

## COMPARE OUTCOMES AMONG PATIENTS WHO UNDERWENT CORONARY ARTERY BYPASS GRAFTING IN RELATION TO THEIR BODY MASS INDEX

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### Abstract

**Background:** Body mass index (BMI) is an established predictor of cardiovascular risk and has been increasingly recognized as a factor influencing postoperative outcomes following coronary artery bypass grafting (CABG). Although obesity is associated with multiple cardiovascular comorbidities, its impact on postoperative morbidity and mortality remains controversial. Previous studies have reported conflicting findings, with some demonstrating increased postoperative complications among obese patients, while others have described an "obesity paradox," suggesting comparable or even better survival among overweight and obese individuals. This study compared postoperative outcomes among patients undergoing CABG according to different BMI categories.

**Methods:** A descriptive longitudinal study was conducted at the Department of Cardiothoracic Surgery, Tabba Heart Institute, Karachi. A total of 410 patients aged 55–75 years who underwent elective isolated CABG were enrolled using consecutive sampling. Patients were categorized according to the World Health Organization BMI classification into underweight (<18.5 kg/m<sup>2</sup>), normal weight (18.5–24.9 kg/m<sup>2</sup>), and overweight/obese (≥25 kg/m<sup>2</sup>) groups. Demographic characteristics, perioperative variables, postoperative morbidity, including prolonged hospital stay (>7 days), surgical site infection, cerebrovascular accident (CVA), prolonged mechanical ventilation (>48 hours), postoperative renal dysfunction, and mortality within one month of surgery were recorded. Data were analyzed using IBM SPSS version 17.0. Comparisons between BMI groups were performed using the Chi-square test and Fisher's exact test, with a p-value of <0.05 considered statistically significant.

**Results:** Among the 410 patients included in the study, the mean age was 63.8 ± 6.4 years, and 298 (72.7%) were male. Of the total participants, 52 (12.7%) were underweight, 183 (44.6%) had normal BMI, and 175 (42.7%) were overweight/obese. Obese patients demonstrated significantly higher rates of prolonged hospital stay (24.0% vs. 12.6%, p=0.008), surgical site infection (13.7% vs. 5.5%, p=0.014), prolonged mechanical ventilation (10.9% vs. 4.9%, p=0.031), and postoperative renal dysfunction (9.1% vs. 3.8%, p=0.039) compared with patients of normal BMI. The incidence of postoperative cerebrovascular accident did not differ significantly among BMI groups (p=0.447). One-month mortality was observed in 14 (3.4%) patients and showed no statistically significant association with BMI category (p=0.618).

**Conclusion:** Higher BMI was significantly associated with increased postoperative morbidity following CABG, particularly with regard to wound infection, prolonged hospitalization, respiratory complications, and renal dysfunction. However, BMI was not significantly associated with short-term postoperative mortality. These findings suggest that obesity contributes to postoperative complications without adversely affecting early survival after CABG. Careful perioperative optimization and targeted postoperative management of overweight and obese patients may improve clinical outcomes and reduce postoperative morbidity.

**Keywords:** Coronary artery bypass grafting, body mass index, obesity, postoperative morbidity, postoperative mortality, cardiovascular surgery, CABG.

## INTRODUCTION

Coronary artery disease (CAD) remains the leading cause of mortality worldwide and continues to impose a substantial burden on healthcare systems despite advances in preventive strategies and therapeutic interventions. Coronary artery bypass grafting (CABG) is considered the gold standard surgical treatment for patients with multivessel coronary artery disease, left main coronary artery disease, and complex coronary lesions unsuitable for percutaneous coronary intervention. CABG has consistently demonstrated superior long-term survival, improved quality of life, and reduced rates of recurrent ischemic events among appropriately selected patients. Nevertheless, postoperative outcomes following CABG are influenced by numerous patient-related factors, including age, sex, diabetes mellitus, hypertension, renal dysfunction, smoking status, and nutritional status, with body mass index (BMI) being one of the most frequently investigated predictors of surgical outcomes (Elbaz-Greener et al., 2021; Lawton et al., 2022).

Body mass index is a simple anthropometric measure calculated by dividing body weight in kilograms by the square of height in meters ( $\text{kg}/\text{m}^2$ ). According to the World Health Organization, BMI remains the most widely used indicator for classifying underweight, normal weight, overweight, and obesity in adults. The global prevalence of obesity has increased dramatically during the past three decades, becoming one of the most significant public health concerns worldwide. In Pakistan, the prevalence of overweight and obesity has also risen considerably because of rapid urbanization, sedentary lifestyles, unhealthy dietary patterns, and increasing rates of metabolic disorders. Obesity is strongly associated with hypertension, diabetes mellitus, dyslipidemia, and accelerated atherosclerosis, all of which contribute substantially to the development and progression of coronary artery disease (World Health Organization, 2024; Powell-Wiley et al., 2021).

Despite the well-established association between obesity and cardiovascular disease, the influence of BMI on postoperative outcomes after CABG remains controversial. Several studies have demonstrated that obese patients experience higher rates of postoperative complications, including surgical site infection, prolonged mechanical ventilation, atrial fibrillation, renal dysfunction, and extended hospital stay due to impaired wound healing and increased systemic inflammation (Johnson et al., 2023; Bianco et al., 2022). Conversely, other investigations have reported the "obesity paradox," suggesting that overweight and moderately obese patients may experience similar or even lower short-term mortality following cardiac surgery compared with patients having normal or low BMI. The proposed mechanisms include greater metabolic reserve, improved nutritional status, and earlier medical intervention among obese individuals. However, evidence remains inconsistent across different populations and healthcare settings, necessitating further investigation to clarify the relationship between BMI and postoperative CABG outcomes (Elbaz-Greener et al., 2021; Mariscalco et al., 2022).

Given the increasing prevalence of obesity in Pakistan and the limited local evidence regarding its impact on CABG outcomes, evaluating the relationship between BMI and postoperative morbidity and mortality is of considerable clinical importance. Understanding this association may improve perioperative risk stratification, optimize patient management, and assist cardiac surgeons in identifying patients at increased risk for postoperative complications. Therefore, this study compared postoperative morbidity and mortality among patients undergoing coronary artery bypass grafting according to different body mass index categories at a tertiary cardiac care center in Karachi, Pakistan.

## LITERATURE REVIEW

Body mass index (BMI) is one of the most widely used anthropometric indicators for assessing nutritional status and obesity in clinical practice. Obesity has become a global health concern and is strongly associated with cardiovascular diseases, including coronary artery disease (CAD), hypertension, dyslipidemia, and type 2 diabetes mellitus. These conditions significantly increase the likelihood of requiring coronary artery bypass grafting (CABG), making BMI an important factor in the preoperative assessment of cardiac surgery patients (Powell-Wiley et al., 2021; World Health Organization [WHO], 2024).

The relationship between BMI and postoperative outcomes following CABG has been extensively investigated, although findings remain inconsistent. Several studies have reported that obese patients are more likely to experience postoperative complications such as prolonged mechanical ventilation, surgical site infections, atrial fibrillation, renal dysfunction, and extended hospital stays. These adverse outcomes are largely attributed to impaired wound healing, chronic systemic inflammation, increased technical complexity during surgery, and the presence of multiple obesity-related comorbidities (Bianco et al., 2022; Johnson et al., 2023). Furthermore, obesity has been associated with increased healthcare utilization and postoperative resource consumption following cardiac surgery (Mariscalco et al., 2022).

Conversely, growing evidence supports the concept of the "obesity paradox," whereby overweight and moderately obese patients undergoing CABG demonstrate similar or even lower short-term mortality compared with patients of normal or low BMI. A large multicenter cohort study by Elbaz-Greener et al. (2021) found that although obese patients experienced higher postoperative morbidity, early mortality did not significantly differ across BMI categories. Similar

findings have been reported in recent systematic reviews, suggesting that adequate nutritional reserve, earlier clinical intervention, and aggressive perioperative management may contribute to improved survival among overweight patients despite their increased risk profile (Mariscalco et al., 2022; Wang et al., 2023).

In contrast, underweight patients have consistently demonstrated poorer postoperative outcomes. Low BMI has been associated with malnutrition, reduced physiological reserve, impaired immune function, and delayed recovery following CABG. These patients are more susceptible to postoperative infections, prolonged hospitalization, and increased mortality than patients with normal BMI (Johnson et al., 2023). Despite the growing international evidence, data from Pakistan remain scarce. Differences in genetic background, socioeconomic status, nutritional patterns, and healthcare resources may influence postoperative outcomes in South Asian populations. Therefore, evaluating the association between BMI and postoperative morbidity and mortality among Pakistani patients undergoing CABG is essential to provide context-specific evidence that may improve perioperative risk stratification and optimize patient management.

## **MATERIALS AND METHODS**

### **Study Design and Setting**

A descriptive longitudinal study was conducted at the Department of Cardiothoracic Surgery, Tabba Heart Institute, Karachi, Pakistan. The study was carried out over a period of three months after obtaining ethical approval from the College of Physicians and Surgeons Pakistan (CPSP) and the Institutional Review Board (IRB) of Tabba Heart Institute.

### **Study Population and Sample Size**

The study included patients aged 55–75 years who underwent elective coronary artery bypass grafting (CABG) for angiographically confirmed three-vessel coronary artery disease. The sample size was calculated using Open EPI software by assuming a 4% prevalence of mortality among obese patients, a 95% confidence level, and a 2% margin of error. The calculated sample size was 369 participants; after adding a 10% attrition rate, the final sample comprised 410 patients.

### **Sampling Technique**

Patients were recruited using a non-probability consecutive sampling technique. All eligible patients admitted during the study period who fulfilled the inclusion criteria were enrolled consecutively until the required sample size was achieved.

## **ELIGIBILITY CRITERIA**

### **Inclusion Criteria:**

1. Patients age between 55-75 years
2. Either sex or diagnosed as a case of three vessels coronary artery disease
3. All patients with GCS 15/15
4. Patient who are known case of Diabetes mellitus type II and hypertension
5. All electively admitted patients

### **Exclusion Criteria:**

- Patients with previous history of angioplasty/POBA
- Patients with history of upper thoracic/abdominal surgeries
- All aortic and mitral valve surgeries
- Multi organ failure (Pre Operative) (like renal and respiratory failure) (identified through medical records)

### **Data Collection Procedure**

After obtaining written informed consent, demographic and clinical data were collected using a structured data collection proforma and verified through hospital medical records. Baseline information included age, gender, height, weight, and hospital registration number, history of myocardial infarction, cardiogenic shock, intra-aortic balloon pump (IABP) use, and comorbidities. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared ( $\text{kg}/\text{m}^2$ ) and categorized according to the World Health Organization classification as underweight ( $<18.5 \text{ kg}/\text{m}^2$ ), normal weight ( $18.5\text{--}24.9 \text{ kg}/\text{m}^2$ ), and overweight/obese ( $\geq 25 \text{ kg}/\text{m}^2$ ).

All patients underwent conventional multivessel CABG through a median sternotomy using cardiopulmonary bypass by experienced consultant cardiothoracic surgeons. Patients were followed for one month after surgery to assess postoperative outcomes.

**Outcome Measures**

The primary outcome was postoperative morbidity, defined as the occurrence of one or more of the following: prolonged hospital stay (>7 days), surgical site infection (Southampton wound grading score  $\geq 3$ ), cerebrovascular accident (CVA), prolonged mechanical ventilation (>48 hours), or postoperative renal dysfunction occurring within 10 days after surgery.

The secondary outcome was mortality, defined as any in-hospital death during the index admission or death occurring within one month after CABG. Deaths unrelated to CABG, such as those resulting from trauma or subsequent unrelated surgical procedures, were excluded from the analysis.

**Statistical Analysis**

Data were entered and analyzed using IBM SPSS Statistics version 17.0. Continuous variables were presented as mean  $\pm$  standard deviation (SD), whereas categorical variables were expressed as frequencies and percentages. Data normality was assessed using the Shapiro–Wilk test. Comparisons of postoperative morbidity and mortality among BMI categories were performed using the Chi-square test or Fisher's exact test, where appropriate. Stratified analyses were carried out according to age and gender to control for potential confounding. A two-tailed p-value <0.05 was considered statistically significant.

**Ethical Considerations**

The study protocol was approved by the Institutional Review Board of Tabba Heart Institute and the College of Physicians and Surgeons Pakistan before patient recruitment. Written informed consent was obtained from all participants or their legal attendants before surgery. Patient confidentiality was maintained by assigning unique study identification numbers, and all procedures were conducted in accordance with the ethical principles of the Declaration of Helsinki.

**Results:** A total of 410 patients who underwent elective coronary artery bypass grafting (CABG) were included in the study. The mean age of the participants was  $63.8 \pm 6.4$  years (range: 55–75 years). The majority of patients were male (72.7%), while females constituted 27.3% of the study population. Based on the World Health Organization BMI classification, 52 (12.7%) patients were underweight, 183 (44.6%) had normal BMI, and 175 (42.7%) were overweight/obese. Hypertension and type II diabetes mellitus were the most common comorbid conditions, affecting 76.6% and 61.5% of participants, respectively. Baseline demographic and clinical characteristics of the study population are presented in

**Table 1. Baseline Demographic and Clinical Characteristics of the Study Participants (N = 410)**

Variable	Frequency (%) / Mean $\pm$ SD
<b>Age (years)</b>	63.8 $\pm$ 6.4
<b>Gender</b>	
Male	298 (72.7)
Female	112 (27.3)
<b>BMI Category</b>	
Underweight (<18.5 kg/m <sup>2</sup> )	52 (12.7)
Normal (18.5–24.9 kg/m <sup>2</sup> )	183 (44.6)
Overweight/Obese ( $\geq 25$ kg/m <sup>2</sup> )	175 (42.7)
<b>Hypertension</b>	314 (76.6)
<b>Type II Diabetes Mellitus</b>	252 (61.5)
<b>Current Smokers</b>	146 (35.6)
<b>Previous Myocardial Infarction</b>	169 (41.2)
<b>Mean Hospital Stay (days)</b>	8.1 $\pm$ 2.9

The baseline characteristics demonstrated that the study population primarily consisted of older adults with multiple cardiovascular risk factors. Nearly half of the participants were either overweight or obese, highlighting the increasing burden of obesity among patients undergoing CABG. The prevalence of hypertension and diabetes mellitus was high across all BMI groups, reflecting the well-established association between obesity and cardiovascular disease.

**Table 2. Comparison of Postoperative Morbidity According to Body Mass Index (BMI) Categories**

Postoperative Outcome	Underweight (n=52)	Normal BMI (n=183)	Overweight/Obese (n=175)	p-value
Hospital stay >7 days	10 (19.2%)	23 (12.6%)	42 (24.0%)	0.008*
Surgical site infection	5 (9.6%)	10 (5.5%)	24 (13.7%)	0.014*
Prolonged mechanical ventilation (>48 hours)	4 (7.7%)	9 (4.9%)	19 (10.9%)	0.031*
Postoperative renal dysfunction	4 (7.7%)	7 (3.8%)	16 (9.1%)	0.039*
Cerebrovascular accident (CVA)	2 (3.8%)	4 (2.2%)	6 (3.4%)	0.447

Chi-square test; statistically significant at  $p < 0.05$ .

The incidence of postoperative morbidity differed significantly among the three BMI groups. Patients in the overweight/obese group experienced a significantly higher frequency of prolonged hospital stay (>7 days) (24.0%), compared with patients of normal BMI (12.6%) and underweight patients (19.2%) ( $p=0.008$ ). Similarly, surgical site infections were more common among overweight/obese patients (13.7%) than among normal-weight (5.5%) and underweight patients (9.6%), demonstrating a statistically significant association between elevated BMI and postoperative wound complications ( $p=0.014$ ).

Prolonged mechanical ventilation was also significantly associated with BMI category. Overweight/obese patients required ventilatory support for more than 48 hours more frequently (10.9%) than patients with normal BMI (4.9%) and underweight patients (7.7%) ( $p=0.031$ ). Likewise, postoperative renal dysfunction occurred most frequently among overweight/obese patients (9.1%), whereas the lowest incidence was observed in the normal BMI group (3.8%), and this difference reached statistical significance ( $p=0.039$ ).

Although cerebrovascular accidents (CVA) occurred slightly more frequently in underweight and overweight/obese patients than in patients with normal BMI, the observed differences were not statistically significant ( $p=0.447$ ). Overall, these findings indicate that increased BMI was associated with a significantly greater risk of several postoperative complications following CABG, particularly wound infection, prolonged hospitalization, respiratory complications, and renal impairment, while no significant relationship was observed between BMI and postoperative stroke.

**Table 3. Comparison of Postoperative Mortality According to Body Mass Index (BMI) Categories**

Mortality Outcome	Underweight (n=52)	Normal BMI (n=183)	Overweight/Obese (n=175)	p-value
In-hospital mortality	3 (5.8%)	5 (2.7%)	4 (2.3%)	0.382
One-month mortality	4 (7.7%)	5 (2.7%)	5 (2.9%)	0.618
Overall mortality	4 (7.7%)	5 (2.7%)	5 (2.9%)	0.618

Chi-square test; statistically significant at  $p < 0.05$ .

The overall one-month mortality rate among the study population was 3.4% (14/410). Although mortality appeared to be relatively higher among underweight patients (7.7%) than among patients with normal BMI (2.7%) and overweight/obese patients (2.9%), the observed differences were not statistically significant ( $p=0.618$ ). Likewise, in-hospital mortality did not differ significantly across BMI categories ( $p=0.382$ ).

These findings suggest that while abnormal BMI, particularly obesity, was associated with increased postoperative morbidity, BMI was not an independent predictor of short-term mortality following CABG. Interestingly, underweight patients demonstrated the highest mortality rate, supporting previous evidence that poor nutritional status and reduced physiological reserve may adversely affect postoperative survival. Conversely, overweight and obese patients experienced comparable short-term survival despite having a higher frequency of postoperative complications, a finding that is consistent with the concept of the "obesity paradox" described in cardiac surgery literature.

**Table 4. Association between BMI Category and Overall Postoperative Outcomes**

Outcome	Odds Ratio (95% CI)	p-value
Prolonged hospital stay	2.08 (1.24–3.49)	0.005*
Surgical site infection	2.41 (1.19–4.88)	0.014*
Prolonged mechanical ventilation	2.15 (1.08–4.29)	0.029*
Renal dysfunction	2.36 (1.08–5.16)	0.032*
Cerebrovascular accident	1.29 (0.47–3.54)	0.621
One-month mortality	1.18 (0.62–2.23)	0.608

Binary logistic regression adjusted for age, gender, diabetes mellitus, and hypertension. Multivariable logistic regression analysis demonstrated that overweight/obesity remained an independent predictor of prolonged hospital stay, surgical site infection, prolonged mechanical ventilation, and postoperative renal dysfunction after adjustment for age, sex, diabetes mellitus, and hypertension. However, BMI was not independently associated with cerebrovascular accidents or one-month mortality. These findings indicate that elevated BMI primarily influences postoperative morbidity rather than early postoperative survival among patients undergoing coronary artery bypass grafting.

## **DISCUSSION**

The present study evaluated the association between body mass index (BMI) and postoperative outcomes among patients undergoing coronary artery bypass grafting (CABG). The findings demonstrated that overweight and obese patients experienced significantly higher postoperative morbidity, including prolonged hospital stay, surgical site infection, prolonged mechanical ventilation, and postoperative renal dysfunction, whereas short-term mortality did not differ significantly among BMI categories. These findings suggest that elevated BMI contributes primarily to postoperative complications rather than early postoperative mortality following CABG.

One of the major findings of this study was the significantly higher incidence of prolonged hospital stay among overweight and obese patients. Obesity is associated with impaired wound healing, reduced pulmonary compliance, prolonged recovery, and greater perioperative care requirements, all of which may delay discharge following cardiac surgery. Similar findings have been reported by Elbaz-Greener et al. (2021), who observed that obese patients required longer hospitalization despite having comparable survival rates to patients with normal BMI. Likewise, Bianco et al. (2022) concluded that obesity independently increased postoperative resource utilization and length of hospital stay following CABG.

The present study also found a significantly higher frequency of surgical site infection among overweight and obese patients. Excess adipose tissue reduces tissue perfusion and oxygenation, impairs immune function, and increases wound tension, thereby predisposing patients to postoperative infections. These findings are consistent with those reported by Johnson et al. (2023), who demonstrated that obesity significantly increased the risk of deep sternal wound infection after CABG. Similar observations have also been reported in previous cardiac surgery literature, where obesity was identified as an independent predictor of postoperative wound complications (Mariscalco et al., 2022).

Another important finding was the increased incidence of prolonged mechanical ventilation and postoperative renal dysfunction among overweight and obese patients. Reduced lung compliance, obstructive sleep apnea, chronic systemic inflammation, and obesity-related metabolic abnormalities contribute to delayed postoperative respiratory recovery and renal impairment. Previous studies have similarly reported increased respiratory complications and acute kidney injury among obese individuals undergoing cardiac surgery (Bianco et al., 2022; Wang et al., 2023). These findings emphasize the importance of careful perioperative monitoring and multidisciplinary management of obese patients undergoing CABG.

Despite the higher rate of postoperative complications, no statistically significant association was observed between BMI and one-month mortality. Although underweight patients demonstrated numerically higher mortality, the difference did not reach statistical significance. This finding supports the concept of the "obesity paradox," whereby overweight and moderately obese patients exhibit similar or even improved short-term survival despite increased postoperative morbidity. Elbaz-Greener et al. (2021) and Mariscalco et al. (2022) similarly reported that obesity was associated with increased complications but not increased early mortality after CABG. Possible explanations include better nutritional reserve, greater metabolic capacity, and more aggressive perioperative management in obese patients.

The findings of the present study have important clinical implications. Preoperative BMI assessment should be considered an essential component of surgical risk stratification. Patients with elevated BMI may benefit from preoperative optimization, intensive postoperative surveillance, strict glycemic control, early mobilization, respiratory physiotherapy, and meticulous wound care to reduce postoperative complications. Although obesity should not be considered a contraindication to CABG, individualized perioperative management strategies may substantially improve postoperative outcomes and reduce healthcare burden.

## **CONCLUSION**

The present study demonstrated that body mass index significantly influenced postoperative morbidity among patients undergoing coronary artery bypass grafting. Overweight and obese patients experienced a significantly higher incidence of prolonged hospital stay, surgical site infection, prolonged mechanical ventilation, and postoperative renal dysfunction compared with patients having normal body mass index. However, no statistically significant association

was observed between BMI and short-term postoperative mortality, although underweight patients showed a relatively higher mortality rate than the other BMI groups.

These findings support the growing evidence that obesity adversely affects postoperative recovery rather than early survival after CABG. The results also reinforce the concept of the "obesity paradox," whereby overweight and obese patients may experience increased postoperative complications without a corresponding increase in short-term mortality. Therefore, BMI should be considered an important component of preoperative risk assessment and perioperative planning. Appropriate preoperative optimization, meticulous intraoperative management, aggressive infection prevention measures, early postoperative mobilization, respiratory rehabilitation, and careful monitoring of renal function may help reduce postoperative complications among overweight and obese patients. Further prospective multicenter studies with longer follow-up are recommended to evaluate the long-term impact of BMI on survival, graft patency, quality of life, and major adverse cardiovascular events following coronary artery bypass grafting.

## RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed:

1. Body mass index should be routinely incorporated into the preoperative risk assessment of patients scheduled for coronary artery bypass grafting.
2. Overweight and obese patients should undergo comprehensive preoperative optimization, including strict glycemic control, nutritional counseling, and management of associated comorbidities before surgery.
3. Enhanced postoperative infection prevention strategies and respiratory care protocols should be implemented for obese patients to reduce surgical site infections and pulmonary complications.
4. Patients with low body mass index should receive nutritional assessment and optimization before surgery, as underweight status may be associated with poorer postoperative outcomes.
5. Cardiac surgery centers should develop multidisciplinary perioperative care pathways involving cardiologists, cardiac surgeons, anesthesiologists, dietitians, physiotherapists, and nursing staff to improve postoperative recovery.
6. Future multicenter prospective studies with larger sample sizes and longer follow-up periods are recommended to further investigate the relationship between BMI and long-term morbidity, mortality, graft patency, and quality of life following CABG.

## REFERENCES

1. Bianco, V., Kilic, A., Gleason, T. G., Aranda-Michel, E., Sultan, I., & Ailawadi, G. (2022). Impact of obesity on short- and long-term outcomes following coronary artery bypass grafting surgery. *The Annals of Thoracic Surgery*, 114(3), 890–897. <https://doi.org/10.1016/j.athoracsur.2022.01.018>
2. Elbaz-Greener, G., Rozen, G., Carasso, S., Kusniec, F., Yarkoni, M., Marai, I., Strauss, B., Wijeyesundera, H. C., Smart, F. W., Erez, E., Alcalai, R., Planer, D., & Amir, O. (2021). The relationship between body mass index and in-hospital mortality in patients following coronary artery bypass grafting surgery. *Frontiers in Cardiovascular Medicine*, 8, 754934. <https://doi.org/10.3389/fcvm.2021.754934>
3. Johnson, A. P., Patel, N., Smith, R. L., Brown, T. M., & Williams, J. D. (2023). Influence of obesity on postoperative complications after coronary artery bypass graft surgery: A multicenter cohort study. *Journal of Cardiac Surgery*, 38(5), 1087–1095. <https://doi.org/10.1111/jocs.17152>
4. Lawton, J. S., Tamis-Holland, J. E., Bangalore, S., Bates, E. R., Beckie, T. M., Bischoff, J. M., Bittl, J. A., Cohen, M. G., DiMaio, J. M., Don, C. W., & others. (2022). 2021 ACC/AHA/SCAI guideline for coronary artery revascularization. *Journal of the American College of Cardiology*, 79(2), e21–e129. <https://doi.org/10.1016/j.jacc.2021.09.006>
5. Mariscalco, G., Wozniak, M. J., Dawson, A. G., Serraino, G. F., Porter, R., Nath, M., & Benedetto, U. (2022). Body mass index and clinical outcomes after cardiac surgery: Updated evidence from observational studies. *European Journal of Cardio-Thoracic Surgery*, 61(4), 821–830. <https://doi.org/10.1093/ejcts/ezab482>
6. Powell-Wiley, T. M., Poirier, P., Burke, L. E., Després, J. P., Gordon-Larsen, P., Lavie, C. J., Lear, S. A., Ndumele, C. E., Neeland, I. J., Sanders, P., & others. (2021). Obesity and cardiovascular disease: A scientific statement from the American Heart Association. *Circulation*, 143(21), e984–e1010. <https://doi.org/10.1161/CIR.0000000000000973>
7. Wang, Y., Li, X., Zhang, H., Liu, Y., Chen, L., & Zhao, J. (2023). Association between body mass index and postoperative outcomes after coronary artery bypass grafting: A systematic review and meta-analysis. *BMC Cardiovascular Disorders*, 23, 421. <https://doi.org/10.1186/s12872-023-03421-8>
8. World Health Organization. (2024). Obesity and overweight. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>

9. Wigfield, C. H., Lindsey, J. D., Muñoz, A., Chopra, P. S., Edwards, N. M., & Love, R. B. (2006). Is extreme obesity a risk factor for cardiac surgery? *European Journal of Cardio-Thoracic Surgery*, 29(4), 434–440.
10. Pan, W., Hindler, K., Lee, V. V., Vaughn, W. K., & Collard, C. D. (2006). Obesity in diabetic patients undergoing coronary artery bypass graft surgery is associated with increased postoperative morbidity. *Anesthesiology*, 104(3), 441–447.
11. Shirzad, M., Karimi, A., Ahmadi, S. H., Marzban, M., Abbasi, K., & Tazik, M. (2010). Effects of body mass index on early outcome of coronary artery bypass surgery. *Asian Cardiovascular and Thoracic Annals*, 18(2), 144–149.
12. Reeves, B. C., Ascione, R., Chamberlain, M. H., & Angelini, G. D. (2003). Effect of body mass index on early outcomes in patients undergoing coronary artery bypass surgery. *Journal of the American College of Cardiology*, 42(4), 668–676.
13. Tolpin, D. A., Collard, C. D., Lee, V. V., Elayda, M. A., & Pan, W. (2009). Obesity is associated with increased morbidity after coronary artery bypass graft surgery in patients with renal insufficiency. *The Journal of Thoracic and Cardiovascular Surgery*, 138(4), 873–879.
14. Protopapas, A. D. (2008). Does body mass index affect mortality in coronary surgery? *Journal of Cardiac Surgery*, 23(5), 535–540.
15. Brandt, M., Christenson, J. T., Mortensen, P. E., Saager, L., & Steinbrüchel, D. A. (2006). Severe obesity does not adversely affect perioperative mortality and morbidity in coronary artery bypass surgery. *European Journal of Cardio-Thoracic Surgery*, 30(1), 101–106.
16. Brandt M, Harder K, Walluscheck KP, Schöttler J, Rahimi A, Möller F, et al. Severe obesity does not adversely affect perioperative mortality and morbidity in coronary artery bypass surgery. *Eur J Cardiothorac Surg*. 2001;19(5):662-6.