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ORIGINAL ARTICLE

Obesity and postoperative early complications in open heart surgery

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Abstract

Purpose We investigated the distribution of early clinical outcomes among normal, obese, and morbidly obese patients undergoing open heart surgery.

Methods Medical records of 1,000 patients undergoing open heart surgery since February 2011 at our hospital were investigated retrospectively after permission was obtained from the Council of Education Planning of the hospital. The comorbidities and perioperative and discharge data were analyzed for 279 patients with a body mass index (BMI) score between 18 and <30 [non-obese reference group (NRG, $n = 279$)]; 166 patients with BMI between 30 and <35 [obese group (OG, $n = 166$); and 192 seriously obese patients with BMI ≥ 35 [extreme obese group (EOG, $n = 192$)]. Distribution of the patients according to BMI scores was found to represent the BMI distribution of the Turkish population.

Results Pulmonary and infective complications were significantly higher in EOG patients compared to NRG based on crude confidence interval. Based on adjusted multiple logistic regression analysis, by adjusting the effects of age, sex, comorbidities (diabetes mellitus, hypertension, hyperlipidemia, chronic obstructive pulmonary disease), and smoking, the incidence of pulmonary and gastrointestinal complications in EOG was higher compared to NRG. Discharge with morbidity was significantly higher in OG and EOG compared to NRG.

Conclusions We found that obesity does not increase short-term mortality for open heart surgery; however, it increases the risk of postoperative pulmonary and gastrointestinal complications and discharge with morbidity.

Keywords Obesity · Cardiac surgery · Cardiac anesthesia · Postoperative complications · Morbidity · Mortality

Introduction

Obesity has become one of the leading health problems of the century. Obesity prevalence has dramatically increased in the United States as well as in most European countries in the past decade [1, 2]. In Turkey, one fourth of men over 30 years old (25.2 %) and almost half of women (44.2 %) are obese [3]. Obesity prevalence among middle-aged Turkish men has already reached the twice of the prevalence recorded in various European countries (10–15 %) [4].

The role of obesity in morbidity and mortality following cardiac surgery has been investigated thoroughly, and controversial results have been reported. Although there is a consensus on the hypothesis that obesity is not a risk

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factor for mortality, discussions taken place regarding it as a risk factor for morbidity. Recently, obesity has been reported as an independent predictor for mortality and morbidity following coronary bypass surgery [5].

In the present study, we investigated the prognostic factors and distribution of early clinical outcomes among normal, obese, and morbidly obese patients undergoing open heart surgery.

Methods

Study subjects

In the present study, medical records of 1,000 patients undergoing open heart surgery since February 2011 at our high-volume cardiac surgery hospital (the Ankara Yüksek İhtisas Hospital of Turkey) were investigated retrospectively after permission was obtained from the Council of Education Planning of the hospital. Using the computerized database of the hospital, we excluded vascular surgery patients and obtained the records of 1,000 patients. The comorbidities and perioperative and discharge data were analyzed for 298 patients who underwent surgical coronary revascularization of the beating heart, cardiac transplantation, or congenital cardiac surgery; 65 patients with incomplete medical records were excluded from the study. Six hundred and thirty-seven patients who underwent coronary, heart valve, or other heart surgery via cardiopulmonary bypass were divided into three groups according to body mass index (BMI) scores: 279 patients with BMI score between 18 and <30 [non-obese reference group (NRG, $n = 279$)]; 166 patients with BMI between 30 and <35 [obese group (OG, $n = 166$)]; and 192 seriously obese patients with BMI score ≥35 [extreme obese group (EOG, $n = 192$)].

Distribution of the patients according to BMI scores was representative of the BMI distribution of the Turkish population.

Comorbidities and definitions

Age, sex, smoking status, ejection fraction, and American Society of Anesthesiologists (ASA) physical status classification scores were obtained and analyzed. The standard European System for Cardiac Operative Risk Evaluation (EuroSCORE), which is widely used for quality control purposes in heart surgery and is also used for individual risk estimation, was calculated retrospectively for each patient. Because standard EuroSCORE may be erroneous in high-risk patients with some particular risk combinations, logistic EuroSCORE was also calculated for each patient. Preoperative pathological criteria are listed below [5]:

Diabetes mellitus: preprandial blood glucose >200 mg/dl or use of medication for the treatment of diabetes mellitus.

Hypertension: blood pressure >140/90 mmHg or use of medication for the treatment of hypertension.

Hyperlipidemia: total cholesterol >200 mg/dl or use of medication for the treatment of hypercholesterolemia.

Chronic obstructive pulmonary disease (COPD): long-term bronchodilator or steroid use for a lung disease diagnosed with spirometry.

Chronic kidney failure: occurrence of a disease requiring regular dialysis.

Peripheral vascular disease: occurrence of claudication, amputation because of arterial insufficiency, occurrence of surgery because of abdominal aortic aneurysm, aortoiliac disease, or peripheral vascular disease.

Neurological disease: history of stroke or transient ischemic attack.

Critical condition: occurrence of ventricular fibrillation, ventricular tachycardia, or cardiopulmonary resuscitation.

Operative data

Mallampati scores, length of cross-clamp time, length of cardiopulmonary bypass time, length of operation, use of intraaortic balloon pump, and use of blood and fresh frozen plasma were recorded for each patient. Surgical procedures were classified as elective or emergency. Operations were grouped by reason as follows: coronary artery bypass graft (CABG) surgeries, valve operations (involving one or more valves), and other procedures (aortic aneurysm repair surgeries, valve + CABG surgeries, aneurysm + CABG surgeries).

Definitions of early postoperative clinical conditions and discharge data

Pathologies specified as early postoperative clinical conditions are defined as follows:

Neurological conditions: postoperative stroke causing permanent or temporary neurological sequelae.

Prolonged mechanical ventilation: use of mechanical ventilation longer than 24 h.

Renal complications: recently developed renal complications requiring dialysis.

Perioperative myocardial infarction: ST segment elevation with or without ST segment elevation (four times 12-lead ECG per day during ICU, one time 12-lead ECG per day after ICU).

Arrhythmia: arrhythmia requiring cardioversion or antiarrhythmic medication, or disturbing hemodynamic stability.
Pulmonary complications: pneumonia, respiratory insufficiency, reintubation, tracheostomy.
Gastrointestinal complications: gastrointestinal bleeding, ileus, subileus, mesenteric ischemia, cholecystitis, extremely elevated liver enzymes, pancreatitis, hepatitis.
Infective complications: septicemia requiring antibiotherapy because of positive culture; sternal, leg and urinary tract infection.
Revision: caused by complications other than bleeding.
Multisystem failure: respiratory + circulatory + renal and other organ failures.
Pulmonary embolism: diagnosed via spiral CT, angiography, and/or V/Q scintigraphy.
Tamponade: bleeding requiring revision or percutaneous aspiration.

The length of ICU stay (days), length of hospital stay (days), and whether the patient was discharged with full recovery or with morbidity were investigated.

Discharged with morbidity: discharge with newly emerged and not transient complications during postoperative period.

The patients were called by telephone to obtain their consent to review their files; via this call their mortality information for the previous 30 days was also obtained.

Statistical methods

Nominal variables were assessed by chi-square test. One-way analysis of variance (ANOVA) was used to test the differences among groups for the continuous variables. Differences among the three groups for ordinal or nonnormally distributed continuous variables were evaluated by Kruskal–Wallis variance analysis. When the p value from the Kruskal–Wallis test statistics is statistically significant, the multiple comparison test was used to find which group differs from which other(s) [6]. To define independent risk factors of outcome variables, univariate and multiple logistic regression analysis was used. The significance of the individual regression coefficients were evaluated by Wald statistics [7]. Crude and adjusted odds ratios and their 95 % confidence intervals were calculated. There were no missing data. p values less than 0.05 were considered significant. SPSS for Windows 11.5 was used for statistical analysis.

Results

Patient characteristic variables, reason for operation, and whether the operation was elective are presented in Table 1. Female gender and incidence of preoperative DM, hypertension, hyperlipidemia, and COPD significantly increased with increasing obesity ($p < 0.001$). It was observed that obesity decreased with increased smoking status. Mallampati scores of 3 and 4 were significantly higher in OG and EOG compared to NRG (NRG vs. EOG, $p = 0.03$; NRG vs. OG, $p = 0.041$; OG vs. EOG, $p = 1.000$) (Table 1). Occurrence of coronary surgery increased with increasing obesity; in NRG, along with coronary surgery, there was a considerable number of heart valve surgeries.

American Society of Anesthesiologists physical status classification, length of cross-clamp time, cardiopulmonary bypass, and operation, and erythrocyte-plasma transfusion values are presented in Table 2 as mean (SD) and median (min–max). No difference between groups was observed in terms of intraoperative duration and transfusion values. Logistic and standard EuroSCORE levels were found to be significantly higher in EOG compared to NRG ($p = 0.001$ for both) (Table 2).

Early postoperative complications, length of stay at both ICU and hospital, and discharge information are presented in Table 3. A difference was observed between groups in terms of perioperative myocardial infarction and pulmonary complications. Pulmonary and infective complications were significantly higher in EOG based on crude confidence interval (for pulmonary, $p = 0.012$; for infection, $p = 0.031$) (Table 4). Table 5 shows complications resulting from obesity alone after adjusting for the effects of age, sex, comorbidities (DM, hypertension, hyperlipidemia, COPD), and smoking. Based on the adjusted multiple logistic regression analysis (after excluding variables), incidence of pulmonary and gastrointestinal complications in EOG was higher compared to NRG (for pulmonary, $p = 0.029$; for gastrointestinal, $p = 0.040$). No difference was observed among groups in terms of perioperative myocardial infarction and infective complications. In terms of the length of ICU stay (less than 3 days and more than 3 days) and the length of hospital stay (less than 10 days or more than 10 days), no difference was observed among groups. Discharge with morbidity was significantly higher in OG and EOG compared to NRG (for OG, $p = 0.016$; for EOG, $p = 0.034$). There was no mortality in EOG. There was no difference between OG and NRG in terms of mortality.

Discussion

In the present study, the risk of postoperative pulmonary complication was found higher in EOG compared to NRG via both percentage statistical analysis and crude and adjusted confidence level analyses (Tables 3, 4, 5). It is known that obese individuals experience lower respiratory

Table 1 Preoperative prognostic variables and operative data of the patients

Prognostic variables	NRG = 279		OG = 166		EOG = 192		*p* value
	n	%	*n*	%	*n*	%	
Age (years)							<0.001
≥18 and <45	73	26.2	21	12.7	14	7.3	
≥45 and <55	57	20.4	41	24.7	62	32.3	
≥55 and <65	67	24	64	38.6	71	37	
≥65 and <75	62	22.2	29	17.5	38	19.8	
≥75	20	7.2	11	6.6	7	3.6	
Male	198	71	100	60.2	78	40.6	<0.001
ASA scores							<0.001
1	54	19.4	0	0	3	1.6	
2	167	59.9	143	86.1	152	79.2	
3	55	19.7	23	13.9	37	19.3	
4	2	0.7	0	0	0	0	
5	1	0.4	0	0	0	0	
Diabetes mellitus	52	18.6	59	35.5	80	41.7	<0.001
Hypertension	142	50.9	111	66.9	149	77.6	<0.001
COPD	40	14.3	38	22.9	56	29.2	<0.001
Chronic renal failure	5	1.8	2	1.2	4	2.1	0.812
Peripheral vascular disease	6	2.2	0	0	1	0.5	0.072
Hyperlipidemia	56	20.1	58	34.9	67	34.9	<0.001
Active smoking	71	25.4	31	18.7	30	15.6	0.027
Critical condition	13	4.7	4	2.4	10	5.2	0.380
Cerebrovascular accident	21	7.5	10	6	8	4.2	0.327
Ejection fraction (%)							0.258
≥50	215	77.1	124	74.7	156	81.3	
50–30	62	22.2	39	23.5	36	18.8	
<30	2	0.7	3	1.8	0	0	
Mallampati score							0.507
1	256	91.8	140	84.3	162	84.4	
2	21	7.5	21	12.7	20	10.4	
3 and 4	2	0.7	5	3	10	5.2	
Operative data							
Elective operation	268	96.1	163	98.2	182	94.8	0.237
Reason for operation							<0.001
CABG	153	54.8	121	72.9	137	71.9	
Valve	77	27.6	24	14.5	36	18.8	
Other	49	17.6	21	12.7	19	9.9	

For Mallampati scores of 3 and 4: NRG versus EOG, $p = 0.03$; NRG versus OG, $p = 0.041$; OG versus EOG, $p = 1.000$

NRG non-obese reference group, *OG* obese group *EOG* extreme obese group, *COPD* chronic obstructive pulmonary disease, *CABG* coronary artery bypass graft surgery

reserve, deteriorated ventilation/perfusion ratio, and lower functional residual capacity [8]. Obesity negatively affects several respiratory system parameters, such as respiratory muscles, respiratory system resistance, lung volume, and energy consumption for respiratory gas exchange, and thus causes pulmonary functions to fail and lowers exercise capacity. The lower inspiratory and vital capacity levels are a result of the lower muscle performance [9]. Respiratory symptoms, such as dyspnea, increase as BMI increases [9, 10]. Furthermore, pulmonary artery diastolic pressure–pulmonary capillary wedge pressure (PADP–PCWP) gradient was found increased in obese individuals [11]. Increasing abdominal and diaphragm pressure affect the pleural pressure, which eventually lowers the total lung capacity, pulmonary compliance, and volume [12]. Although there are conflicting reports regarding the effects of increasing BMI on intraabdominal pressure [13, 14], several researchers reported that obesity eventually distresses restrictive pulmonary functions [9, 15]. Hamoui et al. [16] suggested that lowered vital capacity, which is a result of intraabdominal pressure increase and thoracic wall compliance decrease, is the most important predictor of

Table 2 American Society of Anesthesiologists (ASA) status, length of cross-clamp time, cardiopulmonary bypass, and operation, erythrocyte-plasma transfusion values, and logistic and standard EuroSCORE levels

Numerical variables	NRG = 279		OG = 166		EOG = 192		p value
	Mean ± SD	Median (min–max)	Mean ± SD	Median (min–max)	Mean ± SD	Median (min–max)	
Age (year)	53.4 ± 15.7	56 (18–82)	57.6 ± 11.0	59 (24–81)	57.0 ± 9.6	57 (30–79)	0.089
Cross-clamp duration (min)	66.3 ± 30.16	61 (14–212)	60.7 ± 32.08	56 (10–226)	62.16 ± 28.22	61.5 (17–147)	0.120
CPB duration (min)	96.3 ± 38.7	92 (23–258)	91.0 ± 40.11	84 (23–308)	93.4 ± 37.07	91.5 (29–202)	0.371
Operation duration (min)	257.8 ± 68.61	240 (120–540)	256.3 ± 62.97	240 (120–540)	263 ± 63.08	240 (150–480)	0.545
Erythrocyte transfusion (U)	2.0 ± 1.39	2 (0–1)	1.8 ± 1.35	2 (0–6)	2.1 ± 1.43	2 (0–6)	0.056
Fresh frozen plasma transfusion (U)	2.0 ± 0.92	2 (0–6)	2.1 ± 0.90	2 (0–5)	2.2 ± 0.98	2 (0–10)	0.080
Logistic EuroSCORE	2.6 ± 3.53	1.51 (0.88–37.95)	2.9 ± 3.43	1.96 (0.88–21.30)	2.9 ± 2.61	2.12 (0.88–20.8)	0.002
Standard EuroSCORE	2.3 ± 2.22	2.00 (0.0–12)	2.7 ± 2.33	2.00 (0.0–10)	2.8 ± 1.99	3.00 (0.0–8)	0.005

For logistic EuroSCORE: NRG versus EOG, $p = 0.001$; NRG versus OG, $p = 0.103$; OG versus EOG, $p = 0.116$. For standard EuroSCORE: NRG versus EOG, $p = 0.001$; NRG versus OG, $p = 0.124$; OG versus EOG, $p = 0.157$

Table 3 Early postoperative complications, length of stay at both ICU and hospital, and discharge information

Outcome	NRG = 279		OG = 166		EOG = 192		p value
	n	%	n	%	n	%	
Neurological complication	3	1.1	5	3.0	2	1.0	0.221
Prolonged ventilation	5	1.8	3	1.8	3	1.6	0.978
Renal complication	5	1.8	5	3.0	5	2.6	0.688
Revision for a reason other than bleeding	12	4.3	5	3.0	3	1.6	0.245
Need for intraaortic balloon pump (IABP)	5	1.8	3	1.8	4	2.1	0.971
Perioperative myocardial infarction (MI)	1	0.4	0	0	4	2.1	0.047
Arrhythmia	18	6.5	7	4.2	13	6.8	0.537
Pulmonary complication	9	3.2	8	4.8	17	8.9	0.027
Gastrointestinal complication	2	0.7	4	2.4	6	3.1	0.142
Infective complications	9	3.2	6	3.6	15	7.8	0.052
Multisystem failure	2	0.7	1	0.6	1	0.5	0.964
Pulmonary embolism	1	0.4	0	0	3	1.6	0.131
Tamponade	12	4.3	6	3.6	3	1.6	0.253
Length of stay in ICU (days)							0.748
0–2	246	88.2	152	91.6	175	91.1	
3–10	30	10.8	13	7.8	16	8.3	
>11	3	1.1	1	0.6	1	0.5	
Length of hospital stay (days)							0.282
0–10	206	73.8	123	74.1	127	66.1	
11–30	68	24.4	42	25.3	61	31.8	
>30	5	1.8	1	0.6	4	2.1	
Discharge with morbidity	1	0.4	6	3.6	5	2.6	0.046
30-day mortality	1	0.4	2	1.2	0	0	0.236

postoperative pulmonary complications. Use of waist circumference (WC) and waist-to-hip ratio (WHR), instead of BMI, in the evaluation of the relationship of obesity with pulmonary functions was suggested to be a better predictor in observing effects of intraabdominal pressure on the lung [17, 18]. Although BMI is easy to measure, it is not

Table 4 Crude odds ratio, early postoperative complications, length of stay at both ICU and hospital, and discharge information

Crude odds ratio (OR) univariate analysis	NRG = 279 OR (95 % CI)	OG = 166 OR (95 % CI)	EOG = 192 OR (95 % CI)	*p* value for OG	*p* value for EOG
Neurological complication	1.00 (–)	2.85 (0.67–12.11)	0.96 (0.16–5.85)	0.154	0.972
Prolonged ventilation	1.00 (–)	1.00 (0.23–4.27)	0.87 (0.20–3.68)	0.991	0.850
Renal complication	1.00 (–)	1.70 (0.48–5.96)	1.46 (0.41–5.13)	0.406	0.550
Revision for a reason other than bleeding	1.00 (–)	0.69 (0.23–1.99)	0.35 (0.09–1.26)	0.495	0.111
Need for IABP	1.00 (–)	1.00 (0.23–4.27)	1.16 (0.30–4.39)	0.991	0.821
Perioperative MI	1.00 (–)	3.14 (0.34–28.26)		0.307	
Arrhythmia	1.00 (–)	0.63 (0.26–1.56)	1.05 (0.50–2.20)	0.326	0.891
Pulmonary complication	1.00 (–)	1.51 (0.57–4.01)	2.91 (1.27–6.68)	0.399	0.012
Gastrointestinal complication	1.00 (–)	3.42 (0.61–18.87)	4.46 (0.89–22.37)	0.158	0.069
Infective complications	1.00 (–)	1.12 (0.39–3.21)	2.54 (1.08–5.93)	0.826	0.031
Multisystem failure	1.00 (–)	0.83 (0.07–9.32)	0.725 (0.06–8.05)	0.887	0.794
Pulmonary embolism	1.00 (–)	2.34 (0.24–22.70)		0.461	
Tamponade	1.00 (–)	0.83 (0.30–2.26)	0.35 (0.09–1.26)	0.723	0.111
Length of stay in ICU (days)	1.00 (–)				
0–2 and ≥3	1.00 (–)	0.68 (0.35–1.32)	0.72 (0.39–1.34)	0.262	0.305
Length of hospital stay (days)	1.00 (–)				
0–10 and ≥11	1.00 (–)	0.98 (0.63–1.52)	1.44 (0.96–2.15)	0.952	0.072
Discharge with morbidity	1.00 (–)	10.51 (1.25–88.16)	7.40 (0.85–63.90)	0.030	0.069
30-day mortality	1.00 (–)	1.56 (0.14–17.31)		0.716	

Table 5 Adjusted odds ratio, early postoperative complications, length of stay at both ICU and hospital, and discharge information (age, gender, hypertension, hyperlipidemia, diabetes mellitus, COPD, and smoking status have been adjusted for multiple logistic regression analysis)

Adjusted odds ratio (OR) multivariate analysis	NRG = 279 OR (95 % CI)	OG = 166 OR (95 % CI)	EOG = 192 OR (95 % CI)	*p* values for OG	*p* values for EOG
Outcome					
Neurological complication	1.00	2.56 (0.56–11.65)	0.95 (0.13–6.66)	0.224	0.963
Prolonged ventilation	1.00	0.58 (0.12–2.79)	0.55 (0.10–2.90)	0.498	0.487
Renal complication	1.00	1.08 (0.28–4.08)	0.80 (0.20–3.22)	0.903	0.761
Revision for a reason other than bleeding	1.00	0.71 (0.23–2.17)	0.44 (0.11–1.77)	0.558	0.249
Need for IABP	1.00	0.48 (0.10–2.30)	0.46 (0.10–2.09)	0.362	0.322
Perioperative MI	1.00	0.55 (0.04–7.62)		0.661	
Arrhythmia	1.00	0.55 (0.21–1.41)	0.84 (0.37–1.93)	0.218	0.692
Pulmonary complication	1.00	1.48 (0.54–4.05)	2.79 (1.11–7.02)	0.440	0.029
Gastrointestinal complication	1.00	4.22 (0.73–24.36)	6.12 (1.08–34.58)	0.107	0.040
Infective complications	1.00	0.90 (0.30–2.71)	1.84 (0.71–4.77)	0.859	0.206
Multisystem failure	1.00	0.65 (0.04–9.83)	0.73 (0.04–11.74)	0.762	0.828
Pulmonary embolism	1.00	2.43 (0.21–28.11)		0.210	
Tamponade	1.00	1.02 (0.36–2.89)	0.44 (0.11–1.74)	0.964	0.248
Length of stay in ICU (days)	1.00				
0–2 and ≥3	1.00	0.54 (0.27–1.09)	0.58 (0.29–1.16)	0.088	0.126
Length of hospital stay (days)	1.00				
0–10 and ≥11	1.00	0.85 (0.53–1.35)	1.19 (0.75–1.87)	0.502	0.444
Discharge with morbidity	1.00	14.47 (1.65–126.65)	11.52 (1.19–110.78)	0.016	0.034
30-day mortality	1.00	1.04 (0.08–13.30)		0.975	

sufficient in distinguishing body fat and lean muscle tissue [19–21]. However, BMI is still widely used in studies. Prasad et al. [22] reported a higher rate of respiratory complications, and Ranucci et al. [23] reported an increased number of minor respiratory complications among obese individuals. Similar to other complications, results are conflicting regarding pulmonary complications. Definitions of complications and BMI groupings vary in these studies.

Several studies showed that extremely underweight and extremely overweight patients are risk groups for prolonged ventilation. For example, Engel et al. [24] reported that morbidly obese patients who had experienced prolonged ventilation were older, female, non-Caucasian, and had a history of preoperative COPD. In the present study, we have demonstrated that prolonged ventilation is not correlated with obesity.

In terms of gastrointestinal complications (GIC), adjusted multiple logistic regression analyses presented a significant difference in EOG. Because the confidence interval for this complication was quite wide, it is difficult to verify its incidence rate. In studies concerned with the relationship between obesity and heart surgery, GIC was reported as rare. It was reported that underweight patients are at a higher risk of developing GIC compared to normal patients [25]. It was also reported that BMI increases with increasing GIC [26]. Reflux esophagitis, hiatus hernia, cholecystitis, steatohepatitis, and abdominal compartment syndrome have been reported to be more frequent among obese individuals [27]. Furthermore, although the rate of GIC is 1–2 %, the mortality rate is notably high [28]. It is not surprising to see GIC following heart surgery, considering the negative effects of anesthetics in addition to the negative effects of obesity.

In this study, it was observed that BMI scores were higher among females compared to males. About 50 % of Turkish women are obese, whereas this rate is 25 % among men. Therefore, it is an expected outcome. OG and EOG patients were found to be 55–65 years old, whereas NRG included more patients 45 years old and younger compared to other groups.

In the present study it was observed that occurrence of hypertension, hyperlipidemia, DM, and COPD increased with increasing obesity. Although hypertension, DM, hyperlipidemia, stroke, and coronary artery disease are the five most frequent comorbidities accompanying obesity, many other organ systems are also negatively affected by obesity [15, 29–31]. Comorbidities increase postoperative risk scores for heart surgeries. Both EuroSCORE and Parsonnet scoring systems are more appropriate for mortality estimations but not for morbidity estimations. Although obesity increases the probability of comorbidity occurrence, EuroSCORE does not include BMI among risk factors, but Parsonnet assigns 3 points for BMI score over 35. In the present study, comorbidity rates increasing with BMI increased EuroSCORE levels and a significant difference between EOG and NRG was observed. EuroSCORE values were between 2 and 3, which fall into low- to mid-risk class in terms of clinical mortality risk. We observed no difference between groups in terms of mortality risk.

Although obesity is considered a risk factor for difficult intubation, for several reasons, such as the changes in the anatomy of airway of obese people and limitation in head and neck movement, airway examination for such patients is important. Mallampati scores were found significantly higher in OG and EOG compared to NRG, but there was no failed intubation attempt.

Although previous studies reported obesity as one of the factors decreasing surgical hemorrhage and thus the need for blood transfusion, our study does not support this finding [32–34]. Sun et al. [35] concluded that the lesser need for blood transfusion for extremely obese patients is a result of less use of hemodilution because CPB cycle volumes are relatively stable. Therefore, CPB-related coagulopathy occurs less and postoperative bleeding decreases. In another study, excess mediastinal fat and high intraabdominal pressure-related intrathoracic pressure were reported to lower bleeding in CABG by pressuring on minor bleeding zones [36]. Birkmeyer et al. [37] claimed that the incidence of postoperative mediastinal reexploration is lower in obese patients and highlighted this independent coexistence in a study involving 11,101 consecutive patients. We have not studied chest tube drainage in detail, but we rather focused on tamponade development caused by hemorrhage requiring intervention (percutaneous drainage or surgery). In line with Kuduvalli's study [38], we did not observe any difference between groups in terms of tamponade development and the amount of transfused blood and fresh frozen plasma.

It has been reported in several studies that renal complications occur more frequently among obese individuals [26, 31]. However, because there also exist studies suggesting the opposite, obesity has not been defined as an independent risk factor for renal complications [38, 39]. Wigfield et al. [8] reported high acute renal failure in obese patients, but there was no difference between obese and non-obese individuals in terms of need for dialysis. We have observed that the risk for development of renal complication in obese individuals was not higher compared to non-obese individuals.

It has been reported that postoperative myocardial infarction risk is higher in obese individuals in both noncardiac and cardiac surgery [40, 41]. It has been reported that, for cardiac muscle to satisfy submaximal workload in obese individuals, it needs a higher rate-pressure product

(RPP) and higher oxygen consumption [42]. Dramatic increase of RPP during physical exercise causes cardiac consumption, which triggers angina pectoris and/or malign arrhythmia in the presence of underlying coronary disease [43]. Furthermore, it has been suggested that decreased maximum oxygen uptake as well as decreased aerobic capacity increase cardiovascular and all-cause mortality [44, 45]. In the present study, simple percentage statistical analysis showed a difference between groups in terms of myocardial infarction (MI). However, because there was no MI patient in OG, both OG and EOG were combined and the exclusion criteria given above were applied. As a result, it was observed that obesity alone does not increase myocardial infarction risk, which agrees with the results reported by Kuduvalli et al. [38]. Stamou et al. [46] reported a paradoxic relationship between obesity and cardiac surgery; lower systemic vascular resistance, lower levels of atrial natriuretic peptide, and plasma renin activity attenuate the sympathetic nervous system. Furthermore, adipose tissue releases soluble tumor necrosis factor receptors, and they then neutralize the effects of tumor necrosis factor-α, which are believed to be detrimental to the myocardium. Based on these data, Stamou et al. [46] suggests that obesity may even have positive effects for coronary artery disease.

Infections are among the complications frequently considered with obesity. Results of the crude analysis of our data showed that infection rates in EOG were significantly higher. However, comorbidities, such as diabetes, have a huge impact on the development of infection; therefore, adjusted analysis showed that obesity alone is not a risk factor for infection. In several studies, it is reported that infection is more common among obese individuals because adipose tissue receives less blood flow and recovers slowly. Elahi et al. [47] reported that 14 % of obese patients who underwent CABG were rehospitalized, mainly for infection. After adjusting the comorbidities, some researchers maintained that obesity is an independent risk factor for infection [22, 34, 42], although other studies found no difference in terms of infection [8]. This difference might be because hygiene practices are carefully followed for obese patients, or the result of differences between hygiene control policies among health centers, as well as different prophylaxis applications.

The length of ICU and hospital stays of the obese patients was not different than normal patients. Even though these stays are no longer than those of normal patients, discharge with morbidities in OG and EOG was higher compared to NRG.

To date several studies have investigated the relationship between open heart surgery and postoperative complications, both studies utilizing computer databases including a large number of patient records and those involving detailed statistical analyses. Nevertheless, other than the one regarding that obesity does not increase mortality, no consensus has been reached in terms of the relationship between complications and obesity. Obesity, which is very common among European and U.S. citizens and is widely investigated in this population, is also a public health issue for the Turkish population. Investigation of the outcomes of the same problem in genetically and geographically different populations with different nutritional preferences would be beneficial in efforts against this global plague. Therefore, we think that results of the present cross-sectional study, which investigated the data of 1,000 patient records of a health center where 2,000 open heart surgeries are conducted annually, will be useful in the literature. For a much clearer understanding of the relationship between obesity and heart surgery, WC and WHR, instead of BMI, should be used, definitions of complications should be standardized, and prospective studies involving larger samples should be conducted. Finally, we found that obesity does not increase short-term mortality for open heart surgery; however, it increases the risk of postoperative pulmonary and gastrointestinal complications and discharge with morbidity.

Conflict of interest None.

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