The Effect of Body Mass Index on Bleeding After on Pump Coronary Artery Bypass Grafting


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ABSTRACT

Objective: To study the relationship of body mass index (BMI) and postoperative bleeding in patients undergoing isolated coronary artery bypass grafting (CABG) using cardiopulmonary bypass (CPB).

Study Design: Analytical cross-sectional study.

Place and Duration of Study: Cardiothoracic services, Almana General Hospital, Al Khobar, Saudi Arabia, from Oct 2019 to Oct 2021.

Methodology: Two hundred and twenty (220) consecutive patients who underwent CABG using cardiopulmonary bypass were included in the study. Patients who had additional procedures, those who were operated in emergency and those with significant comorbidities like hepatic and liver dysfunction were excluded from the final analysis. Patients were divided into three groups according to their BMI, healthy weight (BMI 18.5 to <25), overweight (BMI 25 to <30) and obese (BMI >30). The world health organization (WHO) definition was used to define different categories of BMI. Various perioperative variables were recorded for all the patients. The immediate postoperative follow up period was included in the study. Data was analyzed using IBM SPSS-statistics 23.0 (IBM, SPSS Inc., Chicago, IL).

Results: Of the 220 patients included in the study, 184(83%) were male patients and 36(16%) female patients. There was no significant difference in the mean age of the patients in the three groups (p=0.481). There were significantly more hypertensive patients 46(45%) in the overweight group compared to other two groups (p=0.025). Baseline diabetic status was not significantly different among the three categories (p=0.978). Total mediastinal drainage in the first 24 hours was significantly less in the obese group (3.7±4.45 ml) compared to overweight (4.4±2.7 ml) and healthy (7.35±8.5 ml) patients (p=0.001). There was no mortality in the studied cohort.

Conclusion: Bleeding after isolated coronary artery bypass grafting is inversely related to BMI. Patients with healthy and overweight BMI are at higher risk of bleeding compared to obese patients.

Keywords: Body mass index, Coronary artery bypass grafting, Mediastinal drainage, Obesity.


INTRODUCTION

An abnormal body mass index (BMI) is a known risk factor for coronary artery disease.1 Many of these patients need coronary artery bypass grafting (CABG) due to the severity of the coronary disease. CABG has been performed traditionally through median sternotomy using cardiopulmonary bypass. Advances in minimally invasive techniques have allowed us to avoid median sternotomy in many types of open-heart surgeries including CABG. Minimally invasive techniques are known to reduce recovery time and wound complications.2 Both minimally invasive and off pump techniques are known to mitigate the need for blood product usage due to less bleeding. But obesity has traditionally been considered a relative contraindication to minimally invasive procedures. Also, only select centers perform minimally invasive procedures. This leaves CABG with median sternotomy with or without the use of cardiopulmonary bypass as the most common approach for patients with high BMI.

Traditionally, obese patients have been considered high risk for open heart surgery especially diabetic patients. Complications like increased ventilation time, long ICU stay and sternal wound complications have been found to be associated with obesity when these patients are subjected to open heart surgery.3 Paradoxically, obesity has an inverse relationship with adverse outcomes in patients with renal and pulmonary procedures. The concept of obesity paradox in cardiac surgery was described for the first time in 2003.4 Since then, it has been extensively studied in the literature from various aspects. Whether an obesity paradox exists in cardiac surgery has been debated in the literature. Studies have shown that overweight and mild obesity is associated with better long-term survival after CABG.5 The same benefit was not observed for patients with...
morbid obesity. Underweight patients have also been found to have high early mortality compared to overweight and obese patients.6,7

Bleeding is a common complication after cardiac surgery. Cardiac surgeries are mostly performed with the use of cardiopulmonary bypass which induces a generalized inflammatory state, platelets dysfunction and coagulation factors dysfunction and dilution. The resultant effect is increased propensity for bleeding in the immediate postoperative period. Additionally, many patients are already on antiplatelet medications or anticoagulants before the surgery, hence increasing the risk of bleeding postoperative. About 5% patients undergoing CABG are re-explored for bleeding.8 Bleeding in the immediate postoperative period not only predisposes patients to complications like atrial fibrillation and wound infection but also the increased transfusion requirements as a result of bleeding increases the risks of graft failure and kidney injury.9 Although increasing BMI has been associated with increased risk of acute kidney injury, increased ventilation time and ICU stay and significantly more chance of sternal wound complications, the effect of BMI on early postoperative mediastinal bleeding is less well described. The purpose of this work to study the association of BMI with bleeding after CABG in the immediate postoperative period.

METHODLOGY

An analytical cross sectional study was conducted at Almana General Hospital, Saudi Arabia from October 2019 to October 2021. Since this was a retrospective study and did not involve any new intervention, hence the need for individual consent from the patients was waived. Data was recorded prospectively in the hospital database system after approval from institutional IERB(Ltr#21/21/ALM/21/1).

Sample Size: Sample size was calculated using 5% prevalence which was found to be 73, as it was retrospective study, we recruited all patients enrolled during the study duration.

Inclusion Criteria: Consecutive patients who underwent CABG for atherosclerotic coronary artery disease using cardiopulmonary bypass through median sternotomy were included in the study.

Exclusion Criteria: Patients who had additional procedures like mitral or aortic valve replacement, emergency procedures and redo procedures were excluded from the study. Those with significant comorbidities like liver and hepatic derangements were also excluded from the final analysis.

All the patients were managed by the same heart team so standardized preoperative decision-making protocols were implied for all the patients. Body mass index was defined as weight in kilogram divided by height in meters square (Kg/m²). Patients were divided into three categories according to their BMI as per the world health organization (WHO) definition. The normal BMI category included patients with BMI 18.5 to those less than 25. The overweight category included patients with BMI from 25 to less than 30. Patients with BMI more than 30 were categorized as obese. There was no patient with BMI below 18.5 (underweight) in our cohort. The use of preoperative medications was standardized with all the patients receiving β-blocker and Angiotensin Converting Enzyme (ACE) inhibitors preoperatively.

Patients underwent CABG through median sternotomy with general anesthesia and cardiopulmonary bypass (CPB). CPB was established after heparinization with unfractionated heparin targeting an activated coagulation time (ACT) of more than 450 seconds. Priming of CPB was done with crystalloids or blood depending the preoperative hemoglobin. CPB flows were calculated according to the weight and standardized for all the patients. Reversal of heparin was done through protamine sulphate in a dose-by-dose fashion. The conduits used for grafting were left internal mammary artery and one or more great saphenous veins.

Shedding of mediastinal blood was minimized through meticulous technique thus minimum of shed blood was returned to the CPB machine. The residual volume left in the CPB circuit was returned to the patient at the end of bypass as tolerated by the hemodynamics and loading conditions of the heart.

Postoperatively, mediastinal drainage was calculated from the drainage bottle system by an experienced staff. Total drainage in the first 24 hours was recorded.

Continuous variables were presented as mean and standard deviations and categorical variables as frequencies and percentages. Categorical variables were analyzed using chi square (χ²) test. The three categories of BMI were analyzed in the context of postoperative bleeding ml/Kg using One Way ANOVA (Analysis of Variance) test. Linear correlation was calculated between BMI as a continuous variable and postoperative bleeding in ml/Kg. To assess the
effect of individual category of BMI, the three subsets were converted into dummy variables and linear regression was used to determine the category of BMI with significant effect on the outcome. Data was analyzed using IBM SPSS-statistics 23.0 (IBM, SPSS Inc., Chicago, IL).

RESULTS

Body mass index (BMI) was measured as a categorical variable with three levels across all the patients (n=220) included in the study i.e., healthy weight group BMI (18.5 to <25, n=73), overweight (25 to <30, n=103) and obese (BMI >30, n=44). There was no one in the underweight category (BMI<18.5) in our cohort.

Table-I: Important Demographic and Preoperative Characteristics of the Patients

<table>
<thead>
<tr>
<th>Patient Characteristics</th>
<th>BMI Groups (n=220)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy weight (n=73)</td>
<td>Overweight (n=103)</td>
</tr>
<tr>
<td>Gender</td>
<td>Male 184 (83.64%)</td>
<td>51 (69.86%)</td>
</tr>
<tr>
<td></td>
<td>Female 36 (16.36%)</td>
<td>22 (30.14%)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>52.6 ± 8.9</td>
<td>51.35 ± 7.9</td>
</tr>
<tr>
<td>Diabetes</td>
<td>42 (57.53%)</td>
<td>58 (56.31%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>38 (52.05%)</td>
<td>46 (44.66%)</td>
</tr>
<tr>
<td>Current smokers</td>
<td>19 (26.02%)</td>
<td>21 (20.36%)</td>
</tr>
<tr>
<td>Preoperative hemoglobin</td>
<td>13.65 ± 1.62</td>
<td>14.1 ± 1.54</td>
</tr>
<tr>
<td>Preoperative platelet count (10^9/L)</td>
<td>248.3 ± 84.9</td>
<td>247.4 ± 68.04</td>
</tr>
<tr>
<td>Preoperative HBA1c (%)</td>
<td>7.62 ± 2.06</td>
<td>7.16 ± 1.7</td>
</tr>
<tr>
<td>Preoperative ejection fraction (%)</td>
<td>48.2 ± 9.7</td>
<td>51.6 ± 8.9</td>
</tr>
<tr>
<td>MI within previous 7 days</td>
<td>30 (41.09%)</td>
<td>53 (51.45%)</td>
</tr>
<tr>
<td>Initial Presentation</td>
<td>Stable angina</td>
<td>6 (8.3%)</td>
</tr>
<tr>
<td></td>
<td>Unstable angina</td>
<td>14 (19.17%)</td>
</tr>
<tr>
<td></td>
<td>NSTEMI</td>
<td>42 (57.53%)</td>
</tr>
<tr>
<td></td>
<td>STEMI</td>
<td>11 (15.06%)</td>
</tr>
<tr>
<td>Preoperative Plavix taken within 5 days of surgery</td>
<td>21 (28.76%)</td>
<td>34 (33.00%)</td>
</tr>
</tbody>
</table>

All the three categories were comparable with respect to age (p=0.481), diabetes (p=0.978), preoperative ejection fraction (p=0.066) and incidence of myocardial infarction in the previous 7 days (0.082). Hypertension was significantly more prevalent in obese patients (68.18%), compared to healthy (52.05%) and overweight patients (44.66%), (p=0.025). Preoperative hemoglobin levels were significantly high in the overweight category (14.1±1.54, p=0.02) compared to obese and normal weight patients. Although, numerically more patients in the overweight category took clopidogrel in the previous 5 days of surgery 34 (33.3%) compared to healthy weight patients 21 (28.76%) and obese patients 9 (20.45%), the comparison of the means was not statistically significant (p=0.569) (Table-I).

Intraoperatively, obese patients had high cross clamp time (144.17±70.6 minutes) compared to healthy (128±43.1 minutes) and overweight patients (119.98±32 minutes), (p=0.017). (Table-II) Cross clamp time was not significantly different among the three categories (p=0.15). Mean intraoperative hematocrit was significantly lower in people with healthy BMI (24.61±2.3, p=0.008).

There was no significant difference among the three categories with respect to total postoperative drainage (p=0.07), although patients with normal BMI had a trend towards higher bleeding (442±447 ml) (Table-III). But when drainage was calculated in ml/Kg body weight, postoperative drainage was significantly more (7.35±8.5 ml) compared to overweight (4.4±2.7 ml) and obese patients (3.7±4.45ml) (p=0.001). A negative correlation was observed between BMI as a continuous variable and postoperative bleeding (R2=0.07), (Figure-1). Multiple comparison analysis showed that this difference was mainly because of patients in the normal BMI category (normal vs Overweight t=0.02 & normal vs obese, p=0.003).

Figure-1: Linear Correlation Between BMI and Bleeding in ml/Kg
On Pump Coronary Artery Bypass Grafting

Table-II: Intraoperative Variables

<table>
<thead>
<tr>
<th>Patient Characteristics</th>
<th>Healthy weight (n=73)</th>
<th>Overweight (n=103)</th>
<th>Obese (n=44)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPB time (minutes)</td>
<td>128 ± 43.1</td>
<td>119.98 ± 32</td>
<td>144.17 ± 70.6</td>
<td>0.017</td>
</tr>
<tr>
<td>Cross clamp time (minutes)</td>
<td>86.1 ± 30.9</td>
<td>78.4 ± 26</td>
<td>86.32 ± 31.1</td>
<td>0.15</td>
</tr>
<tr>
<td>Lowest intraoperative hematocrit during CPB (%)</td>
<td>24.61 ± 2.3</td>
<td>25.14 ± 3.22</td>
<td>26.6 ± 3.9</td>
<td>0.008</td>
</tr>
<tr>
<td>Urine output on CPB (ml)</td>
<td>544.9 ± 425</td>
<td>605.6 ± 357</td>
<td>625.8 ± 498.7</td>
<td>0.519</td>
</tr>
</tbody>
</table>

Table-III: Important Postoperative Variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Healthy weight</th>
<th>Overweight</th>
<th>Obese</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total mediastinal drainage in first 24 hours (ml)</td>
<td>442 ± 447</td>
<td>325 ± 195.2</td>
<td>361.1 ± 393.5</td>
<td>0.07</td>
</tr>
<tr>
<td>Total mediastinal drainage in first 24 hours in ml/Kg</td>
<td>7.35 ± 8.5</td>
<td>4.4 ± 2.7</td>
<td>3.7 ± 4.45</td>
<td>0.001</td>
</tr>
<tr>
<td>Re-exploration for bleeding</td>
<td>4 (5.4%)</td>
<td>2 (1.94%)</td>
<td>4 (9.09%)</td>
<td>0.14</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Our study has brought some important findings into limelight. Our population cohort is young compared to most other major studies conducted in this context. The cohort is predominantly male pointing to the high incidence of coronary artery disease in males and is consistent with literature in this regard.

Lower BMI, although in the healthy range, has been found to be associated with more bleeding postoperatively in the literature compared to the overweight and obese patients. This finding was confirmed in our study. Obesity has been associated with lower rate of reoperation for bleeding postcardiac surgery. Wang et al studied the outcomes of 1007 patients with respect to obesity and postoperative bleeding after open heart surgery. They found higher bleeding rates in patient with BMI in the normal and overweight category. Similarly higher rates of blood transfusion were observed in patients who have BMI in the normal and overweight category. This finding was also confirmed in our study where the rate of bleeding, when considered as a function of ml/Kg, was more in patients with lower BMI. Hence, a negative correlation was observed between bleeding and BMI.

Many investigators have shed light on the procoagulant effect of obese patients undergoing cardiac surgery and the resultant lower bleeding risk in these patients. Kindo et al, assessed the various laboratory tests used to assess coagulation and found that obese patients after cardiac surgery have increased thrombin formation and reduced thrombolysis after cardiac surgery. In their study, patients with severe obesity had high levels of fibrinogen even before the surgery. Fibrinogen plays an important role in coagulation. Another mechanism that may be responsible for this prothrombotic state in obese patients is described by Vilahur and colleagues. They described the production of plasminogen activation inhibitor, an inhibitor of fibrinolytic system, by the adipose tissue as the contributing factor in decreasing blood loss after open heart surgery. It has also been suggested that a selection bias may be involved in the comparatively better outcome of obese patients when compared to non-obese patients. In their cohort of more than four thousand patients, Gao et al did not find obesity as a risk factor for early mortality or adverse events including bleeding. Also, many studies have shown no protective effect of obesity according to bleeding.

Although our study had a short term follows up, it showed that there was no difference in the outcome with respect to mortality when all the categories of BMI were compared. This is in agreement with the literature which largely favors the concept that the outcomes in obese patients after open heart surgery may not be as bad as thought previously. Patients with obesity have been shown to be of younger age compared to patients with lower BMI. This was not the case in our study where there was no significant difference in the age of all the three groups studied. This can be explained by the generally younger age of our patient cohort and hence the more aggressive nature of coronary artery disease in our population. Moreover, patients of Asian origin have generally been considered at high risk of coronary artery disease with worse demographic profile. Questions have also been raised about the validity of the obesity classification system & its application to non-Caucasian population, proposing different definition of obesity and categorization of BMI. Our study shows that the trends of bleeding post CABG in patients with different categories of BMI are not different from those in Caucasians as shown also by Hadjinikolaou and colleagues.

**LIMITATIONS OF STUDY**

This was a non-controlled single center study which may be a source of bias in terms of the patient risk profile.
and the operative technique which may differ from other centers. Our study did not include any patient in the underweight category which suggests the general prevalence of higher BMI in our cohort. Moreover, our study was based upon retrospective database review which has its inherent limitations. A prospectively conducted case-control study comparing the short as well as long term outcome of the effect of bleeding in various categories of BMI will be interesting to see. The limitation of our study was the uniformity of sample size. Unequal number of patients were present in both the groups because of the difference of hemodynamic status and cardiovascular disease of each patient, based on which the anesthesiologist would decide the need for either dexmedetomidine or propofol in real time. Limited sample size and duration were also contributing factors.

CONCLUSION

The obesity paradox seems to be real as far as postoperative bleeding and BMI are concerned in patients who have undergone isolated coronary artery bypass grafting using cardiopulmonary bypass. Larger sample sizes involving patients from many centers operated by surgical teams with varied surgical protocols may shed more light on this phenomenon.

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Conflict of Interest: None.

Author’s Contribution

MS: Following authors have made substantial contributions to the manuscript as under:

MS: Concept, Manuscript drafting, analysis
IK: Manuscript writing, idea, review articles
FF: Intellectual contribution, critical review, Analysis
MAD: Data collection, data entry, data management
SMH: Manuscript writing, data management and analysis
HK: Data analysis, data management, critical review

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work appropriately investigated & resolved.

REFERENCES


