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The impact of body mass index on intraoperative and postoperative blood transfusion amounts in coronary artery bypass surgery

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ABSTRACT

Aims: The relationship between obesity, bleeding volume, and transfusion requirements during and after coronary artery bypass surgery remains unclear. This study aimed to investigate the impact of body-mass index (BMI) on the amount of intraoperative and postoperative blood transfusions in patients undergoing coronary artery bypass grafting (CABG).

Methods: This retrospective study included 288 patients who underwent isolated cardiopulmonary bypass for CABG between 2011 and 2017. Patients were stratified into five BMI categories: underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), and obese (30.0 kg /m2 ≤ BMI <35.0 kg/m2), and morbid obese (BMI ≥35.0 kg/m^2). Demographic data, pump times, cross-clamp times, and the amounts of intraoperative and postoperative blood transfusions were retrospectively collected.

Results: Among the patients, obese and morbidly obese individuals comprised 38.2% of the cohort, while underweight patients accounted for only 1.0%. The number of bypassed vessels and mean cross-clamp times did not significantly differ between the BMI groups. The mean amount of blood transfused during surgery ranged from 1.66 to 3.43 units, with the highest amounts observed in the morbidly obese group. However, no significant differences were found in the amount of blood transfused postoperatively between the BMI groups.

Conclusion: Patients at the extremes of the BMI spectrum, specifically morbidly obese individuals, required higher amounts of blood transfusions intraoperatively compared to other groups. In contrast, postoperative transfusion amounts were comparable across all BMI categories. These findings underscore the importance of tailoring perioperative management strategies based on BMI levels to optimize patient outcomes.

Keywords: Blood transfusion, coronary artery bypass grafting, body mass index, obesity, intraoperative bleeding

INTRODUCTION

Obesity, a global public health challenge, is a major risk factor for cardiovascular diseases and is associated with adverse cardiovascular events in patients undergoing coronary artery bypass grafting (CABG).[1-3] Concurrently, obesity may also act as a protective factor in cardiac surgery.[4,5] Some studies have highlighted that underweight patients experience an increased risk of mortality and complications following CABG.[6-8] It has been reported that obesity, compared to a normal body-mass index (BMI), does not significantly elevate the risk of perioperative mortality or adverse outcomes in CABG patients.[9,10] Hence, the concept of the "obesity paradox" in cardiac surgery continues to be an increasingly intriguing subject of interest.[11,12]

Obese patients undergoing cardiac surgery often face a heightened risk of complications due to associated conditions, including a prothrombotic state and impaired microvascular function.[12] These situations can also lead to an increased use of blood products, which contributes to the occurrence of adverse events during the intraoperative and postoperative periods.[13,14] Conversely, some evidence suggests that perioperative bleeding and the need for blood transfusions may be reduced in obese patients undergoing CABG.[15,16] This reduction is hypothesized to result from the production of plasminogen activator inhibitor-1 (PAI-1) by adipocytes, which modulates the coagulation process.[17] Considering these findings, which are consistent with the obesity paradox, there is a need for further research on the impact of BMI on the use of blood products in patients undergoing CABG.

This study aimed to investigate the impact of BMI on the amount of intraoperative and postoperative blood transfusions in patients undergoing CABG.

METHODS

This retrospective study was conducted on patients who underwent CABG at the Cardiovascular Surgery Department of Çanakkale Onsekiz Mart University's Faculty of Medicine, between 2011 and 2016. The study was approved by the Çanakkale Onsekiz Mart University Ethics Committee (Date: 11.01.2018, Decision No: 02/1). The study was carried out in accordance with relevant ethical guidelines, including the principles outlined in the Declaration of Helsinki (2013 Brazil revision).

A total of 288 patients who underwent CABG were included in the study. Patients under the age of 18, those with a previous history of CABG, those with anemia, chronic liver disease, peripheral vascular disease, chronic kidney failure, those with history of bleeding, patients received antiaggregant within 5 days before the operation were excluded from the study.

The demographic and clinical data of the patients was retrospectively collected from patient files or the hospital's electronic information system. Patients were divided into five groups according to their BMI: underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), and obese (30 kg /m^2 ≤ BMI <35 kg/m^2), and morbid obese (BMI ≥35 kg/m^2).[18]

Statistical Analysis

All data were analyzed using IBM SPSS Statistics for Windows 20.0 (IBM Corp., Armonk, NY, USA). Numerical variables with a normal distribution, as determined by Kolmogorov-Smirnov tests, are presented as mean ± standard deviation, while non-normally distributed variables are expressed as median (min–max). Intergroup comparisons were performed using the Kruskal-Wallis H test, followed by Dunn's post hoc test for pairwise comparisons. Categorical variables are reported as frequencies and percentages, with comparisons between groups conducted using the Chi-square test or Fisher's exact test, as appropriate. A P-value of <0.05 (*) was considered statistically significant for all analyses.

RESULTS

The study population consisted of a total of 288 patients, including 208 male (72.2%) and 80 female (27.8%). The mean age of the patients was 62.9±9.6 years (range=37-87 years) and the mean BMI was 27.9±4.3 kg/m^2 (range=17.0–43.4 kg/m^2). When patients were classified according to their BMI levels, 1.0% were categorized as underweight (n=3), 27.4% as normal weight (n=79), 33.3% as overweight (n=96), 32.6% as obese (n=93), and 5.6% as morbid obese (n=16). In the entire population, the mean clamp time was 81.6±27.1 minutes (range=11-197 minutes), the median number of bypassed vessels was 2.9±0.8 (range=1-8 vessels), the median count of blood units used during surgery was 2 (range=0–13 units), and the median count of blood units used after surgery was 2.5 (range=0–13 units) (**Table 1**).

The demographic and clinical characteristics of the groups classified according to BMI levels are presented in **Table 2**. The underweight group was excluded from the statistical analyses due to the limited sample size. Accordingly, the mean age was lower in the morbid obese group compared to other groups (Normal weight: 65.1±9.5 vs. Overweight: 63.3±9.8 vs. Obese: 62.2±9.7 vs. Morbid obese: 57.0±8.5, p=0.013), while the ratio of female was higher (Normal weight: 19.0% vs. Overweight: 22.9% vs. Obese: 36.2% vs. Morbid obese: 57.2%, p = 0.005). The mean clamp time and the median number of bypassed vessels were found to be similar across the groups (p>0.05). The median perioperative number of blood units was higher in the morbid obese group compared to other groups (Normal weight: 2 vs. Overweight: 1.5 vs. Obese: 2 vs. Morbid obese: 3, p=0.012), while the median postoperative number of blood units did not show a significant difference among the groups (Normal weight: 2.5 vs. Overweight: 2 vs. Obese: 2.5 vs. Morbid obese: 3, p=0.116) (**Table 2**).

Table 1. Demographic and clinical characteristics of patients

Variables	All population n=288
Age, years	62.9±9.6
Gender, n (%)	
Female	208 (72.2)
Male	80 (27.8)
BMI, kg/m^2	27.9±4.3
Underweight	3 (1.0)
Normal weight	79 (27.4)
Overweight	96 (33.3)
Morbid obese	16 (5.6)
Clamp time, minute	81.6±27.1
Number of bypassed vessels	2.9±0.8
Count of blood units	
Perioperative	2.0 (0-13)
Postoperative	2.5 (0-13)

Numerical variables were shown as mean±standard deviation or median (min-max). Categorical variables were shown as numbers (%). BMI: Body-mass index

DISCUSSION

To the best of our knowledge, this study is among the few that evaluate perioperative and postoperative blood product utilization across different BMI categories, including morbidly obese individuals. The study's findings indicated that, although cross-clamp times and the number of bypassed vessels were similar across BMI groups, the number of perioperative blood units required was higher in the morbidly obese group. However, postoperative blood unit usage did not significantly differ between the groups.

Our study demonstrated an increased requirement for intraoperative blood transfusion in the morbidly obese group compared to other groups. This finding aligns with previous findings from Engelman et al.[19] who demonstrated that a low BMI (<20 kg/m^2) is associated with higher complication rates, including bleeding, in cardiac surgeries. The elevated intraoperative transfusion requirement observed in the morbidly obese group is consistent with studies suggesting that increased blood loss in obese patients is linked to prolonged operative times and greater surgical complexity.[20,21] Interestingly, postoperative transfusion needs did not differ significantly across BMI groups, suggesting that the perioperative hemodynamic instability seen in obese patients is more critical during surgery than in the recovery phase.

Our findings are consistent with several large cohort studies. For instance, Birkmeyer et al.[22] reported an increased need for re-exploration due to bleeding in obese patients undergoing CABG. Similarly, Potapov et al.[23] found that underweight patients had higher complication rates, including re-exploration for bleeding. In our cohort, although the underweight group

Table 2. Demographic and clinical characteristics of patients according to BMI classification

Variables	Underweight n=3	Normal weight n=79	Overweight n=96	Obese n=94	Morbid obese n=16	p-value
Age, years	62.7±8.1	65.1±9.5	63.3±9.8	62.2±9.7	**57.0±8.5**	0.013*
Gender, n (%)						
Male	3 (100)	64 (81.0)	74 (77.1)	60 (63.8)	7 (43.8)	0.005*
Female	0	15 (19.0)	22 (22.9)	34 (36.2)	9 (57.2)	
Height, cm	175.0±2.6	166.8±7.6	165.5±8.2	163.2±8.4	162.6±8.5	0.075
Weight, kg	55.3±1.2	**64.7±7.3**	**74.0±7.7**	**83.7±9.3**	**99.4±12.7**	<0.001*
Clamp time, minutes	88.7±26.8	77.6±26.1	79.2±27.2	84.6±30.4	77.1±27.2	0.550
Number of bypassed vessel	2 (2 - 3)	2.5 (1 - 4)	3 (1 - 6)	3 (1 - 8)	2.5 (1 - 4)	0.315
Number of blood unit						
Perioperative	2.5 (2 - 3)	2.0 (0 - 6)	1.5 (0 - 10)	2.0 (0 - 13)	**3.0 (0 - 9)**	0.012*
Postoperative	6 (3 - 10)	2.5 (0 - 12)	2.0 (0 - 15)	2.5 (0 - 28)	3.0 (0 - 12)	0.116

Numerical variables were shown as mean±standard deviation or median (min-max). Categorical variables were shown as numbers (%). The underweight group was excluded from the statistical analyses due to the limited sample size. BMI: Body-mass index

was excluded from statistical analysis due to small sample size, the observed trend of increased blood transfusion in low-BMI patients is notable and echoes concerns raised in prior research. Contrary to expectations, we did not observe a significant difference in postoperative blood transfusion requirements across BMI groups. This result contrasts with some studies that have linked obesity to prolonged mechanical ventilation and greater postoperative morbidity.[3,24-26] Our findings suggest that while BMI influences intraoperative blood management, it may not significantly affect postoperative transfusion requirements, potentially due to standardized postoperative care and hemodynamic management protocols.

The increased intraoperative blood transfusion in the morbidly obese group may be attributed to several factors. Obese patients often present with greater surgical challenges due to increased adipose tissue, which can complicate both dissection and homeostasis. Furthermore, the larger body surface area in these patients necessitates greater perfusion, which may increase blood loss during surgery. The observed trend towards increased intraoperative blood transfusion needs in underweight patients aligns with previous studies suggesting heightened perioperative risks in this population. Engelman et al.[19] similarly identified that low BMI was an independent predictor of increased mortality and complications, including bleeding, in cardiac surgery. For underweight patients, the higher transfusion requirements may be linked to frailty, malnutrition, and low baseline hemoglobin levels, all of which can predispose them to hemodynamic instability and increased bleeding. However, due to the small sample size, further research with larger cohorts is needed to confirm these findings.

From a clinical perspective, these findings underscore the importance of preoperative risk stratification and blood management protocols tailored to patients' BMI. Intraoperative strategies to minimize blood loss, such as optimizing coagulation status and utilizing blood-sparing techniques, should be prioritized, particularly in patients at both extremes of the BMI spectrum. The absence of significant differences in postoperative transfusion rates suggests that existing protocols for managing postoperative anemia and bleeding are effective across BMI categories. However, the higher intraoperative transfusion needs in morbidly obese and underweight patients call for heightened vigilance during surgery, with potential adjustments in blood management strategies for these groups.

Limitations

This study has several important limitations. First, the retrospective design and single-center nature of the study may limit the generalizability of the findings. Second, the BMI groups were not matched in terms of sample size, age, or gender, which could introduce potential confounding factors that were not fully accounted for. As noted in the findings section, the underweight BMI group was excluded from statistical analyses due to its small sample size. Our data indicate a trend toward an increased need for intraoperative blood transfusion in this group; however, the sample size was insufficient to draw statistically significant conclusions. Future studies with larger sample sizes are needed to better evaluate this relationship. Additionally, further investigation into the mechanisms underlying the increased intraoperative blood loss in obese patients may aid in the development of targeted interventions to reduce transfusion requirements.

CONCLUSION

Our study underscores a significant association between BMI and intraoperative blood transfusion requirements in patients undergoing CABG surgery. Patients at the extremes of the BMI spectrum, specifically morbidly obese individuals, required higher amounts of blood transfusions intraoperatively compared to other groups. In contrast, postoperative transfusion amounts were comparable across all BMI categories. These findings underscore the importance of tailoring perioperative management strategies based on BMI levels to optimize patient outcomes.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was approved by the Çanakkale Onsekiz Mart University Ethics Committee (Date: 11.01.2018, Decision No: 02/1).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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