11]. Moreover, these preoperative risk assessment tools including revised cardiac risk index and the Goldman cardiac risk index are not age-specific and their reliability is limited for elderly patients undergoing hip replacement surgery, as they do not tend to specific procedures[8,12,13]. In addition, most of the studies[9,11,12] in this field have focused on the repair of hip fractures, so non-traumatic hip replacement surgery is less discussed in the literature. Therefore, this study aimed to retrospectively investigate the effects of perioperative cardiovascular risk factors such as pre-existing cardiovascular comorbidities, diabetes mellitus, kidney disease, anemia and poor functional capacity etc., on early postoperative outcomes such as postoperative hemodynamic instability, unplanned intensive care unit (ICU) admission, length of hospital stay, and mortality rate in patients aged 65 and older undergoing hip replacement surgery. Thus, the primary objective of this study is to identify the postoperative adverse outcomes including mortality rate in patients undergoing total hip replacement surgery.

MATERIALS AND METHODS

This study was approved by the Çukurova University Faculty of Medicine Clinical Investigation and Ethics Committee on September 4, 2019, with approval number: 33 and conducted at Çukurova University in Türkiye.

Sample

For this retrospective clinical study, two hundred twenty-three patients aged 65 and older who underwent total hip replacement surgery between 2014 and 2019 at Cukurova University Hospital were recruited. Exclusion criteria for this study included age < 65 years and partial-type of hip replacement surgery. The sample size of the study consisted of patients who had undergone all total hip replacement surgery within the five-year experience of our tertiary care hospital and met the inclusion criteria of the study. Power analysis was not used in the study.

Data collection

Electronic medical records, anesthesia records, preoperative evaluation records, nursing records, laboratory findings, and postoperative evaluation records and clinical outcomes were reviewed for all patients. All data were collected, recorded and checked by two different independent investigators.

Procedure

From the preoperative records, the demographic characteristics of the patients (age, gender, weight, height), American Society of Anesthesiologists (ASA) physical status classification, cardiac risk index, concomitant diseases, the indication of surgery,

functional capacity status, medications, and preoperative hematocrit values were recorded. From the records during the operation, the method of anesthesia and analgesia, the amount of fluids administered, the amount of blood and blood products, the complications seen during the operation, and the duration of the operation were recorded. From the postoperative period records, the amount of blood and blood products transfusion, mobilization times, need for postoperative ICU admission and length of ICU stay, length of hospital stay, causes of mortality and morbidity were examined.

Hypertension, ischemic heart disease, heart failure, valvular heart disease, and arrhythmia were categorized as preoperative cardiac diseases, while a history of stroke, dementia and Parkinson's disease were classified as neurological and cerebrovascular diseases. Respiratory comorbidities were chronic obstructive pulmonary disease (COPD) and asthma. The systemic inflammatory response syndrome (SIRS), which is considered a clinical syndrome and one of the postoperative adverse events, is a form of dysregulated inflammation. It is defined as two or more abnormalities in temperature, heart rate, respiration, or white blood cell count[14]. The self-reported functional capacity status of the patients was recorded as greater or less than 4 metabolic equivalents (METs) from the preoperative medical records. Furthermore, preoperative cardiac risk assessment was performed according to the revised cardiac risk index (RCRI) classification[6], which is based on a scoring system calculated according to the variables of ischemic heart disease, congestive heart failure, cerebrovascular disease, insulin therapy and creatinine level above 2 mg/dL. According to this index, classes I and II were low risk, class III was moderate, and class IV was high-risk groups for cardiac complications. Indications for surgery were classified as trauma, osteoarthritis, inflammatory arthritis, osteonecrosis and revision surgery.

Postoperative adverse events were defined using the following categories: (a) cardiac complications: myocardial infarction, cardiac failure, arrhythmias, episodes of hypotension requiring intervention, and cardiac arrest; (b) pulmonary complications: hypoxemia, pulmonary aspiration, pleural effusion, respiratory infection, pneumonia, pulmonary edema, and pulmonary embolus; (c) cerebral complications: stroke, and cognitive dysfunction; (d) wound complications: surgical site infection; (e) significant postoperative bleeding requiring more than two units of blood transfusion; (f) immobilization: not being able to mobilize within 30 days postoperatively; (g) systemic inflammatory response syndrome; (h) in-hospital mortality: death in the hospital. The postoperative complications included cardiac, pulmonary and cerebral complications, SIRS, surgical site infection, and mortality.

Statistical analysis

The Chi-square test was used to compare categorical variables between the groups. Student's t-test or Mann-Whitney U test was used to compare continuous variables between two groups and determine whether the statistical hypotheses were fulfilled. The Chi-square test of homogeneity was used to compare the variances of the measured variables in the groups. Logistic regression analysis was performed to determine variables that were predictors of postoperative adverse outcomes and the adjusted odds ratios (aORs) for the age, gender, RCRI classification, diabetes mellitus, renal dysfunction, cardiac disease, type of anesthesia, intraoperative hypotension and drugs variables were obtained. In univariate analysis, variables significantly associated with postoperative complications at the $p < 0.1$ level were entered in logistic regression analysis. Categorical variables were expressed as numbers and percentages, whereas continuous variables were summarized as mean, standard deviation, median and minimum-maximum where appropriate.

All statistical analysis was performed using IBM SPSS Statistics Version 20.0 statistical software package. $P<0.05$ was considered the statistical level of significance for all tests.

RESULTS

Four hundred and nineteen patients were evaluated for this study. A total of 196 patients were excluded from the study because 69 patients were under 65 years of age and 127 patients had partial hip replacement surgery. Thus, this study recruited two hundred twenty-three patients with total hip replacement surgery within 5 years of experience in our hospital. The mean age of the patients was 74.0±7.6 years. Patient, anesthesia and surgery-related characteristics, and information on comorbidities and medications are summarized in Tables 1 and 2. Intraoperative fluid intake, rate of intraoperative hypotension occurrence, frequency of

postoperative erythrocyte suspension transfusion, and mean length of stay in hospital and ICU are shown in Table 3. The in-hospital mortality rate was 2.2% (n=5), and 34.5% (n=77) of subjects suffered from one or more postoperative complications, including cardiac, pulmonary and cerebral complications, SIRS, surgical site infection, and death (Table 4).

Table 1. Patient and operative characteristics

Number of patients	**n=223**
Age (year)*	74.0±7.6
Gender (M/F)†	89(39.9)/134(60.1)
Weight (kg)*	74.7±12.4
BMI*	27.5±4.6
ASA physical status†	
I	32(14.3)
II	156(70.0)
III	35(15.7)
Type of anesthesia†	
GA	82(36.8)
CSE	65(29.1)
SA	76(34.1)
Duration of surgery (min)‡	152.8±40.5 / 140(75-290)
Indication for surgery†	
Trauma	69(30.9)
Osteoarthritis	102(45.7)
Inflammatory arthritis	4(1.8)
Osteonecrosis	12(5.4)
Revision surgery	36(16.1)
RCRI classification†	
Class I	132(59.2)
Class II	52(23.3)
Class III	37(16.6)
Class IV	2(0.9)
Functional capacity†	
< 4METs	41(18.4)
> 4METs	182(81.6)
Preoperative hematocrit level (%)*	36.9±4.6

BMI, body mass index; *ASA*, American Society of Anesthesiologists; *GA*, general anesthesia; *CSE*, combined spinal-epidural anesthesia; *SA*, spinal anesthesia; *RCRI*, revised cardiac risk index; *METs*, Metabolic Equivalents.

*Values are given as mean±standard deviation. ; †Values are given as n (%).; ‡Values are given as mean±standard deviation and median (min-max).

Table 2. Preoperative comorbidities and medications

Variable	**N (%)**
Cardiovascular diseases†	150(67.3)
Hypertension	116(52.0)
Ischemic heart disease	48(21.5)
Congestive heart failure	16(7.2)
Valvular heart disease	4(1.8)
Pulmonary diseases†	25(11.2)
COPD	14(6.3)
Asthma	11(4.9)
Diabetes mellitus†	54(24.2)
Neurological and cerebrovascular diseases†	19(8.5)
History of Stroke	10(4.5)

Dementia	5(2.2)
Parkinson disease	4(1.8)
*Anemia†	99(44.4)
Renal dysfunction†	12(5.4)
Medications†	
Beta-blockers	16(7.2)
ACE inhibitors	34(15.2)
Calcium channel blockers	47(21.1)
Insulin	30(13.5)
Statins	12(5.4)
ASA	15(6.7)

COPD, chronic obstructive pulmonary disease; *ACE*, Angiotensin-converting enzyme; *ASA*, Acetylsalicylic acid.
†Values are given as n (%). *****Anemia is defined according to the World Health Organization definition (Hb levels <12 g/dL in women and <13 g/dL in men).

Table 3. Intraoperative and postoperative patient data

Fluid intake	
Crystalloid (mL)*	1439.2±553.8 / 1500.0(500.0-3000.0)
Colloid (mL)*	336.3±320.1 / 500(0.0-1000.0)
ES 0/1/2 units†	152(68.2) / 48(21.5) / 23(10.3)
Baseline MAP (mmHg) ‡	101.8±16.2
Episodes of intraoperative hypotension†	63(28.3)
Postoperative ES 0/1/2/3≤ units†	136(61.0) / 65(29.1) / 12(5.4) / 10(4.5)
Postoperative mobilization time (day)*	2.26±1.7 / 2.0(0.0-16.0)
Length of ICU stay (day)*	2.28±1.5 / 2.0(1.0-5.0)
Length of hospital stay (day)*	7.2±4.2 / 6.0(3.0-30.0)

ES, erythrocyte suspension; *MAP*, mean arterial pressure; ICU, intensive care unit, *Values are given as mean±standard deviation and median (min-max), †Values are given as n (%), ‡Values are given as mean±standard deviation.

Table 4. Postoperative adverse outcomes

Postoperative complications*	**77(34.5)**
Mortality	5(2.2)
Cardiac complications	
Total	27(12.1)
Myocardial infarction	3(1.3)
Heart failure	4(1.8)
Arrhythmia	4(1.8)
Hemodynamic instability	15(6.7)
Cardiac arrest	1(0.4)
Pulmonary complications	
Total	16(7.2)
Hypoxemia	12(5.4)
Pneumonia	2(0.9)
Respiratory infection	2(0.9)
Cerebral complications	
Total	23(10.3)
Stroke	2(0.9)
Cognitive dysfunction	21(9.4)
SIRS	8(3.6)
Surgical site infection	19(8.5)
Postoperative significant bleeding†	10(4.5)
Postoperative immobilization‡	28(12.6)
Prolonged mobilization§	78(35.0)
Unplanned ICU admission	16(7.2)
Both intra- and postoperative ES transfusion	40(17.9)

SIRS, systemic inflammatory response syndrome; *ICU*, intensive care unit; *ES*, erythrocyte suspension, Values are given as n (%), *Including cardiac, pulmonary and cerebral complications, SIRS, surgical site infection, and mortality, †Requiring more than two units of blood transfusion, ‡Not being able to mobilize within 30 days postoperatively, §Mobilization on postoperative 3rd and subsequent days.

Patients with postoperative complications had a higher rate of preoperative poor functional capacity, the prevalence of preoperative anemia and general anesthesia practice, a longer surgical time and mean length of hospital stay, and a higher amount of colloid infusion than those without postoperative complications. There was no statistically significant relationship between ASA status, RCRI classification, pre-existing cardiac disease and the risk of postoperative complications (Table 5).

When the type of anesthesia management was compared with perioperative adverse events, in the general anesthesia group, perioperative blood transfusion, postoperative prolonged mobilization and immobilization rates were higher, and the mean hospital stay was longer. There was no relationship between anesthesia type and postoperative cardiac complications (Table 6).

Patients with poor functional capacity (<4METs) had higher rates of intraoperative hypotension episodes, postoperative immobilization and prolonged mobilization, and postoperative cardiac complications than those with adequate functional capacity (>4METs).

The multivariate logistic regression analysis found no statistically significant association between age, gender, RCRI classification, cardiac disease, diabetes mellitus, renal dysfunction and postoperative complications. Similarly, there was no significant relationship between cardioprotective medications such as beta-blockers, ACE inhibitors, acetylsalicylic acid, and statins and adverse outcomes (Table 8). The multivariable-adjusted model showed that being ASA II (aOR 5.63, 95% CI 1.75-18.11, p=0.004), having poor functional capacity (aOR 9.50, 95% CI 3.14-28.79, p<0.001), existing traumatic fracture (aOR 2.75, 95% CI 1.22-6.24, p=0.015), having preoperative anemia (aOR 2.15, 95% CI 1.05-4.37, p=0.035), and prolonged surgery (aOR 1.02, 95% CI 1.01-1.02, p<0.001) were associated with increased risk of postoperative complications (Table 8).

Table 5. Comparison of patient outcomes

Variable	Postoperative complications		
	Yes (n=77)	No (n=146)	p value
ASA physical status†			0.064
I	6(7.8)	26(17.8)	
II	55(71.4)	101(69.2)	
III	16(20.8)	19(13.0)	
Functional capacity†			<0.001*
< 4METs	26(33.8)	15(10.3)	
> 4METs	51(66.2)	131(89.7)	
RCRI classification†			0.856
I	47(61.0)	85(58.2)	
II	18(23.4)	34(23.3)	
≥ III	12(15.6)	27(18.5)	
Cardiac disease†			0.874
Yes	24(31.2)	44(30.1)	
No	53(68.8)	102(69.9)	
Type of anesthesia†			0.011*
General	37(48.1)	45(30.8)	
Regional	40(51.9)	101(69.2)	
Preoperative anemia†			0.027*
Yes	42(54.5)	57(39.0)	
No	35(45.5)	89(61.0)	
Duration of surgery (min) ‡	169.8±40.8	145.4±44.7	<0.001*
Intraoperative colloid infusion (mL) ‡	431.2±339.5	286.3±298.6	0.001*
Length of hospital stay (day) ‡	9.7±5.7	5.9±2.0	<0.001*

Abbreviations: *ASA*, American Society of Anesthesiologists; *METs*, Metabolic Equivalents; *RCRI*, revised cardiac risk index, †Values are given as n (%), ‡Values are given as mean±standard deviation, *These values indicate statistical significance (p<0.05).

Table 6. Comparison of type of anesthesia and perioperative adverse events

	Type of Anesthesia		
	Regional Anesthesia n=141	**General Anesthesia n=82**	**p value**
Intraoperative hypotension†	38(27.0)	25(30.5)	0.572
Intraoperative ES transfusion†	33(23.4)	38(46.3)	<0.001*
Both intra- and postoperative ES transfusion†	19(13.5)	21(25.6)	0.023*
Postoperative ES transfusion†	52(36.9)	35(42.7)	0.392
Postoperative immobilization†	12(8.5)	16(19.5)	0.017*
Postoperative prolonged mobilization†	35(24.8)	43(52.4)	<0.001*
Surgical site infection†	14(9.9)	5(6.1)	0.323
Postoperative cardiac complication†	14(9.9)	13(15.9)	0.190
Length of hospital stay (day) ‡	6.7±4.0	8.2±4.5	0.013*

Abbreviations: *ES*, erythrocyte suspension, †Values are given as n (%), ‡Values are given as mean±standard deviation, *These values indicate statistical significance (p<0.05).

Table 7. Comparison of preoperative functional capacity and perioperative adverse events

	Functional Capacity		
	< 4METs n=41	**> 4METs n=182**	**p value**
Intraoperative hypotension†	19(46.3)	44(24.2)	0.004*
Intraoperative ES transfusion†	18(43.9)	53(29.1)	0.066
Both intra- and postoperative ES transfusion†	11(26.8)	29(15.9)	0.100
Postoperative ES transfusion†	17(41.5)	70(38.5)	0.722
Postoperative immobilization†	12(29.3)	16(8.8)	<0.001*
Postoperative prolonged mobilization†	28(68.3)	50(27.5)	<0.001*
Postoperative cardiac complication†	11(26.8)	16(8.8)	0.001*
Length of hospital stay (day) ‡	7.1±3.2	7.2±4.4	0.831

Abbreviations: *METs*, Metabolic Equivalents; *ES*, erythrocyte suspension, †Values are given as n (%), ‡Values are given as mean±standard deviation, *These values indicate statistical significance (p<0.05).

Table 8. Multivariate analysis of the association between postoperative adverse outcomes and perioperative cardiac risk factors and patient characteristics

Variable	**Category**	**Coefficient**	**SE**	**OR**	**Adjusted OR (95% CI)**	**p value**
Age groups (years)	65-74	Reference				
	75-84	-0.139	0.457	0.871	0.356-2.132	0.762
	>85	-0.687	0.739	0.503	0.118-2.143	0.353
Gender	Male	Reference				
	Female	-0.243	0.352	0.489	0.784-1.562	0.394
RCRI classification	I	Reference				
	II	-0.018	0.533	0.982	0.346-2.790	0.973
	≥III	-0.040	0.660	0.961	0.264-3.504	0.952
Diabetes mellitus	No	Reference				
	Yes	-0.740	0.405	0.477	0.216-1.055	0.068
Preoperative anemia	No	Reference				
	Yes	0.764	.363	2.146	1.054-4.368	0.035*
Renal dysfunction	No	Reference				
	Yes	0.920	0.734	2.509	0.595-10.569	0.210
Cardiac disease	No	Reference				
	Yes	-0.343	0.487	0.709	0.273-1.844	0.481
Type of anesthesia	GA	Reference				
	CSE+SA	-0.204	0.401	0.815	0.372-1.788	0.611

Intraoperative hypotension	No	Reference				
	Yes	-0.796	0.412	0.451	0.201-1.012	0.053
Drugs†	No	Reference				
	Yes	-0.721	0.393	0.486	0.225-1.049	0.066
Indication for surgery	Other	Reference				
	Trauma	1.014	0.417	2.756	1.217-6.240	0.015*
ASA classification	I	Reference				
	II	1.729	0.596	5.633	1.752-18.110	0.004*
	III	1.244	0.822	3.468	0.692-17.377	0.130
Functional capacity	> 4METs	Reference				
	< 4METs	2.252	0.565	9.508	3.140-28.791	<0.001*
Duration of surgery (min)		0.016	0.004	1.016	1.008-1.024	<0.001*

OR, odds ratio; *CI*, confidence interval; *RCRI*, revised cardiac risk index; *GA*, general anesthesia; *CSE*, combined spinal-epidural anesthesia; *SA*, spinal anesthesia; *ASA*, American Society of Anesthesiologists; *METs*, Metabolic Equivalents, †Drugs category includes beta-blockers, ACE inhibitors, acetylsalicylic acid and statins, *These values indicate statistical significance (p<0.05).

DISCUSSION

In this retrospective study on patients aged 65 and over who underwent total hip replacement surgery, the postoperative complication rate was 34.5%, including mortality, cardiac, pulmonary, cerebral and infectious morbidities. We did not observe any statistically significant relationship between age, gender, RCRI classification, ASA status, and the presence of comorbidities, including cardiac diseases and the risk of postoperative complications. On the other hand, results coming from a multivariate analysis model, which adjusted for age, gender, RCRI classification, diabetes mellitus, renal dysfunction, cardiac disease, type of anesthesia, intraoperative hypotension and medications, showed that there was a statistically significant association between ASA II physical status, poor functional capacity, preoperative anemia, traumatic fracture, and prolonged surgery and postoperative complications. In univariate analysis, we also found that postoperative complications were significantly associated with poor functional capacity, anemia, general anesthesia, prolonged surgery, a higher amount of colloid infusion, and prolonged hospital stay.

The Revised Cardiac Risk Index is commonly used to predict perioperative cardiac complications and mortality before non-cardiac surgery[6,10,11]. In this study, 27 (12.1%) patients with postoperative cardiac morbidity and mortality did not correlate with the RCRI risk stratification groups. Similarly, RCRI could not predict overall postoperative complications, including cardiac and non-cardiac morbidity. Ackland et al[10]. reported a gradual association between RCRI and postoperative morbidity, including cardiac, pulmonary, renal, neurological, wound, and infectious complications, after elective hip and knee procedures, but it might still be inadequate in routine clinical practice. In a study investigating the prognostic value of RCRI in different age groups, the predictive value of the RCRI was highest in patients under 55 years, which decreased with age[15]. Based on the results of this study, we think that the prognostic value of RCRI for postoperative complications may decrease with age in geriatric patients who are already frail or have reduced physiological reserves in all organ systems.

Determination of preoperative functional capacity is a substantial and accessible tool in cardiac risk assessment. In non-cardiac surgery, estimated functional capacity based on the patient's self-reported activity is associated with increased cardiac risk when less than four metabolic equivalents[16,17]. We also found poor functional capacity is significantly associated with postoperative cardiac complications, intraoperative hemodynamic instability, and mobilization difficulty. In the multivariate-adjusted model, we obtained that poor functional capacity increased the risk of postoperative complications by 9.5 times. On the other hand, there is inconsistent evidence stated that self-report-based assessment of functional capacity is not a good predictor compared to other objective measures such as cardiopulmonary exercise testing (CPET)[18,19]. We believe that the subjective assessment of preoperative functional capacity cannot be superior to objective tests but may be preferred in patients undergoing non-cardiac surgery for ease of application, cost-effectiveness and usefulness.

Cardiac complications are the most important indicator of postoperative mortality, especially in the geriatric population[20,21]. Evidence suggests cardiovascular complications are the leading cause of death in hip replacement surgery[20]. The leading causes of death in our study were similarly cardiovascular complications, and the in-hospital mortality rate was 2.2% (5 of 223 patients). In a systematic literature review by Berstock et al[20]., the overall incidence of mortality at 30 and 90 days after hip replacement was calculated as 0.30% and 0.65%, respectively. The expected mortality rate in total hip replacement surgery performed with the indication of osteoarthritis without age stratification is below 1%[20,22]. In the current study, we think advanced age, traumatic fracture and revision surgery are possible reasons for the higher-than-expected mortality rate. The mean age of the patients who died was 88.6±3.3; the indication for surgery was trauma for four patients and revision for one. Although age alone is not used as a predictor, it is a valid indicator of mortality. In a prospective cohort study of 4158 elderly patients undergoing non-cardiac surgery, 30-day mortality was calculated as 5%, and it was concluded that the most important predictors for mortality were age, ASA physical status, and albumin level rather than the type of surgery[23]. It is well known that perioperative mortality is higher in patients who underwent hip arthroplasty with traumatic fracture indication than in other elective indications[24,25]. In studies investigating the mortality of hip arthroplasty after acute trauma, the 30-day mortality rate was reported as 2.9-6% in elderly patients[24,25]. Trauma indication was determined as a risk factor for postoperative complications in the multivariate analysis model in this study.

44.4% of the patients included in this study were anemic according to the World Health Organization (WHO) definition in the preoperative period. The length of hospital stay and perioperative transfusion rates were significantly higher in these patients compared to non-anemic patients. The multivariate analysis model calculated the risk of developing postoperative complications as 2.1 times higher in anemic cases. Similarly, a recent large database-based study reported that preoperative anemia significantly increased mortality risk and medical complications in total hip arthroplasty[26]. In this respect, we concluded that anemia is a considerable and modifiable risk factor affecting the incidence of postoperative adverse events.

In hip surgery, there is no strong evidence yet to demonstrate the effect of anesthesia choice on perioperative outcomes. A recent meta-analysis stated that regional and general anesthesia are similar regarding postoperative outcomes in hip surgery, but this does not mean equivalence and more evidence is needed in this area[27]. More studies suggest regional anesthesia improves outcomes such as mortality, transfusion requirement, and thromboembolic events in hip surgery[28,29]. In this study, perioperative transfusion rates, length of hospital stay, and ambulation problems were significantly lower in patients who underwent regional anesthesia compared to general anesthesia.

It has been demonstrated in various types of surgery that the duration of anesthesia or surgery is an independent risk factor for postoperative outcomes[21,30]. In our study, the duration of surgery was significantly higher in patients with postoperative complications (169.8 min vs. 145.4 min). In multivariate analysis, a one-unit increase in surgical time increased the risk of postoperative complications 1.0-fold.

The present study had some limitations. First, the study's retrospective design limits the generalization of the results. Possible bias and lack of records are the most critical issues, including that the frequency and accuracy of reported complications may be insufficient to assess risk accurately. Second, the fact that frailty and malnutrition are not routinely evaluated at our institution precluded a complete preoperative evaluation of the geriatric patient. Since the delirium screening tool is not used in every patient, diagnosing a hypoactive form may have been overlooked. Third, although the multivariable-adjusted model was used to control the potential confounding factors such as age, sex, preexisting cardiac disease etc., the sample size was insufficient to evaluate some risk factors and their effects on outcomes.

In conclusion, our data reveal that preoperative poor functional capacity, pre-existing anemia, traumatic hip fracture, ASA II physical status and prolonged case duration are statistically significant risk factors for postoperative morbidity and mortality in elderly patients undergoing total hip replacement surgery. We believe modifiable factors such as poor functional capacity and anemia should be carefully considered in the preoperative period to improve postoperative outcomes. We think that there is a need for further prospective studies with large samples, which include

objective evaluation methods of preoperative functional capacity and investigate the effects of preoperative cardiac risk factors on postoperative outcomes.

Author Contributions: Concept/Design : DLT, MTI; Data acquisition: DLT, MTI; Data analysis and interpretation: DLT, MTI; Drafting manuscript: DLT, MTI; Critical revision of manuscript: DLT, MTI; Final approval and accountability: DLT, MTI; Technical or material support: DLT; Supervision: DLT; Securing funding (if available): n/a.

Ethical Approval: Ethical approval was obtained from the Ethics Committee of Non-Interventional Clinical Trials of the Faculty of Medicine of Çukurova University with the decision dated 04.09.2019 and numbered 91/33.

Peer-review: Externally peer-reviewed.

Conflict of Interest: The authors declare no conflict of interest.

Financial Disclosure: Authors declared no financial support

Acknowledgement: The authors of this article would like to thank everyone who played a role in carrying out this research.

REFERENCES

1. Turrentine FE, Wang H, Simpson VB, Jones RS. Surgical risk factors, morbidity, and mortality in elderly patients. J Am Coll Surg. 2006;203:865-77.
2. Fleischmann KE, Goldman L, Young B, Lee TH. Association between cardiac and noncardiac complications in patients undergoing noncardiac surgery: outcomes and effects on length of stay. Am J Med. 2003;115:515-20.
3. Deiner S, Westlake B, Dutton RP. Patterns of surgical care and complications in elderly adults. J Am Geriatr Soc. 2014;62:829-35.
4. Friedman SM, Mendelson DA. Epidemiology of fragility fractures. Clin Geriatr Med. 2014;30:175-81.
5. Devereaux PJ, Sessler DI. Cardiac complications in patients undergoing major noncardiac surgery. N Engl J Med. 2015;373:2258-69.
6. 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;100:1043-9.
7. Gupta PK, Gupta H, Sundaram A, Kaushik M, Fang X, Miller WJ et al. Development and validation of a risk calculator for prediction of cardiac risk after surgery. Circulation. 2011;124:381-7.
8. Goldman L, Caldera DL, Nussbaum SR, Southwick FS, Krogstad D, Murray B et al. Multifactorial index of cardiac risk in noncardiac surgical procedures. N Engl J Med. 1977;297:845-50.
9. Forssten MP, Mohammad Ismail A, Sjolin G, Ahl R, Wretenberg P, Borg T et al. The association between the Revised Cardiac Risk Index and short-term mortality after hip fracture surgery. Eur J Trauma Emerg Surg. 2022;48:1885-92.
10. Ackland GL, Harris S, Ziabari Y, Grocott M, Mythen M; SOuRCe Investigators. Revised cardiac risk index and postoperative morbidity after elective orthopaedic surgery: a prospective cohort study. Br J Anaesth. 2010;105:744-52.
11. Forssten MP, Mohammad Ismail A, Borg T, Ahl R, Wretenberg P, Cao Y et al. Postoperative mortality in hip fracture patients stratified by the Revised Cardiac Risk Index: a Swedish nationwide retrospective cohort study. Trauma Surg Acute Care Open. 2021;6:e000778.
12. Çiçek V, Cinar T, Hayiroglu MI, Kılıç Ş, Keser N, Uzun M et al. Preoperative cardiac risk factors associated with in-hospital mortality in elderly patients without heart failure undergoing hip fracture surgery: a single-centre study. Postgrad Med J. 2021;97:701-5.
13. Vernooij LM, van Klei WA, Moons KG, Takada T, van Waes J, Damen JA. The comparative and added prognostic value of biomarkers to the Revised Cardiac Risk Index for preoperative prediction of major adverse cardiac events and all-cause mortality in patients who undergo noncardiac surgery. Cochrane Database Syst Rev. 2021;12:CD013139.
14. Levy MM, Fink MP, Marshall JC, Abraham E, Angus D, Cook D et al. 2001 SCCM/ESICM/ACCP/ATS/SIS International Sepsis Definitions Conference. Crit Care Med. 2003;31:1250-6.
15. Welten GM, Schouten O, van Domburg RT, Feringa HH, Hoeks SE, Dunkelgrün M et al. The influence of aging on the prognostic value of the revised cardiac risk index for postoperative cardiac complications in vascular surgery patients. Eur J Vasc Endovasc Surg. 2007;34:632-8.
16. Fleisher LA, Fleischmann KE, Auerbach AD, Barnason SA, Beckman JA, Bozkurt B et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation. 2014;130:2215-45.
17. Marsman M, van Waes JAR, Grobben RB, Weersink CSA, van Klei WA. Added value of subjective assessed functional capacity before non-cardiac surgery in predicting postoperative myocardial injury. Eur J Prev Cardiol. 2021;28:262-9.
18. Struthers R, Erasmus P, Holmes K, Warman P, Collingwood A, Sneyd JR. Assessing fitness for surgery: a comparison of questionnaire, incremental shuttle walk, and cardiopulmonary exercise testing in general surgical patients. Br J Anaesth. 2008;101:774-80.
19. Wijeysundera DN, Pearse RM, Shulman MA, Abbott TEF, Torres E, Ambosta A et al. METS study investigators. Assessment of functional capacity before major non-cardiac surgery: an international, prospective cohort study. Lancet. 2018;391:2631-40.
20. Berstock JR, Beswick AD, Lenguerrand E, Whitehouse MR, Blom AW. Mortality after total hip

replacement surgery: A systematic review. Bone Joint Res. 2014;3:175-82.
21. Gabriel RA, Sztain JF, A'Court AM, Hylton DJ, Waterman RS, Schmidt U. Postoperative mortality and morbidity following non-cardiac surgery in a healthy patient population. J Anesth. 2018;32:112-9.
22. Hunt LP, Ben-Shlomo Y, Clark EM, Dieppe P, Judge A, MacGregor AJ et al; National Joint Registry for England, Wales and Northern Ireland. 90-day mortality after 409,096 total hip replacements for osteoarthritis, from the National Joint Registry for England and Wales: a retrospective analysis. Lancet. 2013;382:1097-104.
23. Mamidanna R, Stonell C, Faiz O. Complications and mortality in older surgical patients in Australia and New Zealand (the REASON study): a multicentre, prospective, observational study. Anaesthesia. 2011;66:132-3.
24. Parvizi J, Ereth MH, Lewallen DG. Thirty-day mortality following hip arthroplasty for acute fracture. J Bone Joint Surg Am. 2004;86:1983-8.
25. Blanco JF, da Casa C, Pablos-Hernández C, González-Ramírez A, Julián-Enríquez JM, Díaz-Álvarez A. 30-day mortality after hip fracture surgery: Influence of postoperative factors. PLoS One. 2021;16:e0246963.
26. Grosso MJ, Boddapati V, Cooper HJ, Geller JA, Shah RP, Neuwirth AL. The effect of preoperative anemia on complications after total hip arthroplasty. J Arthroplasty. 2020;35:S214-8.
27. Kunutsor SK, Hamal PB, Tomassini S, Yeung J, Whitehouse MR, Matharu GS. Clinical effectiveness and safety of spinal anaesthesia compared with general anaesthesia in patients undergoing hip fracture surgery using a consensus-based core outcome set and patient-and public-informed outcomes: a systematic review and meta-analysis of randomised controlled trials. Br J Anaesth. 2022;129:788-800.
28. Opperer M, Danninger T, Stundner O, Memtsoudis SG. Perioperative outcomes and type of anesthesia in hip surgical patients: An evidence based review. World J Orthop. 2014;5:336-43.
29. Guay J. The effect of neuraxial blocks on surgical blood loss and blood transfusion requirements: a meta-analysis. J Clin Anesth. 2006;18:124-8.
30. Cheng H, Clymer JW, Po-Han Chen B, Sadeghirad B, Ferko NC, Cameron CG et al. Prolonged operative duration is associated with complications: a systematic review and meta-analysis. J Surg Res. 2018;229:134-44.