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ORIGINAL ARTICLE

Low Body Mass Index Versus Obesity: Which is Worse During Cardiac Surgery?

ABSTRACT

Objectives: Obesity can cause many diseases and leads to poor prognosis in the course of many diseases. Some researchers report that obesity positively affects cardiac surgery, and they refer to this phenomenon as the "obesity paradox." Although there are many articles in the literature on obesity, there are no detailed studies on low BMI, especially in cardiac surgery. We wonder whether an extremely low body mass index is a risk factor, similar to obesity, in cardiac surgery patients.

Methods: We conducted an analysis of the data from 786 patients who underwent elective isolated coronary artery bypass surgery in the last two years. The patients were categorized into four groups based on their BMI: Low BMI (<18.5 kg/m^2, n=72), Normal BMI (18.5-24.9 kg/m^2, n=228), Overweight BMI (25.0-29.9 kg/m^2, n=321), and Obese BMI (≥30.0 kg/m^2, n=166). Demographic data, co-existing diseases, surgical techniques, cross-clamp times, postoperative bleeding, ICU stay, and extubation times were recorded and compared across the groups. The bleeding index and the transfusion index were calculated and compared.

Results: Although the number of grafts used was the same for all groups, the cross-clamp and total operation times were significantly longer for obese patients. During the postoperative intensive care follow-up, intubation times were also much longer for obese patients. Similarly, the amount of postoperative drainage was statistically significantly higher in obese patients. On the other hand, it was observed that the "bleeding index" was significantly higher in patients with LBMI (p<0.001). When comparing blood products, it was found that fresh frozen plasma and erythrocyte suspension were used in significantly higher numbers in the OBMI group (p<0.001).

Conclusion: Obesity remains an independent risk factor in cardiac surgery. In light of the information obtained in our current study, the bleeding index in patients with low BMI (BMI<18.5 kg/m^2) is much higher than in obese patients. Patients with lower BMI require more blood transfusions than obese patients, indicating that low BMI is also a risk factor in cardiac surgery.

Keywords: Cardiac surgery, low body mass index, obesity

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Obesity can cause many diseases and leads to poor prognosis in the course of many diseases. According to WHO sources, in 2022, one in every eight people in the world was living with obesity. Obesity is known to be an essential risk factor, especially for cardiovascular diseases (1).

While obesity causes diseases that require cardiac surgery, some publications report conflicting results stating that obese patients undergoing cardiac surgery have a better prognosis than normal-weight patients (2,3). Some researchers have concluded that obesity positively affects cardiac surgery and have termed this phenomenon the "obesity paradox" (4,5). On the other hand, some researchers, unlike others, have concluded that obesity is a significant risk factor for cardiac surgery and that there is no obesity paradox (6).

However, a lower-than-normal BMI may also have negative consequences and be an important risk factor in cardiac surgery patients. Although there are many articles in the literature on obesity, there are no detailed studies on low BMI, especially in cardiac surgery. We wonder whether an extremely low body mass index is a risk factor, similar to obesity, in cardiac surgery patients. For this purpose, we aimed to investigate whether the obesity paradox exists in cardiac surgery or whether low BMI is a risk factor, and to elucidate the possible reasons.

Table 1. Demographic data of the patients

	Low BMI (n=72)	Normal BMI (n=228)	Overweigth BMI (n=321)	Obese BMI (n=166)	r value
Age	63.01 (±12.1)	63.37 (±10.9)	61.84 (±10.4)	62.14 (±11.1)	0.333
F/M	27/45	92/135	126/195	74/92	0.665
BMI	18.03 (±0.49)	23.47 (±0.89)	27.36 (±1.27)	33.26 (±2.47)	N.A.
Diabetes	18 (25.0%)	53 (23.2%)	100 (31.2%)	59 (35.5%)	0.039
COPD	22 (30.5%)	42 (18.4%)	67 (20.9%)	60 (36.1%)	<0.001
PAD	11 (15.3%)	21 (9.2%)	22 (6.9%)	24 (14.5%)	0.022
Renal disease					
Smoking	25 (34.7%)	102 (44.7%)	139 (43.3%)	59 (35.7%)	0.158
Hypertension	34 (42.7%)	103 (45.2%)	136 (42.4)	78 (44.6%)	0.738
LVEF	45.70 (±9.2)	45.78 (±9.1)	46.10 (±9.4)	46.24 (±9.3)	0.948

COPD: Chronic obstructive pulmonary disease; PAD: Peripheral artery disease; LVEF: Left ventricular ejection fraction. N.A.: Not applicable.

PATIENTS AND METHODS

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Etlik City Hospital. We retrospectively examined the data of 786 patients who underwent elective isolated coronary artery bypass surgery in our clinic in the last two years. Patients who underwent different surgical interventions, such as ascending aortic and heart valve surgery, were excluded from this study to explore a more isolated patient group. Patients who were receiving dual antiplatelet therapy in the last five days before the surgery and patients who were loaded with these medications due to the diagnosis of acute coronary syndrome were also excluded from the study because they may affect the results regarding bleeding. Patients included in the study within these criteria were divided into four groups according to their body mass index (BMI). Those with BMI<18.5 kg/m^2 were considered as the low BMI group (LBMI, n=72), those with 18.5 kg/m^2≤BMI<24.9 kg/m^2 were considered as the normal BMI group (NBMI, n=228), those with 25.0 kg/m^2≤BMI<29.9 kg/m^2 were considered as the overweight BMI group (OWBMI, n=321), and those with 30.0 kg/m^2≤BMI were considered as the obese BMI group (OBMI, n=166). The preoperative demographic data of the patients are shown in Table 1. Operative and postoperative data are given in Table 2. Demographic data, co-existing diseases, surgical techniques, cross-clamp times, postoperative bleeding, ICU stay, and extubation times were recorded and compared across the groups. One of the critical calculations involved dividing the amount of bleeding by BMI to determine "the bleeding index." Additionally, the blood products administered to patients due to bleeding were recorded, and "the transfusion index" was determined by dividing the average number of erythrocyte suspensions given by BMI.

Statistical Analysis

Categorical data were shown as percentages and continuous data were provided as mean±SD. A $\chi 2$ test was used to test categorical variables. The allocation of the variables was normal. Variables were compared using one-way ANOVA and a Tukey HSD test as a post hoc test. A ρ-value less than 0.05 was considered statistically significant. The Bonferroni correction was applied for multiple comparisons. Data analysis was performed using the SPSS (version 27.0.1.0; SPSS Inc, Chicago, IL) statistical package for Mac.

RESULTS

This study included 786 patients; the patients' demographic data are shown in Table 1. No statistically significant difference was observed between the groups regarding age and gender. While diabetes mellitus (DM) and chronic obstructive pulmonary disease (COPD) were observed to be statistically significantly higher in obese patients (p=0.039 and p<0.001, respectively), peripheral artery disease was significantly higher in the low BMI group (p=0.022). Left ventricle ejection fraction, smoking, and hypertension results were similar in the four groups. There were also significant differences between operative and postoperative data. Off-pump surgery rates in all groups were between 14.5-18.7%, and there was no statistically significant difference in terms of surgical techniques applied between the groups (Table 2). Although there was no difference in the number of grafts used for all groups, cross-clamp and total operation times were significantly longer in obese patients. During postoperative intensive care follow-up, intubation times were significantly longer in obese patients (Table 2). Similarly, the amount of postoperative drainage was much higher in obese patients (p<0.001). The amount of drainage was calculated to be statistically significantly higher in obese patients. Conversely, it was observed that the "bleeding index" obtained by dividing the bleeding amount by BMI was statistically significantly higher in patients with LBMI. When the blood products were compared, it was observed that fresh frozen plasma and erythrocyte suspension were used in significantly higher numbers in the OBMI group (p<0.001). Finally, when the mortality rates were evaluated, it was observed that there was no statistically significant difference in the comparison of the four groups.

DISCUSSION

Whether obesity is a risk factor for cardiac surgery has been the subject of many studies for years. While at first glance, the operative and postoperative data of obese patients were expected to be poor, many studies conducted on obese patients showed that the results were much better, and they termed this phenomenon "the obesity paradox" (4). After the emergence of this idea, many articles were written on this subject, and it was reported in these articles that such a paradox did not exist and that the results were worse

Table 2. Operative and postoperative findings of the patients.

	Low BMI (n=72)	Normal BMI (n=228)	Overweigth BMI (n=321)	Obese BMI (n=166)	r value
Off-pump	12 (16.7%)	33 (14.5%)	65 (20.2%)	31 (18.7%)	0.327
Operation time (min)	107.5 (±14.2)	117.4 (±11.2)	119.2 (±10.5)	123.5 (±10.7)	<0.001
X-clamp time (min)	30.4 n=60 (±5.4)	30.0 n=197 (±6.1)	31.0 n=256 (±5.9)	32.5 n=136 (±6.2)	0.021
CPB time (min)	55.2 (±8.7)	54.5 (±9.6)	56.8 (±9.6)	57.1 (±8.9)	0.505
Number of grafts	3.3 (±0.8)	3.4 (±0.8)	3.3 (±0.9)	3.4 (±0.7)	0.200
Duration of intubation (h)	6.1 (±1.3)	6.9 (±1.0)	7.1 (±1.1)	8.5 (±2.1)	<0.001
Total drainage (ml)	493 (±100.4)	491 (±128.4)	521 (±134.5)	611 (±144.8)	<0.001
Drainage/BMI (Bleeding index)	23.6 (±4.9)	19.8 (±5.4)	18.1 (±5.2)	15.08 (±4.7)	<0.001
Need for inotropic agent	16 (22.2%)	46 (20.2%)	66 (20.6%)	58 (34.6%)	0.002
IABP	4 (5.6%)	5 (2.2%)	7 (3.0%)	5 3.0%)	0.425
Transfused blood products					
• FFP	0.50 (±0.5)	0.56 (±0.5)	0.78 (±0.6)	0.89 (±0.7)	<0.001
• ES	1.87 (±0.6)	2.04 (±0.6)	2.67 (±0.7)	2.89 (±0.7)	<0.001
ES/BMI (transfusion index)	0.103	0.086	0.097	0.086	<0.001
Surgical revision	1 (1.4%)	2 (0.9%)	3 (0.9%)	3 (1.8%)	0.818
ICU stay	1.9 (±0.5)	2.0 (±0.5)	1.9 (±0.6)	2.2 (±0.7)	<0.001
Hospital	5 (±1.1)	5.1 (±0.9)	5.2 (±1.1)	5.9 (±1.2)	<0.001
In hospital mortality	1 (1.4%)	0 (0%)	5 (1.6%)	2 (1.2%)	0.332

CPB: Cardiopulmonary bypass, IABP: Intra-aortic balloon pump, FFP: Fresh frozen plasma, ES: Erythrocyte suspension, ICU: Intensive care unit.

in obese patients (7,8). While the issue of obesity has been examined many times in scientific research, the situation of patients with lower-than-normal BMI has been somewhat overlooked, especially in cardiac surgery. In this study, we examined the consequences of low BMI, as well as obesity, in terms of patient outcomes in a more limited group of patients who underwent isolated coronary bypass surgery. In a recent UK-wide meta-analysis, it was observed that overweight and obese patients had less in-hospital mortality than normal-weight patients (4). In the same study, it was also observed that mortality was higher in underweight patients than in normal-weight patients. If we look at the results of this research from another perspective, it means that having a normal BMI is a risk factor for heart surgery.

Although the number of grafts was similar in our study, cross-clamp and operation times were significantly longer in the obese patient group (Table 2). We can explain this as technical difficulties due to the excess fatty tissue in both the myocardial and mediastinal regions. In obese patients, due to the excess of environmental fat tissues, there may be a partial slowdown at every stage, from sternotomy to bleeding control at the end of the surgery.

One of the most interesting issues in our research was the results regarding the amount of postoperative bleeding. As obesity increased, the amount of bleeding increased statistically significantly. On the other hand, when we adjusted the total bleeding amount to BMI, we calculated a kind of "bleeding index." We found the bleeding index was highest in patients with low BMI (23.6±4.9 ml/BMI in LBMI vs. 15.08±4.7 ml/BMI in OBMI, p<0.001). Thanks to this calculation, it was observed that patients with low BMI had much higher bleeding rates than obese patients. The first question that comes to mind when we access bleeding index data is whether there was a statistical difference in blood transfusions between patient groups. According to the bleeding index, it was expected that OBMI patients would need less blood transfusion than LBMI patients. However, the result was the opposite: While OBMI patients were transfused an average of 2.89 units of erythrocyte suspension, it was calculated that 1.87 units of erythrocyte suspension were transfused to LBMI patients (p<0.001).

Similarly, we calculated "the transfusion index" by proportioning the amount of transfused ES to BMI. This rate was higher in the LBMI patient group than in OBMI patients (0.103 ES/BMI and 0.086 ES/BMI, respectively, p<0.001). The conclusion we reached after all these calculations is that LBMI patients are exposed to more bleeding and require more blood product transfusion.

Although Stamou et al. (5) stated that the results were better in obese patients, it is noteworthy that the obese patients in their study were younger than the other patients. In a recently published article, Wu et al. (7) reported that in patients who underwent robotic cardiac surgery, the intensive care period was prolonged, and postoperative kidney damage was higher in the obese patient group. Thus, they concluded that the obesity paradox did not exist. In our study, similar to the results of Wu et al. (7), the duration of intubation, ICU stay, and hospital stay in the OBMI patient group was significantly longer than that of all other groups. Apart from all these, postoperative surgical revision and even mortality rates were similar in all groups.

While discussions about the obesity paradox continue, Samuels et al. (9) reported their concerns about giving the wrong message to the public that obesity provides better results in terms of heart health.

It has been shown that obesity, especially severe obesity, increases cardiovascular, diabetic, cancer, and stroke risks and shortens life expectancy. While most publications investigate whether obesity is a risk factor for cardiac surgery, the issue of whether low BMI is also a risk factor has been somewhat neglected. In a recent study, Shi et al. (10) examined kidney damage in cardiac surgery and reported that low BMI was an important risk factor as high BMI. Reis et al. (11) also reported that low BMI was a risk factor according to early results after cardiac surgery. van Venrooij et al. (12) showed that patients with low BMI had more frequent lung infections in the postoperative period and that mortality was much higher in this patient group.

CONCLUSION

There are ongoing debates in the literature about whether there is an obesity paradox. However, recent publications indicate no such paradox and that obesity is still an important and independent risk factor in cardiac surgery. On the other hand, in light of the information we obtained in our current study, the bleeding index obtained by dividing the amount of bleeding by BMI in patients with low BMI (BMI<18.5 kg/m^2) is much higher than in obese patients. Patients with lower BMI require more blood transfusions than obese patients, indicating that low BMI is also a risk factor. Prospective randomized studies are needed to better elucidate this situation.

Ethics Committee Approval: This study was conducted with the permission of the Ankara Etlik City Hospital Local Ethics Committee (decision no: AEŞH-BADEK-2024-300, date: 03.04.2024).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

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