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Original article

No more broken hearts: weight loss after bariatric surgery returns patients' postoperative risk to baseline following coronary surgery

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Abstract

Background: The obesity epidemic is associated with a rise in coronary surgeries because obesity is a risk factor for coronary artery disease. Bariatric surgery is linked to improvement in cardiovascular co-morbidities and left ventricular function. No studies have investigated survival advantage in postoperative bariatric patients after coronary surgery.

Objectives: To determine if there is a benefit after coronary surgery in patients who have previously undergone bariatric surgery.

Setting: National Inpatient Sample.

Methods: We performed a retrospective, cross-sectional analysis of the National Inpatient Sample database from 2003 to 2010. We selected bariatric surgical patients who later underwent coronary surgery (n = 257). A comparison of postoperative complications and mortality after coronary surgery were compared with controls (n = 1442) using χ^2 tests, linear regression analysis, and multivariate logistical regression models.

Results: A subset population was identified as having undergone coronary surgery (n = 1699); of this population, 257 patients had previously undergone bariatric surgery. They were compared with 1442 controls. The majority was male (67.2%), white (82.6%), and treated in an urban environment (96.8%). Patients with bariatric surgery assumed the risk of postoperative complications after coronary surgery that was associated with their new body mass index (BMI) (BMI $<$25 kg/m^2: odds ratio (OR) 1.01, 95% CI .76–1.34, $P = .94$; BMI 25 to $<$35 kg/m^2: OR .20, 95% CI .02–^{2}.16, $P = .19$; BMI $\geq$35 kg/m^2: OR $>$999.9, 95% CI .18 to $>$999.9, $P = .07$). Length of stay was significantly longer in postbariatric patients (BMI $<$25, OR 1.62, 95% CI 1.14–2.30, $P = .007$).

Conclusions: Postoperative bariatric patients have a return to baseline risk of morbidity and mortality after coronary surgery. (Surg Obes Relat Dis 2017;13:1010–1015.) © 2017 American Society for Metabolic and Bariatric Surgery. All rights reserved.

Keywords: bariatric surgery; coronary surgery; obesity; BMI

An inordinate number of coronary artery surgeries are performed each year in the United States, with the Centers for Disease Control estimating more than 500,000 annual cases [1]. These surgeries carry risks even for an ideal candidate; thus, for patients with clinical co-morbidities, perioperative and postoperative morbidity and mortality can drastically increase. These cases also accrue substantial costs for facilities, secondary to large case volumes, costs, and lengths of stay. Thus, information regarding the ramifications of patient attributes and co-morbidities on the costs and resources of coronary surgery could help to

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decrease the substantial healthcare expenditures associated with these procedures and provide targets for quality improvement efforts.

Risk factors associated with cardiac surgery include age, hypertension, body mass index (BMI) <20 or >35 kg/m^2, congestive heart failure, diabetes, renal insufficiency, and acute coronary syndromes, among others [2]. Because obesity is an ongoing epidemic in the United States, with adult obesity rates nearly tripling since the 1960s and current rates suggesting that up to 35% of adults are obese, ample research has been invested in determining the effects and pathophysiology of obesity on poor outcomes associated with coronary surgery [3,4]. Such studies clearly demonstrate significant associations between obesity and critical clinical co-morbidities such as heart disease, neurovascular disease, and diabetes [5]. Studies report that morbidly obese (BMI ≥ 40 kg/m^2) patients who undergo coronary surgery have a significantly increased risk of complications such as sternal wound infections, kidney failure, and prolonged hospitalization and/or ventilation after surgery [6–10]. Postoperative adverse events such as these have been correlated with significantly longer duration of hospital stay. Additionally, cost regression models have demonstrated that prolonged ventilation and deep sternal wound infections, 2 common adverse events in patients with morbid obesity, are independently associated with the highest additional costs [11].

Bariatric surgery has been offered as an excellent treatment for morbid obesity and is currently recommended to patients with a BMI >40 kg/m^2 or >35 kg/m^2 with co-morbidities [12]. Bariatric surgery leads to significant decreases in risk factors associated with cardiac surgery, including arterial blood pressure and atherogenic dyslipidemia. Bariatric surgery, compared with nonsurgical weight loss, is also associated with a decreased prevalence of diabetes and coronary artery disease and a reduction in overall cardiovascular mortality. These results remained significant at follow-up intervals ranging from 6 months to 10 years after surgery, depending on the study methodology [13–18]. Bariatric surgery also serves a cardioprotective role postoperatively with consistent evidence showing improvements in ventricular structure and performance as assessed by echocardiographic indices and reversals of ventricular remodeling [19–24].

To date, no studies have examined whether there is benefit after coronary surgery in the postoperative bariatric surgical patient. Logically, because bariatric surgery has a cardioprotective effect and decreases surgical risk factors, we hypothesized that weight-loss reduction surgery before coronary surgery should improve outcomes and decrease length of hospital stays.

Methods

This study is a cross-sectional analysis using the Nationwide Inpatient Sample (NIS) database for the years 2003 to 2010. NIS is part of the Healthcare Cost and Utilization Project, sponsored by the Agency for Healthcare Research and Quality. It is the largest all-payor inpatient care database that is publicly available in the United States. It contains data from approximately 8 million hospital stays from about 1000 hospitals sampled to approximate a 20% stratified sample of U.S. community hospitals. The NIS database contains publicly available de-identified data that are exempt from institutional review board approval [25]. The International Classification of Disease, 9th Revision (ICD-9) was used in defining the parameters of the study.

Cases included adult (aged ≥ 18 years) inpatients with a history of bariatric surgery (ICD-9: V45.86) who underwent a surgery that involved the heart vessels (ICD-9: 36). Controls were randomly selected with a ratio of 5 controls:1 case from patients with no history of bariatric surgery who underwent a surgery that involved the heart vessels.

The study objective is to examine postoperative outcomes comparing cases to controls, stratified by BMI. Those outcomes included: (i) postoperative complications: none versus one or more of cardiovascular, pulmonary, urinary, bleeding, infectious, and wound complications; (ii) in-hospital mortality; (iii) length of stay, categorized based on quartile classification into short stay ($\leq$75th percentile, $\leq$8 days) and long stay ($>$75th percentile, $>$8 days); and (iv) cost of health services, adjusted for the inflation rate to reflect 2015 dollar value. Cost was categorized based on quartile classification into low cost ($\leq$75th percentile, $\leq$\$37,047.65), and high cost ($>$75th percentile, $>$\$37,047.65).

Independent factors that were considered for their confounding effect included (i) age: <35, 35 to <65, and ≥ 65 years; (ii) sex; (iii) race: white, black, Hispanic, other; (iv) service payor: private, Medicare, Medicaid, self-pay, no charge, other; (v) modified Charlson co-morbidity index score: 0, 1, ≥ 2 [2]; (vi) admission type: nonelective, elective; (vii) hospital region: Northeast, Midwest, West, South; (viii) hospital location: rural, urban; and (ix) hospital teaching status: nonteaching, teaching.

Statistical Analysis

Statistical analysis used weighted data reflecting a national estimate. The records' weights are available in the NIS data and calculated based on the stratification variables that were used in sampling methodology. These variables include hospital geographic region, urban/rural location, teaching status, bed size, and ownership.

Contingency tables and χ^2 tests were applied to examine the baseline characteristics of the study population and to examine the association between each of the independent factors and the postoperative outcomes. Variables with significant association were considered possible confounders and were included in multivariate logistic regression models. OR and 95% CI were calculated using multivariate logistic regression models. Significance level was set as $\alpha = .05$. All data analyses were performed using SAS 9.3 for Windows (SAS Institute Inc., Cary, NC, USA).

Results

Of the database population identified as having undergone coronary surgery (n = 1699), 257 (15.1%) were identified as having previously undergone bariatric surgery and were designated as "cases." The remaining 1442 patients (84.9%) were used as controls. Demographic patient characteristics for both controls and cases are displayed in Table 1. Of the entire study population, the majority were male (67.2%), white (82.6%), had Medicare or private insurance (50.2% and 37.9%, respectively), and were treated in an urban environment (96.8%). Several significant baseline differences were found between cases and controls using χ^2 tests. The cases on average were significantly younger, included more women, had a higher Charlson co-morbidity score, and had a higher BMI. These demographic differences were controlled for as confounders in the multivariate analysis. There were no significant differences in race, type of admission, hospital region or location, and hospital teaching status (Table 1).

Table 1
Descriptive statistics of the study population, n (%)

	Sample population (n = 1699)	History of bariatric surgery		
		Cases (n = 257)	Controls (n = 1442)	*P* value*
Age (yr)				
<35	7 (0.4)	1 (0.3)	6 (0.4)	
35 to < 65	829 (48.8)	184 (71.6)	643 (44.6)	
≥65	865 (50.9)	72 (28.0)	793 (55.0)	<.001
Sex				
Male	1142 (67.2)	117 (45.6)	1027 (71.2)	
Female	557 (32.8)	140 (54.4)	415 (28.8)	<.001
Race				
White	1403 (82.6)	231 (89.8)	1172 (81.3)	
Black	114 (6.7)	12 (4.8)	102 (7.1)	
Hispanic	97 (5.7)	10 (3.9)	87 (6.0)	
Other	85 (5.0)	4 (1.5)	81 (5.6)	.008
Service payor				
Medicare	853 (50.2)	93 (36.0)	761 (52.8)	
Medicaid	95 (5.6)	11 (4.4)	85 (5.9)	
Private	644 (37.9)	136 (52.8)	508 (35.2)	
Self-pay	56 (3.3)	5 (1.9)	50 (3.5)	
No charge	8 (0.5)	3 (1.2)	4 (0.3)	
Other	44 (2.6)	10 (3.8)	33 (2.3)	<.001
Charlson Co-morbidity Index Score				
0	542 (31.9)	52 (20.4)	489 (33.9)	
1	600 (35.3)	101 (39.3)	499 (34.5)	
≥2	559 (32.9)	104 (40.3)	454 (31.5)	<.001
Body mass index (kg/m^2)				
<25	1663 (97.9)	231 (89.7)	1433 (99.4)	
25 to <30	7 (0.4)	6 (2.2)	1 (0.1)	
30 to <35	14 (0.8)	6 (2.4)	7 (0.5)	
35 to <40	14 (0.8)	13 (4.9)	1 (0.1)	
≥40	2 (0.1)	2 (0.8)	0 (0.0)	<.001
Admission				
Non-elective	992 (58.4)	136 (53.1)	855 (59.3)	
Elective	694 (41.6)	121 (46.9)	587 (40.7)	.07
Hospital region				
Northeast	369 (21.7)	43 (16.8)	326 (22.6)	
Midwest	294 (17.3)	62 (24.1)	231 (16.0)	
South	705 (41.5)	96 (37.5)	610 (42.3)	
West	331 (19.5)	56 (21.6)	275 (19.1)	.11
Hospital location				
Rural	54 (3.2)	16 (6.3)	37 (2.6)	
Urban	1645 (96.8)	241 (93.7)	1405 (97.4)	.005
Hospital teaching status				
Nonteaching	729 (42.9)	131 (51.1)	597 (41.4)	
Teaching	970 (57.1)	126 (48.9)	845 (58.6)	.037

*χ^2 test.

Table 2
Multivariate model for multiple postcoronary surgeries outcomes comparing cases with controls

BMI (kg/m^2)	Risk	Patients	% Risk	OR	95% CI	*P* value
<25 (n = 1665)	Postoperative complications	Cases	**46.7**	1.01*	.76–1.34	.94
		Controls	46.2	*Reference*		
	In-hospital mortality	Cases	.9	.41*	.1–1.67	.21
		Controls	1.9	*Reference*		
	Length of stay >8 d	Cases	25.8	1.62†	1.14–2.30	.007
		Controls	20.0	*Reference*		
	Cost >$37,047.65	Cases	30.5	1.45‡	1.03–2.06	.035
		Controls	23.2	*Reference*		
25 to <35 (n = 19)	Postoperative complications	Cases	**41.0**	.20*	.02–2.16	.19
		Controls	44.3	*Reference*		
	In-hospital mortality	Cases	0.0	NA§		
		Controls	0.0	*Reference*		
	Length of stay >8 d	Cases	16.4	.71†	.01–55.02	.88
		Controls	43.5	*Reference*		
	Cost >$37,047.65	Cases	41.3	<.001‡	<.001 to <.001	<.001
		Controls	64.6	*Reference*		
≥35 (n = 15)	Postoperative complications	Cases	**85.5**	>999.9*	.18 to >999.9	.07
		Controls	0.0	*Reference*		
	In-hospital mortality	Cases	0.0	NA§		
		Controls	0.0	*Reference*		
	Length of stay >8 d	Cases	42.6	NA§		
		Controls	0.0	*Reference*		
	Cost >$37,047.65	Cases	71.6	>999.9‡	>999.9 to >999.9	<.001
		Controls	0.0	*Reference*		

BMI = body mass index; OR = adjusted odds ratio; CI = confidence interval; NA = not applicable.
*The model includes history of bariatric surgery, Charlson co-morbidity index score, and admission status.
†The model includes history of bariatric surgery, age, service payor, Charlson co-morbidity index score, admission status, and hospital region.
‡The model includes history of bariatric surgery, age, Charlson co-morbidity index score, admission status, hospital region, and hospital teaching status.
§Odds ratio cannot be calculated because of the very low sample for the response variable.

Bariatric surgery and postoperative complications

A multivariate logistic regression model was constructed and stratified by BMI groups of >35 kg/m^2 (n = 15), 25 to <35 kg/m^2 (n = 19), and <25 kg/m^2 (n = 1665) (Table 2). The model revealed that in patients with a BMI >35, cases had an increased risk of postoperative complications compared with BMI controls with a percent risk of 85.5% in cases versus .0% in controls (BMI ≥35: OR >999.9, 95% CI .18 to >999.9, *P* = .07). When cases were able to decrease their BMI to 25–35 kg/m^2, they began to assume the risk of postoperative complications after coronary surgery associated with their new BMI, with a risk of 41% in cases and 44.3% in controls (BMI 25 to <35 kg/m^2: OR .20, 95% CI .02–2.16, *P* = .19). This also held true when cases assumed a BMI <25 kg/m^2, with a risk of 46.7% in cases and 46.2% in controls (BMI <25: OR 1.01, 95% CI .76–1.34, *P* = .94).

Bariatric surgery and economics

In analyzing the difference in hospital admission, length of stay was significantly longer in the postbariatric patients compared with controls in the BMI group <25 kg/m^2 (OR 1.62, 95% CI 1.14–2.30, *P* = .007).

Discussion

This retrospective cross-sectional analysis found that postoperative bariatric surgical patients assumed the risk of complications associated with their new BMI after coronary surgery in BMI groups <35 kg/m^2. This implies that there is benefit after coronary surgery in the postoperative bariatric surgical patient because bariatric surgery not only affects weight but also confers a survival advantage that returns the patient to the same morbidity and mortality as their control BMI counterparts. This impact of bariatric surgery was independent of age, sex, and co-morbidity index score because these were controlled for as possible confounders in the statistical analysis. The postoperative bariatric patients with BMI >35 did not do as well as their counterparts, and this is suspected to be secondary to the small sample size for this group (n = 15).

This is a novel finding because there are currently no studies investigating survival advantages in postoperative bariatric patients. Multiple studies do show, however, that bariatric surgery acts as a significant intervention to reduce myocardial infarctions, vascular disease, and cardiovascular death by significantly lowering the Framingham risk score for cardiovascular disease [26–28]. Johnson et al. reported a 65% reduction in major micro- and macrovascular events after bariatric surgery compared with matched controls, and Adams et al. reported a decrease in mortality by coronary artery disease by 56% after bariatric surgery, with a decrease by 40% in long-term mortality [29,30]. Other studies have demonstrated that long-term mortality after bariatric surgery is significantly improved compared with obese populations [31]. This is believed to be due to a resolution of co-morbidities that negatively affect life span; an example is a 92% reduction in mortality related to diabetes [32–34]. The benefits seen after coronary surgery in the postoperative bariatric surgical patient are related to the effect of weight loss on cardiac remodeling, ventricular structure, and co-morbidities. Further studies report a reduced risk of cardiovascular events after weight loss surgery, such as regression of left ventricular hypertrophy and improvement of diastolic function [35,36].

Additionally, our study found there was a significantly longer length of stay and increased cost in the bariatric patient compared with controls in the BMI group <25 kg/m^2. The length of stay and cost for the patient population with a BMI >35 kg/m^2 is unreliable given the low sample size ($n = 15$). Patients with a BMI <25 may have had increased length of stay and increased cost for many reasons, the most plausible being the caution exhibited by physicians who are hype-vigilant in regard to patients who have already undergone bariatric surgery before coronary bypass. Additional testing and caution with early discharge may explain this population's increased length of stay and cost, although the database lacks sufficient information to fully elucidate these details. Unfortunately, we did not have enough data points to compare the postoperative bariatric group with other groups with elevated BMI. We suspect that although the postoperative bariatric group has a longer length of stay compared with the controls, the length of stay would be shorter than those patients with an elevated BMI. Further research needs to be done to evaluate this statement.

Strengths of this study include the large sample size and completeness of the NIS data set for metrics studied in this paper. However, there are also several limitations present in this study. The cases on average were significantly younger and skewed more female, which can skew the results to appear more favorable for the postbariatric patients. Our multivariate analysis did account for these discrepancies for certain models. Regardless, further studies with matched cases and controls should be considered. Additionally, although the NIS database is large, it is based on administrative coding and thus has inherent limitations resulting from potential insufficient coding or coding errors. The detail of some metrics is also lost with coding, leading to an observation of increased length of stay and cost in the BMI <25 study group that we are not able to further investigate. Because this is a cross-sectional analysis, there is a possibility of selection and information bias that cannot be disregarded. The study design also relies on others for accurate record keeping, and thus it is not possible to definitively trust the reliability of the data set.

Our findings highlight the need for future studies to investigate the impact of bariatric surgery on subsequent surgical procedures. Other prospective studies should assess whether length of time between surgeries has an impact on the results.

Conclusion

This cross-sectional analysis demonstrates that the postoperative bariatric patient assumed the risk of their new BMI of postoperative complications after coronary surgery. This finding suggests that bariatric surgery confers a survival advantage in obese surgical patients. This in turn suggests that bariatric surgery could be cardioprotective and confers such advantage by decreasing risk factors and obesity-associated co-morbidities such as hyperlipidemia. Future studies investigating these relationships need to be done to confidently state a causative relationship.

Disclosures

The authors have no commercial associations that might be a conflict of interest in relation to this article.

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