Original Article

Impact of Obesity on Early Outcomes after Cardiac Surgery: Experience in a Saudi Arabian Center

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Purpose: The prevalence of obesity is a public health concern in most countries, including Saudi Arabia. Obesity has been considered a major risk factor for adverse outcomes after cardiac surgery.
Materials and Methods: A single-center retrospective review (2001–2005) of adverse outcome after coronary artery bypass grafting (CABG) and valve surgery (total = 462) categorized by body mass index (BMI) was performed. The patients with BMI ≥30 were defined as the obese group and patients whose BMI <30 were labeled as the nonobese group.
Results: Overall, 315 (68.2%) were classified as nonobese, and 147 (31.8%) were obese. Obese patients were older and more likely to have diabetes and hypertension. There were no significant differences between the two groups with regard to other comorbidity and risk factors. There was no association between the two groups and the outcomes of operative mortality and morbidities.
Conclusion: This study demonstrated that obesity does not increase the risk of death and most complications after cardiac surgery, aside from the unexplained increased risk of reoperation during the same admission. (Ann Thorac Cardiovasc Surg 2008; 14: 369–375)

Key words: obesity, outcome, cardiac surgery

Introduction

Over recent decades, improvement of socioeconomic conditions has led to an expansion of the overweight population worldwide. Obesity is well known to be a risk factor for the development of diabetes mellitus (DM), hypertension, and coronary artery disease.[1] It is also thought to be a risk factor for perioperative morbidity and mortality with cardiac surgery, evidenced by its inclusion in the Parsonnet system for stratification of risk for perioperative death.[2]

The body mass index (BMI) expresses nutritional status, metabolic abnormalities, and general organ function of patients. Several studies have shown the influence of BMI on morbidity and mortality following cardiac surgery.[1,3,4] However, the significance of obesity in patients undergoing cardiac surgery remains unclear. Moreover, because of the increase in the prevalence of obesity, cardiothoracic surgeons will soon be treating more obese patients.[5]

The aim of this paper is to retrospectively study the effect of increased BMI on early clinical outcome in patients undergoing valve and coronary artery bypass surgery in a single institution in Saudi Arabia.

Materials and Methods

From January 2001 to December 2005, a total of 462 consecutive adult patients underwent coronary artery bypass grafting (CABG), valve surgery, and combined CABG and valve surgery on cardiopulmonary bypass (CPB) and aortic cross-clamp at King Faisal Specialist

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Hospital and Research Center, Jeddah, Saudi Arabia. All cases were included in this retrospective review except adult congenital heart surgery cases, thoracic aorta procedures, transplantations, beating heart, and off-pump operations (CABG, pericardiectomy, and insertion of a permanent epicardial pacemaker). Patients' data were retrospectively obtained from the medical records with the approval of the institutional board review of the hospital. Operative techniques with regard to heart and lung machine, myocardial protection, anesthesia protocol, anticoagulation protocol, intraoperative hemodynamics, and respiratory management were similar in all patients. BMI was calculated using patient's height and weight (BMI = weight [kg] / height [m]^2). The patients with BMI ≥30 were defined as the obese group, and patients whose BMI <30 were labeled as the nonobese group.

The preoperative information included the following variables: age, sex, BMI, surgical diagnosis, priority of the procedure. Preoperative comorbidity and risk factors were also documented, such as left ventricular ejection fraction (EF%), serum albumin level (g/L), previous cardiac operations, smoking, hypertension, DM, renal failure (RF), chronic obstructive pulmonary disease (COPD), cerebrovascular accident (CVA), peripheral vascular disease (PVD), preoperative mechanical ventilation, low cardiac output (COP) state, carotid artery disease, and septicemia.

Priorities of the procedures were defined by the surgeons as "elective" when the operation was scheduled on a chosen date; "urgent" when it had to be performed before discharge from the hospital; "emergent" when it was performed immediately. The preoperative comorbidities and risk factors were defined for the purpose of this review. Smoking history was considered positive if the patient had smoked cigarettes within the past year. Hypertension was defined for patients with a positive history of hypertension or that currently underwent treatment for hypertension. DM was documented if a patient was on insulin or oral hypoglycemic agents. RF was considered present if a patient was on temporary or permanent dialysis. COPD was determined positive if a patient was on bronchodilator therapy ≥ 3 months. CVA was defined by a history of stroke with or without residual deficit. PVD was determined to be present if there was radiological evidence of a 50% narrowing in a major vessel distal to the abdominal aorta, previous surgery for such disease, difficulty during the insertion of intra-aortic balloon pump (IABP) because of atherosclerotic iliofemoral disease, or absent femoral or pedal pulses. Low COP state was considered if the patient was on ≥ 3 inotropes. Carotid artery disease was determined to be present if there was radiological evidence of ≥ 50% narrowing in a major carotid artery. Septicemia was defined if positive blood culture was documented with the addition or modification of antimicrobial treatment.

Documented operative details included type of surgery (CABG alone, valve alone, or combined), and CPB time. Recorded in-hospital postoperative outcomes were operative mortality (death within 30 days from operation or later than 30 days if patient remained in the hospital), exploration (required for tamponade or hemostasis), sternal dehiscence (noninfectious mechanical stress related and required rewiring and primary closure), deep sternal and leg wound infection (involving muscle and bone as demonstrated by surgical exploration and positive cultures or treatment with antibiotics, mediastinitis, arrhythmias (requiring specific treatment such as defibrillation or introduction of an antiarrhythmic agent), insertion of transvenous or epicardial permanent pacemaker, readmission to intensive care unit (ICU), use of IABP, new CVA (new focal neurological deficit lasted > 24 hours prior to discharge), reoperation (return to theater for any cause during the same admission other than exploration, debridement, or sternal rewiring for dehiscence), new RF (new requirement for dialysis or hemofiltration), reintubation (for acute respiratory insufficiency), prolonged mechanical ventilation for more than 5 days, and the need for tracheostomy, septicemia, or ischemic limb (proved radiologically and requiring vascular surgery attention). Readmission to the hospital within 30 days from hospital discharge was also documented. The antiplatelet/anticoagulation protocols for all postoperative CABG and valve cases were in accordance with the evidence-based guidelines of the seventh American college of chest physicians conference on antithrombotic and thrombolytic therapy.[6,7]

Continuous variables are presented as mean ± standard deviation. A Kruskall-Wallis test was used to compare continuous variables across all groups. A Mann-Whitney U-test was used to compare two groups of continuous variables. A chi-square test was used to compare groups of categorical variables. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated using standard statistical methods. Multivariate logistic regression was used to examine the effect of obesity category on early morbidity and mortality, while adjusting for patient characteristics. These characteristics were age, sex, use of tobacco, DM, hypertension, RF, CVA, PVD, COPD, carotid artery disease, preoperative mechanical ventilation, low COP state, and septicemia. P values <0.05 were considered significant. All statistical analyses were performed retrospectively using SPSS 11.5 for Windows (SPSS Inc., Chicago, IL, USA).

Results

A total of 462 adult patients (319 men and 143 women), with a median age of 53 years (range 14–89) underwent CABG, valve surgery, and combined CABG and valve surgery on cardiopulmonary bypass; 285 CABG (61.7%), 101 single valve surgery (21.9%), 41 double valve surgery (8.9%), 16 triple valve surgical procedures (3.5%), and 19 combined CABG and valve surgery (4.1%). Twenty-three cases (5%) had previous cardiac operations. Here are the priorities applying to the primary surgical procedures: 375 elective procedures (81%), 65 urgent procedures (14%), and 22 emergent procedures (5%). The median length of stay in the ICU and the hospital was 3 days (range 1–138) and 12 days (range 2–220), respectively. The operative mortality was 25 cases (5.4%), and the hospital readmission was 12 (2.6%).

The conduits of choice for CABG used in this series were the left internal thoracic artery (LITA) and greater saphenous veins. The average number of coronary bypass grafts was 3.8 with the use of LITA in 87.9% for the CABG-alone group (285 patients). In the combined CABG and valve surgery group (19 patients), the LITA was used in 15.8% of the group, and the valve procedures totaled 9 aortic valve replacements (AVRs), 6 mitral valve repairs (MVr's), 6 mitral valve replacements (MVRs), and one tricuspid valve repair (TVr). There were 43 AVRs, 57 MVRs, and one MVr in the single valve surgery group (101 patients). In the double-valve surgery group (41 patients), there were 32 AVRs, 39 MVRs, 9 TVr's, one tricuspid valve replacement (TVR), and one pulmonary valve replacement (PVR). Sixteen patients underwent triple valve surgery: 15 AVRs, 15 MVRs, 14 TVr's, 2 TVRs, and 2 PVRs. In general, the type of prosthetic valve used in this series was mechanical in 58% of patients and tissue in 42%.

Overall, 315 (68.2%) were patients classified as nonobese and 147 (31.8%) as obese. Table 1 shows the patient demographics and preoperative characteristics based on obesity categories. Obese patients were older and more likely to have the comorbidities of diabetes and hypertension. Moreover, they had undergone more CABG procedures and less isolated valve surgery compared to the nonobese group. There were no significant differences between the two groups with regard to the preoperative serum albumin level (g/L) and EF percent. Also, there were no significant differences in the prevalence of smoking, COPD, CVA, RF, PVD, carotid artery disease, preoperative mechanical ventilation, low COP state, or septicemia.

The incidences of postoperative outcomes for the nonobese and obese groups are shown in Table 2. There was no association between the two groups and the outcomes of operative mortality, use of IABP, exploration, mediastinitis, arrhythmias and the insertion of permanent pacemakers, CVA, RF, reintubation, tracheostomy, prolonged ventilation, deep wound infections, septicemia, reoperation, ischemic limb, sternal dehiscence, readmission to ICU, or readmission to the hospital within 30 days.

The indications for the use of IABP were perioperative myocardial ischemia in 38 patients and low COP with the progressive increase in inotropic requirement in 21. Postoperatively, by means of the standard percutaneous transvenous subclavian access being used under fluoroscopic visualization, 6 patients required permanent dual chamber pacemaker insertions by the electrophysiologist, 3 for sinus node dysfunction and 3 for complete heart block.

The reasons for hospital readmission for 12 patients were wound infection (2), pleural effusion (2), congestive heart failure (1), wound dehiscence (1), epistaxis (1), subdural hematoma (1), pneumonia (1), femoral pseudoaneurysm (1), inadequate anticoagulation (1), and myocardial ischemia (1).

Compared to the obese reference category (Table 3), two significant adjusted ORs in the nonobese group were found: the use of IABP was 2.33 ($P = 0.05$), and reoperation was 0.03 ($P = 0.05$). Adjusted ORs did not reach statistical significance with regard to arrhythmias, infection-related morbidity (mediastinitis, deep wound infection, and septicemia) or ventilatory-related complications (reintubation, tracheostomy, prolonged ventilation, and sternal dehiscence).

Discussion

Obesity is associated with the increased risks of cardio-

Table 1. Patients' pre-, intra-, and postoperative characteristics

	Nonobese (N = 315)	Obese (N = 147)	P value
Age (yr)	49 ± 16	55 ± 13	0.000
Male gender (%)	69.8	67.3	0.589
BMI	24.6 ± 3.3	34.3 ± 5.1	0.000
Previous cardiac surgery (%)	5.7	3.4	0.249
Priority of the procedure			
Elective (%)	82	80	0.000
Urgent (%)	13	16	0.035
Emergent (%)	5	4	0.033
EF (%)	45 ± 11	45 ± 11	0.922
Serum albumin (g/L)	35.8 ± 7.4	34.9 ± 5.8	0.185
Smoking (%)	30.7	36.6	0.212
Hypertension (%)	38.4	59.2	0.000
DM (%)	39.4	55.1	0.002
RF (%)	2.5	2.0	0.743
COPD (%)	1.9	4.1	0.171
CVA (%)	5.1	2.7	0.247
PVD (%)	1.6	2.0	0.728
Carotid artery disease (%)	2.9	2.7	0.934
Low COP (%)	6.7	4.1	0.270
Preoperative mechanically ventilated (%)	3.8	3.4	0.828
Septicemia (%)	2.9	0.7	0.135
Operative procedure			
CABG (%)	57.5	70.7	0.000
Valve (%)	39.0	23.8	0.000
CABG & valve (%)	3.5	5.5	0.491
CPB time (min)	161 ± 79	158 ± 66	0.932
ICU stay (days)	6 ± 13	5 ± 9	0.728
Hospitalization (days)	16 ± 15	17 ± 21	0.848

P values <0.05.

BMI, body mass index; EF, ejection fraction; DM, diabetes mellitus; RF, renal failure; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; PVD, peripheral vascular disease; COP, cardiac output; CABG, coronary artery bypass grafting; CPB, cardiopulmonary bypass; ICU, intensive care unit.

vascular disease, hypertension, DM, and peripheral vascular disease. Theories about why obese patients may incur select postoperative complications include a greater myocardial workload, inadequate myocardial protection of a hypertrophied heart, an imbalance in myocardial oxygen demand and supply, and decreased respiratory muscle reserve.[8] Obesity is increasing as a major health problem in the developing countries, such as Saudi Arabia, because of improvements in living conditions, urbanization, hot climate, dietary habits, and lifestyle. In 1997, El-Hazmi and Warsy reported the prevalence of obesity (BMI ≥30) in the population of Saudi Arabia as 13.05% and 20.26% in males and females, respectively.[9] Recently, Al-Nozha et al. stated that the overall prevalence of obesity (BMI ≥30) in Saudi Arabia has increased to 35.6%, from 22.1%.[5]

We conducted a study on an unselected cohort of patients undergoing cardiac surgery at our cardiothoracic surgical units. As with other reports, the obese patients were more likely to be diabetic and hypertensive.[10,11] However, these differences and others were taken into account when analysis was being performed to assess the impact of obesity on postoperative outcomes. We found no difference in operative or in-hospital mortality in obese patients. This finding is similar to other recent studies viewing outcomes in obese patients.[3,4,12]

Obesity is related to altered pulmonary functions, including decreased lung compliance and increased chest wall impedance, ventilation-perfusion abnormalities, reduced strength and endurance of respiratory muscles, depressed ventilatory drive, obstructive sleep apnea, and bronchospasm.[13] Although these pulmonary function alterations may theoretically lead to higher

Table 2. Complications and postoperative outcomes (expressed as percentages)

	Nonobese (N = 315)	Obese (N = 147)	P value
Operative mortality	5.7	4.8	0.674
IABP use	13.7	10.9	0.407
Exploration	7.3	8.2	0.745
Mediastinitis	0.3	0.7	0.581
Arrhythmia	10.2	10.2	0.988
Permanent pacemaker insertion	0.6	2.7	0.065
CVA	1.9	1.4	0.677
RF	3.2	2.7	0.791
Reintubation	5.4	5.4	0.984
Tracheostomy	3.8	3.4	0.828
Ventilated > 5 days	9.2	8.8	0.900
Deep wound infection	2.7	2.7	0.934
Septicemia	15.2	15.6	0.910
Reoperation	0.3	0.7	0.581
Ischemic limb	1.6	2.0	0.728
Sternal dehiscence	1.6	2.7	0.412
ICU readmission	3.8	2.7	0.552
Hospital readmission	2.9	2.0	0.608

P values <0.05.

IABP, intra-aortic balloon pump; CVA, cerebrovascular accident; RF, renal failure; ICU, intensive care unit.

ventilatory-related complications following cardiac surgery, we found no significant increase in pulmonary complications of tracheostomy (3.4% obese vs. 3.8% nonobese, P = 0.828), reintubation (5.4% obese vs. 5.4% nonobese, P = 0.984), prolonged ventilation (8.8% obese vs. 9.2% nonobese, P = 0.9), or sternal dehiscence (2.7% obese vs. 1.6% nonobese, P = 0.412). Possibly obese patients were treated more aggressively with vigorous pulmonary toilet and physiotherapy by the nursing staff, but our data did not indicate a different treatment strategy by the surgeons or anesthesiologists with respect to perioperative ventilatory management. The current study, like many others, may be underpowered because of the relatively small sampling to detect the increased incidence of ventilatory-related complications in obese patients.

Although some studies have found evidence that obesity and a BMI above 30 is predictive of an increased chance of morbidity,[6,12,14] we demonstrated that increased BMI was not a predictor of any of the major complications. The studies have found that obesity increases the risk of sternal wound infection and leg infections, but not in-hospital death. Quoted risk factors for sternal wound infection included DM, bilateral internal mammary artery bypass grafting, time on bypass, postoperative hemorrhage, age, RF, and COPD. These studies postulated that the problems with wound surveillance, the large and poorly vascularized panniculus, and the higher incidence of hyperglycemia in the obese patient contributed to postoperative complications. Moreover, many obese patients are diabetic, and DM itself confers an added risk of impaired wound healing and heart disease. Nevertheless, our data did not show that obesity was associated with major postoperative complications such as deep wound infection (2.7% obese vs. 2.7% nonobese, P = 0.934), septicemia (15.6% obese vs. 15.2% nonobese, P = 0.910), and mediastinitis (0.7% obese vs. 0.3% nonobese, P = 0.581).

Zacharias et al. reported that increased levels of obesity represent systematically greater risk for the development of new onset atrial fibrillation after cardiac surgery, which may potentially be responsible for substantial utilization of resources and adverse outcome.[15] Their proposed mechanism for the association between atrial fibrillation and obesity was not the DM, as proposed by Kannel et al.,[16] but the left atrial enlargement as a result of elevated plasma volume, altered autonomic tone, and enhanced neurohormonal activation. However, others demonstrated a similar incidence of both atrial and ventricular arrhythmias in their cohorts[4,10,12] with no significant impact on postoperative morbidities or hospital cost. In our study, we found no

Table 3. Crude and adjusted odds ratios (ORs) for postoperative outcomes**

	OR*	95% CI	P value		OR*	95% CI	P value
Operative mortality				Tracheostomy			
Crude	1.33	0.43–4.14	0.63	Crude	1.28	0.25–6.48	0.77
Adjusted	0.95	0.25–3.57	0.94	Adjusted	0.77	0.13–4.72	0.78
IABP use				Ventilated > 5 days			
Crude	1.52	0.74–3.10	0.25	Crude	1.05	0.30–3.69	0.94
Adjusted	2.33	1.00–5.41	0.048	Adjusted	0.96	0.24–3.84	0.95
Exploration				Deep wound infection			
Crude	0.75	0.31–1.79	0.51	Crude	1.80	0.35–9.37	0.49
Adjusted	0.69	0.27–1.76	0.43	Adjusted	2.31	0.37–14.32	0.37
Mediastinitis				Septicemia			
Crude	1.35	0.04–45.97	0.87	Crude	0.82	0.39–1.74	0.60
Adjusted	1.08	0.01–158.43	0.98	Adjusted	0.84	0.36–1.99	0.69
Arrhythmia				Reoperation			
Crude	1.07	0.52–2.22	0.86	Crude	0.14	0.00–4.35	0.26
Adjusted	1.11	0.51–2.45	0.79	Adjusted	0.03	0.00–1.03	0.049
Permanent pacemaker insertion				Ischemic limb			
Crude	0.17	0.02–1.25	0.08	Crude	0.61	0.13–2.93	0.53
Adjusted	0.26	0.04–1.92	0.19	Adjusted	1.04	0.19–5.53	0.96
CVA				Sternal dehiscence			
Crude	1.93	0.30–12.40	0.49	Crude	0.25	0.04–1.65	0.15
Adjusted	1.96	0.27–14.46	0.51	Adjusted	0.23	0.03–1.85	0.17
RF				ICU readmission			
Crude	0.81	0.16–3.99	0.79	Crude	2.58	0.56–11.92	0.22
Adjusted	0.93	0.18–5.13	0.93	Adjusted	3.09	0.58–16.34	0.19
Reintubation				Hospital readmission			
Crude	0.90	0.21–3.88	0.89	Crude	1.34	0.35–5.15	0.67
Adjusted	1.36	0.28–6.75	0.71	Adjusted	0.90	0.22–3.77	0.89

*The reference category is obese group.
**Adjusted for preoperative characteristics: age, gender, smoking, hypertension, diabetes, RF, mechanical ventilation, cerebrovascular disease, peripheral vascular disease, obstructive airway disease, low cardiac output, carotid artery disease, and septicemia.
P values <0.05.
CI, confidence interval; IABP, intra-aortic balloon pump; CVA, cerebrovascular accident; RF, renal failure; ICU, intensive care unit.

significant difference in the incidence of postoperative arrhythmia between the two groups, but the rate of inserting permanent pacemakers was slightly higher among the obese group (2.7% for the obese patients vs. 0.6% for the nonobese; P = 0.065).

We found that the use of IABP was not significantly different between the two groups, but adjusted OR was higher among the nonobese group (adjusted OR = 2.33, P = 0.048). This could be related to a higher threshold for IABP insertion in the obese patients to avoid potential vascular complications, though the number of CABG procedures was significantly higher among the obese group. Conversely, we found that the reoperation-adjusted OR was significantly higher among the obese patients (0.03, P = 0.049). This could not be verified in this retrospective analysis, though others have found, with unclear reasons, that obesity has a protective effect from reoperation for bleeding and other causes.[4)]

Even though we found no association between obesity, postoperative mortality, and the occurrence of most complications after surgery, it would still be advisable for patients to achieve a normal weight, since the literature has confirmed a positive correlation between BMI greater than 30 and readmission, coronary artery disease, hypercholesteremia, heart failure, DM, and hypertension.[10–12)] Further research needs to be done to study the impact of obesity on the intermediate and long-term outcomes of patients after cardiac operations.

This study has several limitations that need to be considered in the interpretation of the above findings. First, the use of BMI as the measure of obesity is not perfect. However, it is the index that correlates most with percent measures of body fat. This study assessed only in-hospital complications. It may thus underestimate the true extent of early complications because it does not collect data on complications occurring after discharge, with the exception of readmission to a hospital within 30 days. Greater sample size or more-sophisticated statistical methods are quite likely required to compensate for this limitation.

In conclusion, we found no obesity to be associated with higher early postoperative mortality or morbidity, with the exception of reoperation. The observed concern of reoperation requires further study. This study indicates that diabetes and hypertension are more prevalent among obese patients. However, it does not support the commonly held perceptions that obese patients are at higher risk of operative mortality. Overall, cardiac surgery can be performed with acceptable outcomes in obese patients.

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