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Bariatric Surgery Outcomes in the Elderly: An ACS NSQIP Study

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Abstract
Introduction Mortality and complications following bariatric surgery occur at acceptable rates, but its safety in the elderly population is unknown. We hypothesized that short-term operative outcomes in bariatric surgery patients ≥65 years would be comparable to younger persons.
Methods Patients with a body mass index ≥35 kg/m^2 who underwent bariatric surgery in the 2005–2009 American College of Surgeons National Surgical Quality Improvement Program were identified. Controlling for confounders, multivariate regression was used to predict the impact of age on mortality, major events and prolonged length of stay at 30 days.
Results We identified 48,378 patients who underwent bariatric procedures between 2005 and 2009. Multivariate regression analysis demonstrated advancing age trended towards predicting mortality, but was not statistically significant. Additionally, patients ≥65 years did not experience higher risk of major complications for either open or laparoscopic procedures. However, patients age ≥65 years were more likely to experience prolonged length of stay for both open and laparoscopic procedures.
Conclusion This multi-hospital study demonstrates older age predicts short-term prolonged length of stay but not major events following bariatric surgery. Older age trends toward predicting mortality, but it is not statistically significant.

Keywords NSQIP · Bariatric · Elderly · Mortality · Complications

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Introduction

Bariatric surgery results in both long-term weight loss and reduced mortality.[1–3] Compared to medical controls, the Swedish Obesity Study reported a 24% reduction in overall mortality in bariatric surgical patients,[1] but frequently, the primary issue of concern regarding bariatric surgery has been perioperative safety. For Roux-en-Y gastric bypass and laparoscopic adjustable gastric banding, the previously reported overall 30-day mortality rate was 0.3%, with 4.3% of patients having experienced at least one major adverse event.[4] Altogether, mortality and complications following bariatric surgery occur at acceptable rates.

The population of people ≥65 years in the USA is projected to reach 69.4 million people by 2030.[5] Currently, 35% of patients ≥60 years suffer from obesity,[6] and the prevalence of obesity within the elderly population is anticipated to grow as the baby boomer population continues to age. Therefore, the perioperative safety of elderly patients who undergo bariatric surgery has become an active area of investigation. To date, evidence regarding the safety of bariatric surgery in the elderly population is contradictory. Flum et al.[7] described a 30-day mortality rate of 4.8% and 1.7% in 1,517 Medicare enrollees ≥65 years and 14,638 disabled enrollees <65 years, respectively. However, prospective data from the Longitudinal Assessment of Bariatric Surgery Consortium did not identify advancing age as a perioperative risk factor for meeting their composite end point of death, venous thromboembolism, need for percutaneous procedure and failure to discharge from the hospital at 30 days.[4] Therefore, further evidence is required to assess the impact of older age on short-term operative outcomes after bariatric surgery to address the question: Does elderly age alone predict perioperative adverse outcomes following bariatric surgery?

We hypothesized that age alone would not predict adverse outcomes following bariatric surgery during the perioperative period. To address this hypothesis, we utilized the American College of Surgeon's National Surgical Quality Improvement Program (ACS NSQIP) database. This is a robust, nationwide database that collects demographic variables, comorbidities, intraoperative data and postoperative events for 30 days. As such, we sought to determine risk factors associated with mortality, major adverse events, and prolonged length of stay (PLOS) using multivariate regression with adjustment for confounding variables.

Materials and Methods

Data Source

For our study, we utilized the 2005–2009 ACS NSQIP Participant Use File, which represents a large, prospective, multi-hospital database that collects detailed data from patients undergoing inpatient and outpatient surgical procedures from over 250 participating university and private sector medical centers. NSQIP collects information on preoperative risk factors, laboratory values, intraoperative variables, and 30-day postoperative mortality and morbidity outcomes.[8,9] Approval to conduct the study was obtained from both the University of Minnesota Institutional Review Board and ACS NSQIP. The ACS NSQIP and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

Patients

We identified patients over the age of 18 who underwent bariatric surgery using specific current procedure terminology (CPT) codes. The bariatric procedures that currently can be identified using specific CPT codes include laparoscopic Roux-en-Y gastric bypass (43644), long-limb laparoscopic Roux-en-Y gastric bypass (43645), open Roux-en-Y gastric bypass (43846), long-limb open Roux-en-Y gastric bypass (43847), laparoscopic adjustable gastric banding (43770), vertical banded gastroplasty (43842) and open duodenal switch (43845). We excluded patients with a body mass index (BMI) <35 kg/m^2. Patients were then categorized into five groups according to the following age ranges in order to assess the impact of age on short-term operative outcomes following bariatric surgery: 19–35, 36–49, 50–64, and ≥65 years. Patients over 65 years of age were further divided into 65–69 and ≥70 year groups when analyzing risk factors for major postoperative events and PLOS. There were too few deaths to analyze these age groups separately with regards to risk factors for mortality.

Comorbid conditions analyzed within our regression within the ACS NSQIP database include functional health status, chronic obstructive pulmonary disease, pneumonia, ascites, congestive heart failure, myocardial infarction within 6 months, previous percutaneous coronary intervention, previous cardiac surgery, angina, hypertension requiring medication, peripheral vascular disease requiring revascularization or amputation, rest pain, gangrene, acute renal failure, current need for hemodialysis, hemiplegia, paraplegia, quadriplegia, history of transient ischemic attacks, history of cerebrovascular accident with or without neurological deficit, open wound infection, chronic steroid use, bleeding disorders, and prior operation within 30 days.

Preoperative laboratory values analyzed included sodium, blood urea nitrogen, creatinine, albumin, bilirubin, serum glutamic oxaloacetic transaminase, alkaline phosphatase, hematocrit, partial thromboplastin time, prothrombin time, and international normalized ratio.

Intraoperative variables and events include wound classification, American Society for Anesthesiology Classification score, number of red blood cell units given, total operation time, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, and unplanned intubation.

Outcome Definitions

We examined 30-day mortality, the occurrence of major postoperative events, and the proportion of patients with PLOS. Length of stay was defined as the number of days from operation to hospital discharge. Prolonged LOS was defined as a stay that was equal to or over the 90th percentile. Consequently, for laparoscopic and open procedures PLOS was defined as ≥3 and ≥6 days, respectively. Major postoperative events included deep incisional surgical site infection, organ or deep tissue space surgical site infection, wound disruptions, pneumonia, need for reintubation, requiring >48 h of ventilator support, pulmonary embolism, progressive renal insufficiency, acute renal failure, cerebrovascular accidents, coma lasting longer than 24 h, peripheral nerve injury, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, hemorrhage requiring transfusion, sepsis, septic shock, and the need for return to the operating room.

Statistical Analyses

For our bivariate analysis, we compared demographics, preoperative comorbid factors, preoperative laboratory values, intraoperative data, 30-day operative mortality, postoperative complications, and LOS by age groups using chi-square tests. We then used the Cochran–Armitage analysis to evaluate unadjusted trends in bariatric surgery in the elderly over time.

To confirm the observations in our bivariate analysis, we performed six multivariable logistic regression analyses to predict the association between older age and the likelihood of developing adverse short-term postoperative outcomes, after adjusting for pre- and intraoperative covariates as well as stratifying by approach (i.e., open versus laparoscopic). Specifically, we examined 30-day operative mortality, the likelihood of developing any major postoperative complication, and PLOS. Reference groups for age and BMI were determined by the average values for the study population.

For our 30-day operative mortality multivariate models, we combined our 65–69 year group with our ≥70 year group due to the low number of deaths in the ≥70 year age group; the prevalence of major events and PLOS was high enough that they could be analyzed as two distinct groups in the multivariate models. Preoperative lab abnormalities such as high serum creatinine, hypoalbuminemia, hyponatremia, hypernatremia, and abnormal hematocrit were of such low prevalence among patients who died that they had to be excluded from the multivariate regression analysis to preserve stability in the mortality models.

Patients with missing values for the potential confounders including comorbidities, preoperative laboratory values, and intraoperative variables were included as an unknown category in our regression analyses. However, to confirm whether our estimates were influenced by including patients with missing values, we performed sensitivity analyses, repeating our multivariable analyses after excluding those patients with missing data for other pre- and intraoperative variables. Additionally, we evaluated potential interactions between age and all other variables in the model to identify whether the effect of age was modified by additional factors in our model. Interactions were considered significant if $P<0.1$.

P values were considered significant when <0.05. Statistical analyses were performed in Statistical Analysis Software version 9.2 (SAS Institute, Cary, NC, USA).

Results

Demographics

We identified 48,378 patients who underwent laparoscopic Roux-en-Y gastric bypass, open Roux-en-Y gastric bypass, laparoscopic adjustable gastric banding, duodenal switch, and vertical banded gastroplasty in the 2005–2009 ACS NSQIP database. Within this population, there were 1,994 (4.1%) patients over the age of 65 years. The average age (mean±SD) and BMI were 45.1±11.4 years and 46.8±7.5 kg/m^2, respectively. Demographic information, prevalence of comorbid conditions, and preoperative laboratory values are shown in Table 1 stratified by age group.

As the number of hospitals that contributed to the ACS NSQIP database has increased over the years, so have the number of annual bariatric operations. While the total proportion of the bariatric operations within the 19–34, 35–49 and 50–64 years has remained relatively consistent, the proportion of bariatric procedures in the older population (age≥65 years) has significantly increased from 1.9% in 2005 to 4.8% in 2009 (Fig. 1, $P<0.001$). This represents a 60% increase.

While older patients are undergoing more bariatric operations in 2009 compared to earlier years, the type of bariatric procedures performed in this age group significantly changes compared to patients <65 years of age. Between the ages of 65–69 years, the proportion of patients undergoing Roux-en-Y gastric bypass significantly decreases and the proportion of patients undergoing laparoscopic adjustable gastric banding significantly increases compared to the younger age groups. (Fig. 2, $P<0.001$).

30-Day Operative Mortality

Overall mortality was low in this study with 72 deaths out of 48,378 operations for an overall 30-day mortality rate of 0.15% (Table 2). Mortality rates did increase as patients aged with a 0.1% mortality rate among 35–49 year olds and a 0.4% and 0.6% mortality rate among 65–69 and ≥70 year olds, respectively. However, this trend was not statistically significant ($P=0.15$). Of the eight deaths in patients ≥65 years, five occurred following laparoscopic Roux-en-Y gastric bypass, two following duodenal switch and one following open Roux-en-Y gastric bypass.

Table 1 Demographic and co-morbid variables stratified by age (N=48,378)

	19–34 years, 19.6% (N=9,486) (%)	35–49 years, 43.1% (N=2,0834) (%)	50–64 years, 33.2% (N=16,064) (%)	65–69 years, 3.4% (N=1,638) (%)	≥70 years, 0.7% (N=356) (%)	P value
Sex						<0.0001
Female	84.5	79.8	76.2	69.7	68.0	
Race						<0.0001
White	64.8	71.5	80.3	85.1	85.7	
Black	16.2	14.2	9.2	5.8	4.2	
Hispanic	9.5	6.1	3.2	2.8	1.9	
Asians	1.1	1.0	0.7	0.5	0.3	
Unknown	8.5	7.2	6.6	5.7	7.9	
History of smoking within 1 year	18.4	13.7	8.1	3.5	2.5	<0.0001
Functional status						<0.0001
Independent	99.7	99.5	98.9	98.1	96.9	
Other[a]	0.3	0.5	1.1	1.9	3.1	
ASA classification						<0.0001
1–2	48.6	36.1	23.8	14.3	8.4	
3–4	51.3	63.9	76.2	85.7	91.6	
Vascular co-morbidities[b]	0	0.2	0.4	0.8	1.7	<0.0001
Cardiac co-morbidities[c]	0.3	1.5	6.5	16.2	15.4	<0.0001
Hypertension requiring medication	24.2	48.8	75.3	86.9	85.1	<0.001
Pulmonary co-morbidities[d]	23.6	26.4	34.0	41.1	42.7	<0.0001
Diabetes mellitus	11.6	23.9	41.2	51.2	47.5	<0.0001
Serum sodium						<0.0001
<136 mmol/L	4.6	5.8	5.6	7.0	7.0	
136–144 mmol/L	82.1	82.1	83.3	81.4	81.2	
>145 mmol/L	0.8	1.0	1.9	2.3	4.8	
Creatinine>1.5 mg/dL	0.4	0.8	2.6	5.7	8.7	<0.0001
Albumin<3.0 g/dL	0.2	0.3	0.3	0.2	0.3	0.59

Less than 5% of the patients used steroids for a chronic condition, had renal failure, had ascites, had esophageal varices, had bleeding disorders, required more than four RBCs units 72 h before surgery, had preoperative sepsis, had a prior operation within 30 days of surgery, had an emergent surgery, or had concurrent procedures

ASA American Society of Anesthesiologists

[a] Other functional status includes partially dependent and totally dependent

[b] Vascular comorbidities include history of revascularization/amputation for peripheral vascular disease and history of rest pain or gangrene

[c] Cardiac comorbidities include: history of congestive heart failure, myocardial infarction, or angina; previous coronary intervention (PCI) or cardiac surgery

[d] Pulmonary comorbidities include: dyspnea, ventilator dependency, chronic obstructive pulmonary disease (COPD), or current pneumonia

Multivariate regression found a trend toward older age being a predictor of mortality; however, it was not statistically significant (laparoscopic, P=0.43; open, P=0.11, Table 3). In open surgeries, BMI≥60 kg/m^2 (vs. 45–49 kg/m^2) was a significant predictor of mortality. For laparoscopic procedures, significant predictors of mortality included BMI≥60 kg/m^2 (vs. 45–49 kg/m^2), male sex, presence of diabetes, and presence of cardiac comorbidities. As the number of deaths from laparoscopic adjustable gastric banding was low and since there were no documented deaths from banding in patients ≥65 years old, this model was further adjusted to determine the risk associated with undergoing laparoscopic Roux-en-Y versus banding. The odds ratio for 30-day mortality was significant for undergoing laparoscopic Roux-en-Y versus laparoscopic banding.

Of the 72 deaths, only two patients had a documented albumin <3 gm/dL, ten patients had a preoperative hematocrit <37 gm/dL, six patients had preoperative serum sodium abnormalities, and four patients had a serum creatinine >1.5 mg/dL. Therefore, these lab values were excluded from the regression analysis based on their low incidence in this patient population.

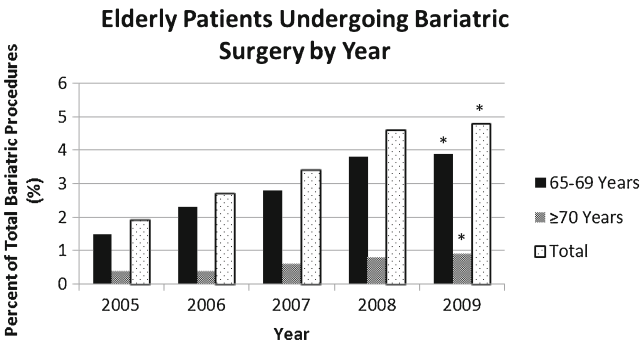

Fig. 1 Trend of increased bariatric surgical procedures among elderly patients. The trend for the percentage of patients in each group, 65–69 and ≥70 years, as well as the total percentage of both groups significantly increased over the 2005–2009 period by 60%. $^*P<0.001$

Major Adverse Events

The overall occurrence of major events was most prevalent in the 50–64-year-old group at 4.7%, followed by the 65–69-year-old patients at 4.3%, and the least prevalent in the ≥70 year olds at 2.8%. Organ space infections, intubations lasting longer than 48 h, acute renal failure, sepsis, and pulmonary embolism were more prevalent among 65–69 year olds compared to younger age groups (Table 2).

When stratified by open versus laparoscopic, elderly age was not identified to be a predictor of adverse events after adjusting for potential confounders (Table 4). For open procedures, patients 50–64 years (vs. 35–49 years), with a BMI>50 kg/m^2 (vs. 45–49 kg/m^2) and a preoperative albumin<3 g/dL (vs. ≥3 g/dL) all experienced higher risk for major postoperative events. For laparoscopic procedures, patients 50–64 years (vs. 35–49 years), with BMI>55 kg/m^2 (vs. 45–49 kg/m^2), diabetes, cardiac comorbidities, and a

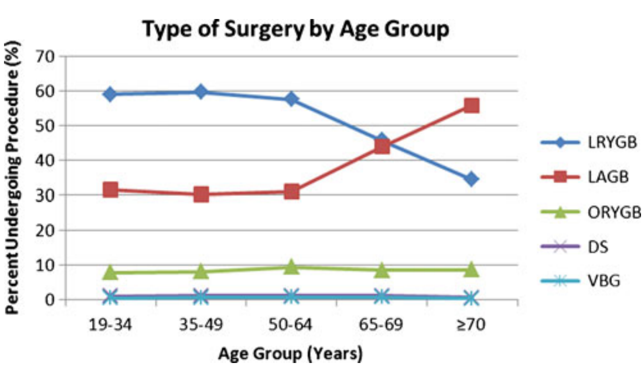

Fig. 2 Percentage of patients in each age group undergoing specific bariatric operations between 2005 and 2009. In the 65–69- and ≥70-year age groups, there is a significant trend with respect to a decreased proportion of elderly patients undergoing laparoscopic Roux-en-Y gastric bypass and an increased proportion of elderly patients undergoing laparoscopic adjustable gastric banding. $^*P<0.001$, trend analysis is significant. *LRYGB* Laparoscopic Roux-en-Y gastric bypass, *LAGB* laparoscopic adjustable gastric banding, *ORYGB* open Roux-en-Y gastric bypass, *DS* duodenal switch, *VBG* vertical banded gastroplasty

moderate or severe ASA score experienced higher risk of major postoperative events. Protective effects from major events were found in patients who underwent laparoscopic procedures in lower BMI patients.

Prolonged Length of Stay

Prolonged LOS analysis demonstrated that the proportion of patients with a hospital stay exceeding the 90th percentile did not substantially increase in both patients aged 65–69 and ≥70 years for laparoscopic procedures; however, the proportion of patients demonstrating PLOS did increase from 21% in the 50–64-year group to 50% in the ≥70-year group following open procedures (Table 2, $P<0.001$).

Multivariable analysis showed that PLOS was predicted by age ≥65 years (vs. 35–49 years), BMI≥55 kg/m^2 (vs. 45–49 kg/m^2) presence of diabetes and a preoperative serum creatinine ≥1.6 mg/dL in patients who underwent open procedures (Table 4). A protective effect was seen in the open patient population in the 19–34-year age group.

For laparoscopic procedures, PLOS was predicted by the age groups 50–64 and 65–69 years (vs. 35–49 years) as well as a BMI≥50 kg/m^2 (vs. 45–49 kg/m^2), male sex, presence of diabetes, presence of both cardiac and pulmonary comorbidities, a moderate or severe ASA score, and preoperative serum creatinine ≥1.6 gm/dL. Age <35 years and BMI<45 kg/m^2 were protective with regards to PLOS following laparoscopic bariatric procedures. Prolonged LOS was not predicted by age ≥70 years in the laparoscopic cohort.

Discussion

The current study of ACS NSQIP showed that older age (≥65 years) predicted PLOS but did not predict major adverse events, and while elderly age trended toward predicting mortality, it was ultimately not significant. To our knowledge, the current work is one of the largest to investigate the perioperative risk associated with advancing age following bariatric surgery.

Flum et al.[7] reported the most conclusive evidence to date regarding bariatric surgery in the elderly. The Flum study followed 16,155 disabled and elderly Medicare beneficiaries who underwent bariatric surgery between 1997 and 2002. They identified age ≥65 years as a principal risk factor for mortality 90-days postoperatively with additional risk factors being male sex and higher modified Charlson Comorbidity Index scores. Our study differs in several ways; first, the Flum study utilized data from Medicare beneficiaries only regardless of age, with all patients under 65 being disabled. Our study utilized

Table 2 Mortality, LOS and major events stratified by age group (N=48,378)

	19–34 years, % (*N*)	35–49 years, % (*N*)	50–64 years, % (*N*)	65–69 years, % (*N*)	≥70 years, % (*N*)	*P* value
Major events						
Infection						
Deep incisional	0.2 (18)	0.3 (59)	0.4 (65)	0.2 (3)	0 (0)	<0.02
Organ space	0.4 (38)	0.6 (135)	0.6 (104)	0.7 (11)	0.3 (1)	0.07
Dehiscence	0.1 (13)	0.2 (42)	0.3 (45)	0.1 (2)	0.3 (1)	0.14
Respiratory						
Pneumonia	0.4 (38)	0.5 (106)	0.7 (108)	0.7 (12)	0.6 (2)	0.04
Reintubation	0.1 (13)	0.3 (65)	0.7 (107)	0.7 (11)	0.3 (1)	<0.0001
Intubated>48 h	0.2 (23)	0.3 (55)	0.5 (82)	0.7 (12)	0 (0)	<0.0001
PE	0.2 (15)	0.1 (21)	0.3 (41)	0.5 (8)	0 (0)	0.0002
Renal						
Prog. insufficiency	0.1 (8)	0.1 (30)	0.3 (44)	0.3 (5)	0.3 (1)	0.003
Acute failure	0.1 (10)	0.1 (17)	0.2 (36)	0.4 (6)	0.3 (1)	0.0005
Cardiovascular						
MI	0.0 (1)	0.0 (6)	0.0 (7)	0.0 (0)	0.3 (1)	0.04
Required CPR	0.0 (2)	0.1 (19)	0.2 (28)	0.1 (1)	0 (0.0)	0.005
Sepsis	0.4 (43)	0.7 (151)	0.7 (118)	1.0 (17)	0.8 (3)	0.02
Septic shock	0.1 (14)	0.2 (53)	0.5 (74)	0.4 (7)	0 (0)	<0.0001
Return to OR	2.1 (196)	2.2 (465)	2.6 (416)	2.1 (35)	2.0 (7)	0.06
Total	3.0 (289)	3.6 (752)	4.7 (748)	4.3 (71)	2.8 (10)	<0.0001
PLOS						
Open	12 (105)	16 (336)	21 (381)	29 (49)	50 (17)	<0.0001
Laparoscopic	17 (1,471)	19 (3,550)	23 (3,270)	23 (338)	20 (65)	<0.0001
30-day mortality (overall)	0.1 (7)	0.1 (24)	0.2 (33)	0.4 (6)	0.6 (2)	0.15

Neurological complications, such as cerebrovascular accident, coma lasting >24 h and peripheral nerve injury, as well as perioperative bleeding that required transfusion were investigated but not reported due to their very low prevalence and lack of significance between groups

PE pulmonary embolism, *Prog.* progressive, *MI* myocardial infarction, *CPR* cardiopulmonary resuscitation, *OR* operating room, *PLOS* prolonged length of stay

younger comparison groups more representative of the general bariatric population. Second, our study was not dependent on submitted claims data, with the ACS NSQIP database providing multiple variables for risk adjustment. These variables may confound the association between age and operative outcomes, and they were not assessed in previous studies. Third, the Flum study excluded all laparoscopic procedures because specific CPT codes were not available at the time the study was published. Here, we were able to thoroughly analyze laparoscopic procedures and separate them from open approaches as accurate CPT codes have since been employed. This is an important contribution as the improved safety of laparoscopic bariatric surgery over open procedures has since been thoroughly described.[10,11]

We have demonstrated here that the proportion of elderly patients undergoing bariatric surgery has increased by 60% over the past 5 years. As procedures become less invasive and the baby boomer generation continues to age, bariatric surgery in the elderly will likely continue to increase. One important finding from this study is the inflection point observed in procedure type by increasing age group, with patients ≥65 years undergoing significantly more laparoscopic adjustable gastric bands and significantly fewer laparoscopic Roux-en-Y gastric bypasses compared to the younger cohorts (Fig. 2). This trend toward a less rigorous procedure is likely a result of previous studies demonstrating increased mortality and morbidity for elderly patients undergoing bariatric surgery.

The significant increase in laparoscopic adjustable gastric bands in patients ≥65 years compared to younger patient populations could partly explain the reduced effect elderly age has on mortality compared to previous studies. Therefore, we adjusted for banding versus laparoscopic Roux-en-Y gastric bypass in our multivariate regression model. While laparoscopic Roux-en-Y gastric bypass was determined to be a risk factor for mortality, this adjustment did not have an effect on age as a predictor of mortality. Another possible explanation for older patients having comparable risk regarding operative mortality is the overall

Table 3 Predictors of mortality following bariatric procedures stratified by open versus laparoscopic (N=48,378)

Predictors	Open (N=5,017) OR (95% CI)	Laparoscopic (N=43,361) OR (95% CI)
Age (years)		
19–34	1.3 (0.4, 4.4)	0.5 (0.1, 1.8)
35–49	Ref.	Ref.
50–64	1.2 (0.4, 3.1)	1.2 (0.6, 2.4)
≥65	3.3 (0.8, 14.3)	1.9 (0.6, 5.6)
BMI (kg/m^2)		
35–39	1.1 (0.1, 10.8)	1.3 (0.4, 3.9)
40–44	1.3 (0.2, 6.4)	1.0 (0.4, 2.6)
45–49	Ref.	Ref.
50–54	1.8 (0.4, 8.1)	2.3 (0.9, 5.8)
55–59	2.6 (0.6, 11.7)	2.1 (0.7, 6.2)
≥60	*5.3 (1.4, 20.1)*	*3.6 (1.3, 9.9)*
Ethnicity	NS	NS
Male sex	1.3 (0.6, 3.0)	*2.4 (1.3, 4.3)*
Diabetes	1.8 (0.8, 4.3)	*2.4 (1.3, 4.6)*
Tobacco use	0.3 (0.0, 2.1)	0.7 (0.3, 2.1)
Cardiac comorbidities	2.0 (0.5, 7.7)	*5.0 (2.4, 10.4)*
Severe ASA score	2.1 (0.5, 9.7)	1.4 (0.5, 3.4)
Pulmonary comorbidities	1.1 (0.5, 2.4)	1.8 (1.0, 3.3)
LRYGB vs. LAGB	NT	*3.7 (1.4, 9.6)*
Total events, N (%)	25 (0.5)	47 (0.1)
C-statistic	0.77	0.72

Due to the low prevalence of deaths in the ≥70-year cohort, it was combined with the 65–69-year group for this model. Mortality analysis also adjusted for admission year but there was no significant effect. Significant ORs are displayed in italics

OR odds ratio, *CI* confidence interval, *BMI* body mass index, *NS* not significant, *ASA* American Society of Anesthesiologists, *LRYGB* laparoscopic Roux-en-Y gastric bypass, *LAGB* laparoscopic adjustable gastric banding, *NT* not tested

low incidence of events with only eight deaths occurring in patients ≥65 years. As the database continues to be populated over the next several years and the mortality numbers increase, elderly age may become more or less significant.

While elderly age was not a significant risk factor for major adverse events, we identified several other important predictors including BMI≥55 kg/m^2, albumin<3 gm/dL, and presence of cardiac comorbidities. Elderly age did predict PLOS except in the ≥70-year group following laparoscopic procedures, and several other risk factors for PLOS identified include BMI>55 kg/m^2, diabetes, and creatinine≥1.6 mg/dL. These findings support the use of the ACS NSQIP database in addressing a question that could be complicated by several confounding variables. While age is important, we have also identified several other factors that should be given equal, if not greater, attention when performing perioperative risk assessments for any patient undergoing bariatric surgery, such as BMI over 55 kg/m^2. Very recently, an ACS NSQIP study published a nomogram to serve as a risk assessment tool for patients undergoing bariatric surgery.[12] They concluded, and we agree, that age alone should not serve as an absolute contraindication to bariatric surgery.

Additional studies utilizing national databases have also reported increased complication rates and mortality among the elderly population. The University HealthSystem Consortium Clinical Database was used to analyze outcomes in the elderly following bariatric surgery. This study found the elderly population experienced increased mortality and complications at a greater frequency, but the observed mortality was found to be less than the expected mortality.[13] Limitations of this study included subjective definitions of complications, lack of BMI values, and restriction of the study population to academic centers. A National Inpatient Survey study identified advancing age, particularly ≥65 years, to be an independent risk factor for mortality; however, procedure-specific information and BMI were not available.[14] Single institution studies have been variable in their conclusions regarding perioperative safety of the elderly following bariatric surgery.[15–19]

The utility of bariatric surgery in the elderly population is often queried. While this is beyond the scope of this paper, previous studies have demonstrated significant excess weight loss, improvement in quality of life, reduction in daily medication use, and improvement in obesity-related comorbid illness in the elderly population.[15,16,18,19] Therefore, elderly patients do experience the benefits of bariatric surgery with acceptable rates of morbidity and mortality, and age alone should not function as an absolute deterrent.

Table 4 Predictors of major events and PLOS after bariatric procedures stratified by open versus laparoscopic

Predictors	Major events open, N=5,017 OR (95% CI)	Major events laparoscopic, N=43,361 OR (95% CI)	PLOS open, N=4,992[a] OR (95% CI)	PLOS laparoscopic N=43,314[a] OR (95% CI)
Age (years)				
19–34	1.0 (0.7, 1.3)	0.8 (0.7, 1.0)	*0.7 (0.6, 0.9)*	*0.9 (0.8, 0.9)*
35–49	Ref.	Ref.	Ref.	Ref.
50–64	*1.4 (1.1, 1.7)*	*1.2 (1.0, 1.3)*	1.2 (1.0, 1.5)	*1.2 (1.2, 1.3)*
65–69	0.9 (0.5, 1.6)	1.1 (0.8, 1.5)	*1.8 (1.2, 2.6)*	*1.2 (1.1, 1.4)*
≥70	0.7 (0.1, 2.9)	0.7 (0.3, 1.4)	*4.2 (2.1, 8.5)*	1.1 (0.8, 1.4)
BMI (kg/m^2)				
35–39	1.0 (0.6, 1.6)	*0.9 (0.7, 1.0)*	1.0 (0.7, 1.4)	*0.8 (0.7, 0.8)*
40–44	1.2 (0.9, 1.6)	1.0 (0.9, 1.2)	1.0 (0.8, 1.3)	*0.8 (0.8, 0.9)*
45–49	Ref.	Ref.	Ref.	Ref.
50–54	*1.4 (1.0, 2.0)*	1.0 (0.9, 1.2)	1.2 (0.9, 1.5)	*1.1 (1.0, 1.2)*
55–59	*1.5 (1.0, 2.1)*	*1.4 (1.1, 1.7)*	*1.4 (1.1, 1.8)*	*1.3 (1.2, 1.5)*
≥60	*2.0 (1.5, 2.8)*	*1.5 (1.2, 1.8)*	*1.5 (1.2, 1.9)*	*1.7 (1.6, 1.9)*
Ethnicity				
African-American	NS	*1.2 (1.0, 1.4)*	NS	*1.1 (1.0, 1.2)*
Hispanic		1.1 (0.9, 1.4)		*1.3 (1.2, 1.5)*
Asian/PI		*0.8 (0.6, 1.0)*		*0.8 (0.7, 0.9)*
Caucasian		Ref.		Ref.
Male sex	0.9 (0.7, 1.1)	0.9 (0.8, 1.1)	1.0 (0.8, 1.2)	*1.1 (1.0, 1.1)*
Diabetes	1.2 (1.0, 1.5)	*1.2 (1.0, 1.3)*	*1.4 (1.2, 1.6)*	*1.3 (1.3, 1.4)*
Tobacco use	1.1 (0.9, 1.5)	*1.2 (1.0, 1.4)*	1.2 (0.9, 1.4)	*1.1 (1.0, 1.2)*
Cardiac Comorb.	1.4 (0.9, 2.2)	*1.3 (1.0, 1.4)*	1.3 (1.0, 1.9)	*1.2 (1.1, 1.4)*
Severe ASA score	1.0 (0.7, 1.3)	*1.2 (1.1, 1.4)*	1.4 (1.2, 1.8)	*1.2 (1.1, 1.3)*
Pulm. Comorb.	1.2 (1.0, 1.5)	1.1 (1.0, 1.2)	1.1 (1.0, 1.3)	*1.1 (1.0, 1.2)*
Creatinine (mg/dL) ≥1.6 vs. ≤1.5	1.4 (0.8, 2.6)	*1.9 (1.4, 2.6)*	*1.8 (1.1, 2.8)*	*1.3 (1.1, 1.6)*
Albumin (g/dL) ≤3 vs. >3	*4.4 (1.4, 13.3)*	1.8 (0.9, 3.8)	1.7 (0.5, 6.1)	1.5 (1.0, 2.2)
Serum sodium (mmol/L)				
≤135	*1.5 (1.1, 2.2)*	NS	NS	NS
135–144	Ref.			
≥145	1.0 (0.4, 2.1)			
Hemotocrit (g/dL)				
<37	NS	1.0 (0.8, 1.1)	NS	*1.1 (1.1, 1.2)*
37–44		Ref.		Ref.
>44		*1.2 (1.0, 1.4)*		0.9 (0.9, 1.0)
Total events, N (%)	437 (8.7)	1433 (3.3)	888 (17.8)	8694 (20.1)
C-Index of model	0.62	0.60	0.65	0.63

Significant ORs are displayed in italics. PLOS is defined as those who experienced hospital stay beyond 90th percentile of the cohort. Analysis also adjusted for admission year, but there was no significant effect

PLOS prolonged length of stay, *OR* odds ratio, *CI* confidence interval, *BMI* body mass index, *PI* Pacific Islander, *Comorb.* comorbidities, *ASA* American Society of Anesthesiologists, *Pulm.* pulmonary

[a] For prolonged LOS multivariate analyses, only patients discharged alive were included

While this study contributes to the current knowledge of bariatric surgery, several limitations exist. First, ACS NSQIP does not provide procedure specific outcomes. Therefore, we are unable to study complications such as strictures, anastomotic leaks, and marginal ulcers. Second, the database does not provide information on surgeon volume, a factor that has proven to be significant in previous studies.[20–22] Finally, ACS NSQIP does not follow patients beyond 30 days; therefore, long-term follow-up data are not available. Despite these limitations, our results are derived from a large, national patient sample, which reduces the effect of bias inherent in single-institutional studies.

The strengths of the ACS NSQIP database include a diverse population, rigorous requirements for data collection and entry, as well as a robust number of available patient records. The knowledge provided by the vast number of available preoperative demographic and medical comorbidity variables assists in distinguishing the true risk factors involved with major adverse events and mortality.

As the proportion of elderly patients within the population continues to increase, the prevalence of obesity within the elderly population will also rise. The evidence provided in this study will provide a framework for the assessment of perioperative safety in the elderly bariatric population. The change in operative approach over the previous 5 years, with more available laparoscopy and increased gastric band placement, provided an impetus to investigate the risk of age on adverse outcomes with a current database. While our data demonstrate that elderly age does not significantly predict mortality, these data should be interpreted with some caution since our confidence intervals do approach significance. Future studies are warranted to confirm these results because as event rates increase annually so will the ability to detect the effect of age.

Conclusion

Referring physicians and bariatric surgeons should continue to proceed with caution when assessing the candidacy of an elderly, obese patient for bariatric surgery. Elderly patients should not be denied surgery solely based on their age, although the presence of significant risk factors identified in this study as well as elderly age may certainly preclude surgical treatment. These data provide important information to physicians, patients, and payers when determining appropriate surgical intervention for obesity in an elderly patient.

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Discussant

Dr. Bruce D. Schirmer (Charlottesville, VA): I congratulate Dr. Dorman and his coauthors from the University of Minnesota for doing this excellent analysis of the effect of age on outcomes after bariatric surgery. The NSQIP database from 2005–2009 provides an excellent source of procedure-specific outcomes information for the immediate postoperative period. The findings of this study are important for two reasons. First, they substantiate the performance of the occasional bariatric operation on an individual greater than age 65. By 2009, that represented nearly 5% of the operations reported. Insurance companies have not, to my knowledge, yet denied payment based on age, and this report should abort any such potential action. Second, this is yet another large review of a high quality database that confirms the overall 30-day mortality of bariatric surgery procedures to be incredibly low, given the patient population which is undergoing surgery. The overall mortality rate of 0.15% in this series is indeed a remarkable attestation to the significant strides the bariatric surgery community has made toward patient safety and optimal outcomes during the last decade. I think this study will be a frequently cited one going forward when one discusses the safety of bariatric surgery.

Much of the findings of the study, however, are not new and are predictable. This paper confirms that higher BMI, male sex, significant comorbidities, and age to some extent, predict less good outcomes. The age factor was not significant alone, but there was a clear trend toward increased morbidity and mortality. The study does reflect that most surgeons who would consider, for whatever individual reason, performing bariatric operations on patients older than 65 at least do a lap band for more than half those cases. When one looks at the incredibly high incidence of comorbid medical problems in the age 70 and over patient population, one must wonder what particular motivation a surgeon would have for performing bariatric surgery, and in particular open bypass or duodenal switch, in this group. Although sparse, the data suggest this is not a wise course of action.

I have two questions for the authors:

1. Given the remarkable improvement in bariatric surgical outcomes over the past decade, does your study encourage procedures that may decrease optimal outcomes for bariatric surgery in the future by encouraging its performance in older and higher risk patients?

It has been estimated that a person with a BMI of over 40 at age 21 will live 12 years longer as a male and 9 years longer as a female if they undergo bariatric surgery than if they do not. What long-term benefit do you estimate exists for the 65- or even 70-year-old patient to undergo bariatric surgery? Have you any estimate or are you aware of any data on the number of quality life years saved by doing the procedure at this age?

Closing Discussant

Dr. Robert B. Dorman: We appreciate these very insightful comments that raise important concerns regarding policy implication. As it relates to this study we are not recommending that elderly patients undergo bariatric surgery. Instead, we are reporting that they are undergoing bariatric surgery, a greater proportion of elderly patients are undergoing bariatric surgery in 2009 compared to 2005, and that age >65 years is not a significant predictor of perioperative mortality or major adverse events. This study provides an important tool for patients and providers to assess the perioperative risk associated with bariatric surgery in all patients, but it places a particular focus on those greater than 65 years old. As patients over the age of 65 years are very likely to continue to present at surgical centers for evaluation, providers and payers will need the tools to assess the perioperative safety in this growing patient population. Patient selection is a complex and inexact process. This study will provide us with the data necessary to not exclude patients from bariatric surgery based on age alone.

In fact, operating on a greater number of patients over the age of 65 years may worsen overall outcomes for the bariatric population, but we believe patients over 65 years should continue to be considered separately from those of younger age. As the Discussant mentions, our results were ultimately not significant for predicting mortality although the trend toward significance should not be ignored. The lack of significance could be related to the overall low number of deaths. As the database continues to be populated there is a possibility that age over 65 years will predict mortality and/or major adverse events as the total number of adverse events increases. This warrants investigation in the future as the database continues to grow and procedures evolve.

There is no data on long-term outcomes for patients who are 65 years or older at the time of their primary bariatric operation. Thus, we have included in our manuscript several short-term studies that follow elderly patients for up to 1 year, and the findings support significant improvements in BMI, comorbid illnesses, medication use, and quality of life. While these effects were not as significant as those experienced in younger patients, they were still significant. The population in the USA is living longer, and they are also required to work longer. While no data exist investigating quality of life years saved in this patient population, there is an opportunity here to reduce disease burden in this age group allowing them to continue to be productive members of society.