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Original article

# Bariatric surgery in the elderly: outcomes analysis of patients over 70 using the ACS-NSQIP database

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**Abstract**

**Background:** Bariatric surgery offers patients with morbid obesity and related diseases short- and long-term benefits to their health and quality of life. Evidence-based medicine is integral in the evaluation of risk versus benefit; however, data are lacking for several high-risk patient populations, including the elderly.

**Objectives:** This study assessed morbidity and mortality data for patients age ≥70 undergoing laparoscopic sleeve gastrectomy (SG) or laparoscopic Roux-en-Y gastric bypass (RYGB).

**Setting:** University Hospital, Bronx, New York, United States using national database.

**Methods:** We used the American College of Surgeons-National Surgical Quality Improvement Project database for years 2005–2016 and identified patients who underwent primary SG or RYGB. Patients age ≥70 were assigned to the over age 70 (AGE70+) cohort and younger patients were assigned to the under age 70 (U70) cohort. Postoperative length of stay and 30-day morbidity and mortality were assessed.

**Results:** A total of 1498 patients age ≥70 underwent nonrevisional bariatric surgery, including 751 (50.1%) SG and 747 (49.9%) RYGB. AGE70+ was associated with increased mortality and increased rates of cardiac, pulmonary, renal, and cerebrovascular morbidity. AGE70+ patients had longer mean length of stay, and were more likely to require transfusion and return to operative room. When stratified by procedure, rates of organ-space surgical site infection, acute renal failure, urinary tract infection, myocardial infarction, deep vein thrombosis/thrombophlebitis, and septic shock were significantly increased in AGE70+ patients undergoing RYGB but not SG. Impaired functional status was associated with increased rates of morbidity and mortality for AGE70+ patients and for U70 patients, although the small number of patients within each category limited statistical analysis.

**Conclusions:** Evaluation of risk versus benefit is performed on a case-by-case basis, but evidence-based medicine is critical in empowering surgeons and patients to make informed decisions. The overall rate of morbidity and mortality for AGE70+ patients undergoing bariatric surgery was increased relative to U70 patients. Rates of several adverse events, including acute renal failure and myocardial infarction, were increased in AGE70+ patients undergoing RYGB but not SG, suggesting that SG may be the preferred procedure for elderly patients with organ-specific risk factors. The increased rates of morbidity and mortality observed for patients with impaired functional status supports consideration of functional status when evaluating preoperative risk. (Surg Obes Relat Dis 2019;15:1923–1932.) 

*Key words:* Bariatric surgery; Laparoscopic; Roux-en-Y gastric bypass; Gastric bypass; Sleeve gastrectomy; Elderly; Geriatric; Diabetes; Functional status; Frailty; Weight loss surgery

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Bariatric surgery offers patients with morbid obesity and related diseases tremendous benefits to their short and long-term health and their quality of life. Benefits must be weighed against risk for all surgical procedures. Careful patient selection and consideration of risk is especially critical in elective surgical procedures. Risk aversion is important, however "high-risk" patients, including those at the extremes of age and body mass index (BMI), may have the greatest potential to benefit from weight loss surgery. As morbidly obese patients age, they are more likely to suffer from metabolic syndrome, cardiopulmonary disease, and impaired mobility. Improvement or resolution of these conditions can result in profound and synergistic improvements in a patient's health status and quality of life.

Evidence-based medicine is instrumental in the assessment of risk versus benefit. The benefits of bariatric surgery have been well-documented for patients with BMI >40 kg/m$^2$ and for patients with BMI <40 kg/m$^2$ with obesity-related co-morbidities [1]. Data are lacking, however, for several high-risk patient populations. Elderly patients represent a small minority of bariatric surgery patients and there is a paucity of data-supported recommendations to guide patient selection and operative planning for these patients.

The National Institutes of Health first established guidelines for bariatric surgery patient selection in 1991 and restricted bariatric surgery for patients ≥60 years of age. In 2006, the National Institutes of Health removed this age restriction; however, there is no consensus on whether a patient's age should affect the decision to proceed with weight loss surgery. It is unclear if the same criteria should be applied to all patients, regardless of age [2,3] or if bariatric surgery should be considered only for elderly patients with severe co-morbidities [4].

The American College of Surgeons-National Surgical Quality Improvement Project (ACS-NSQIP) database is a nationwide registry that was created in an effort to compare outcomes, identify potential areas of improvement, and improve the overall quality of surgical care. In addition to providing surgeons and institutions valuable data for quality improvement, the ACS-NSQIP database offers researchers a wealth of de-identified patient data for analysis. In our experience, the database has been especially useful for assessing 30-day outcomes for a specific subset of patients, where data from a single institution would be insufficient for analysis [5].

## Objectives

In this study, we assessed the 30-day morbidity and mortality for patients age ≥70 undergoing SG or RYGB.

## Methods

The ACS-NSQIP database contains >300 variables, including patient demographic characteristics and co-morbidities, preoperative laboratory values, intraoperative variables, and 30-day postoperative morbidity and mortality, for adult patients undergoing major surgical procedures. The program implements a systematic sampling process and certifies surgical clinical reviewers to ensure the quality of data collected at all participating sites.

This study was performed using data from the ACS-NSQIP database for the years 2005 through 2016. Patients were included if they underwent primary laparoscopic sleeve gastrectomy (SG) or laparoscopic Roux-en-Y gastric bypass (RYGB). Specifically, we included patients with primary Current Procedural Terminology (CPT) code of 43775, 43644, or 43645 (Table 1). Patients with primary CPT codes of 43644 (proximal gastric bypass with Roux limb ≤150 cm) and 43645 (distal gastric bypass with Roux limb of >150 cm) were combined and both considered to have undergone RYGB. Patients age ≥70 were assigned to the over age 70 (AGE70+) cohort. All other patients were assigned to the under age 70 (U70) cohort.

Table 1
CPT code documented as primary procedure

| CPT code & procedure | Total | AGE70+ | U70 |
|---|---|---|---|
| Laparoscopic sleeve gastrectomy | 69,217 | 751 | 68,466 |
| 43775: Laparoscopy, surgical, gastric restrictive procedure; longitudinal gastrectomy (i.e., sleeve gastrectomy) | 69,217 | 751 | 68,466 |
| Laparoscopic Roux-en-Y gastric bypass | 94,178 | 747 | 93,431 |
| 43644 (proximal): Laparoscopy, surgical, gastric restrictive procedure; with gastric bypass and Roux-en-Y gastroenterostomy (Roux limb ≤150 cm) | 91,755 | 722 | 91,033 |
| 43645 (distal): Laparoscopy, surgical, gastric restrictive procedure; with gastric bypass and small intestine reconstruction to limit absorption | 2423 | 25 | 2398 |

CPT = Current Procedural Terminology; AGE70+ = cohort including patients age ≥70 yr; U70 = patients under age 70 yr.

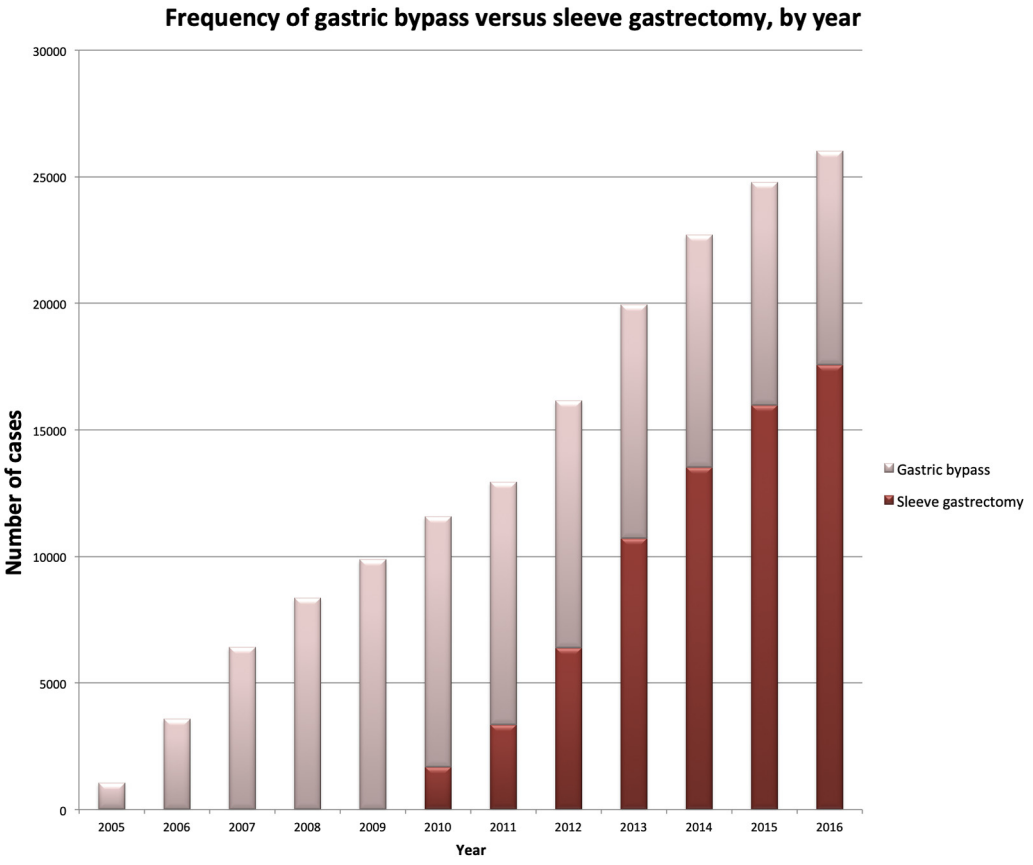


Fig. 1. Frequency of sleeve gastrectomy (Current Procedural Terminology code 43775) versus gastric bypass (Current Procedural Terminology codes 43644 and 43645), by year.

Patient demographic characteristics and preoperative factors were analyzed.

Primary outcomes were 30-day morbidity and mortality and postoperative length of stay (LOS) for AGE70+ versus U70. Assessment of 30-day morbidity included postoperative occurrences of superficial-incisional surgical-site infection (SSI), deep-incisional SSI, organ-space SSI, pneumonia, unplanned intubation, pulmonary embolism, failure to wean from a ventilator >48 hours, progressive renal insufficiency, acute renal failure, urinary tract infection, stroke/cerebrovascular accident, cardiac arrest requiring cardiopulmonary resuscitation, myocardial

Table 2
Frequency and mortality of sleeve gastrectomy (CPT 43775) versus gastric bypass (CPT 43644 and CPT 43645), by year

| Year | Total | | Sleeve gastrectomy | | | Roux-en-Y gastric bypass | | |
|---|---|---|---|---|---|---|---|---|
| | n | Mortality | n | % | Mortality | n | % | Mortality |
| 2005 | 1051 | 3 (.29%) | 0 | .0% | n/a | 1051 | 100.0% | 3 (.29%) |
| 2006 | 3580 | 5 (.14%) | 0 | .0% | n/a | 3580 | 100.0% | 5 (.14%) |
| 2007 | 6418 | 10 (.19%) | 0 | .0% | n/a | 6418 | 100.0% | 10 (.16%) |
| 2008 | 8354 | 16 (.19%) | 0 | .0% | n/a | 8354 | 100.0% | 16 (.19%) |
| 2009 | 9868 | 13 (.13%) | 0 | .0% | n/a | 9868 | 100.0% | 13 (.13%) |
| 2010 | 11,573 | 16 (.14%) | 1686 | 14.6% | 3 (.18%) | 9887 | 85.4% | 13 (.13%) |
| 2011 | 12,937 | 21 (.16%) | 3346 | 25.9% | 3 (.09%) | 9591 | 74.2% | 18 (.19%) |
| 2012 | 16,152 | 17 (.11%) | 6397 | 39.6% | 4 (.06%) | 9755 | 60.4% | 13 (.13%) |
| 2013 | 19,948 | 24 (.12%) | 10,706 | 53.7% | 12 (.11%) | 9242 | 46.4% | 12 (.13%) |
| 2014 | 22,703 | 28 (.12%) | 13,530 | 59.6% | 12 (.09%) | 9173 | 40.4% | 16 (.17%) |
| 2015 | 24,788 | 29 (.12%) | 15,983 | 64.5% | 16 (.10%) | 8,805 | 35.5% | 13 (.15%) |
| 2016 | 26,023 | 18 (.07%) | 17,569 | 67.5% | 10 (.06%) | 8,454 | 32.5% | 8 (.09%) |
| Total | 163,395 | 200 (.12%) | 69,217 | 42.4% | 60 (.087%) | 94,178 | 57.6% | 140 (.15%) |

CPT = Current Procedural Terminology.

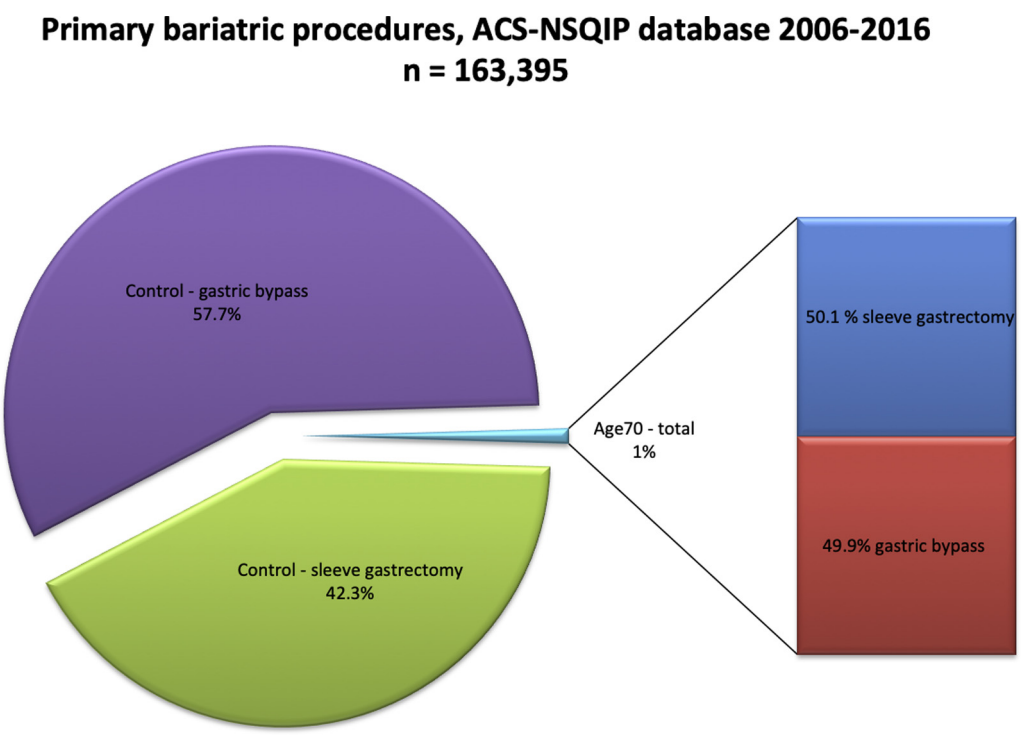


Fig. 2. Frequency of sleeve gastrectomy (Current Procedural Terminology code 43775) versus gastric bypass (Current Procedural Terminology codes 43644 and 43645), by cohort. ACS-NSQIP = American College of Surgeons-National Surgical Quality Improvement Project.

infarction, transfusion required intraoperatively or postoperatively, deep vein thrombosis (DVT)/thrombophlebitis, sepsis, septic shock, and return to operating room. Major morbidity represents the presence of at least 1 of the following: unplanned intubation, pulmonary embolism, failure to wean from ventilator >48 hours, progressive renal insufficiency, acute renal failure, stroke/cerebrovascular accident, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, sepsis, or septic shock. Postoperative LOS was defined by the ACS-NSQIP variable "days from operation to discharge."

Table 3
Patient demographic characteristics, continuous variables

| | AGE70+ | | U70 | | *P* value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Age | 72.5 | 3.1 | 44.4 | 11.5 | <.001 |
| SG | 72.5 | 3.0 | 44.0 | 11.6 | <.001 |
| RYGB | 72.4 | 3.3 | 44.7 | 11.3 | <.001 |
| BMI | 41.3 | 8.4 | 46.0 | 8.4 | <.001 |
| SG | 41.4 | 8.1 | 45.3 | 8.2 | .024 |
| RYGB | 41.2 | 8.8 | 46.5 | 8.4 | .331 |
| ASA class | 3.0 | .4 | 2.7 | .5 | <.001 |
| SG | 3.0 | .4 | 2.7 | .5 | <.001 |
| RYGB | 3.0 | .4 | 2.7 | .5 | <.001 |

AGE70+ = cohort includes patients age ≥70; U70 = patients under age 70; SD = standard deviation; SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass; BMI = body mass index; ASA class = American Society of Anesthesiologists classification.

All data point definitions and descriptions are provided by the annual ACS-NSQIP data user guide. Of note, preoperative functional status is defined as independent, partially dependent, or totally dependent. An independent patient does not require assistance from another person for any activities of daily living (ADLs). This includes a person who is able to function independently with prosthetics, equipment, or devices. A partially dependent patient requires some assistance from another person for ADLs. This includes a person who uses prosthetics, equipment, or devices but requires assistance from another person for ADLs. A totally dependent patient requires total assistance for all ADLs.

Organ-space SSI refers to SSIs occurring below the level of the incision. In bariatric procedures, this is likely a surrogate for leak.

Statistical analyses were performed using 2-tailed *t* tests for continuous variables and $\chi^2$ tests for categoric variables. Fischer exact test was used for categoric variables when an observed value was <5. A *P* value of .05 was considered statistically significant.

Table 4
Patient demographic characteristics, categorical variables

| | AGE70+ (n = 1498) | | U70 (n = 161,897) | | *P* value |
|---|---|---|---|---|---|
| | n | % of cohort | n | % of cohort | |
| Male | 504 | 33.7 | 33,159 | 20.5 | <.001 |
| Minority | 159 | 11.1 | 39,105 | 26.7 | <.001 |
| ASA 1 | 1 | .1 | 667 | .4 | <.001 |
| ASA 2 | 163 | 10.9 | 46,893 | 29 | <.001 |
| ASA 3 | 1225 | 81.8 | 110,161 | 68.1 | <.001 |
| ASA 4 | 108 | 7.2 | 4017 | 2.5 | <.001 |
| ASA 5 | 1 | .1 | 9 | 0 | .02 |
| Not documented | 0 | 0 | 135 | .1 | |
| Functional status - independent | 1446 | 96.5 | 160,797 | 99.3 | <.001 |
| Functional status - partially dependent | 37 | 2.5 | 699 | .4 | <.001 |
| Functional status - totally dependent | 4 | .3 | 36 | .0 | <.001 |
| Not documented | 11 | .7 | 365 | .2 | |
| Hypertension | 1251 | 83.5 | 81,604 | 50.4 | <.001 |
| Diabetes | 718 | 47.9 | 44,643 | 27.6 | <.001 |
| Dyspnea | 343 | 22.9 | 26,736 | 16.5 | <.001 |
| At rest | 10 | .7 | 500 | .3 | <.001 |
| Moderate exertion | 333 | 22.2 | 26,236 | 16.2 | <.001 |
| Ascites | 5 | .3 | 15 | 0 | <.001 |
| COPD | 92 | 6.1 | 2778 | 1.7 | <.001 |
| Smoke | 54 | 3.6 | 16,912 | 10.4 | <.001 |
| Steroid | 34 | 2.3 | 2303 | 1.4 | .006 |
| CHF | 9 | .6 | 368 | .2 | .003 |
| Renal failure | 2 | .1 | 55 | 0 | .04 |
| Dialysis | 6 | .4 | 452 | .3 | .377 |
| Cancer | 13 | .9 | 33 | 0 | <.001 |
| Transfusion | 4 | .3 | 31 | 0 | <.001 |

AGE70+ = cohort includes patients age ≥70; U70 = patients under age 70; ASA = American Society of Anesthesiologists classification; COPD = chronic obstructive pulmonary disease; CHF = congestive heart failure.

## Results

During the study period, a total of 163,395 patients underwent primary bariatric surgery. Of those, 69,217 (42.4%) underwent SG and 94,178 (57.6%) underwent RYGB. Of the 163,395 patients, 1498 (.9%) were age ≥70 (ages ranging from 70–89) on the day of surgery and were assigned to the AGE70+ cohort. AGE70+ included 751 (50.1%) SG and 747 (49.9%) RYGB. SG (CPT 43775) first appeared in the ACS-NSQIP database in 2010 and by 2013, was the most commonly performed primary bariatric surgery. SG and RYGB case frequency, as captured by ACS-NSQIP, is organized by year in Fig. 1 and Table 2 and by cohort in Fig. 2.

Patient demographic characteristics are shown in Tables 3, 4, and 5. The mean age of AGE70+ patients was 72.5 years versus 44.4 years for U70 patients. AGE70+ patients were more frequently male (33.7% versus 20.5%) and less frequently minority (9.8% versus 23.6%) relative to U70 patients. AGE70+ was associated with increased mean American Society of Anesthesiologists classification (3.0 versus 2.7) and decreased BMI (41.3 versus 46.0).

Due to the large size of the cohorts, many factors did display statistically significant differences between AGE70+ and U70 patients. These data identified increased rates of co-morbid disease and decreased functional status for AGE70+ patients. Of note, 1 preoperative risk factor was lower in the AGE70+ cohort, the rate of smoking, defined as current smoker within 1 year, was significantly lower in the AGE70+ cohort relative to U70 (3.6% versus 10.4%). When cohorts were stratified by procedure type, AGE70+ patients undergoing both SG and RYGB displayed increased rates of co-morbid disease, decreased functional status, and decreased rates of smoking.

Operative time, LOS, and 30-day morbidity and mortality data are displayed in Table 6. Relative to U70, AGE70+ was associated with increased mortality and increased rates of cardiac, pulmonary, renal, and cerebrovascular morbidity. AGE70+ patients had longer mean LOS, and were more likely to require transfusion and return to the operating room. Rates of superficial-incisional SSI, deep-incisional SSI, organ-space SSI, pulmonary embolism, acute renal failure, DVT/thrombophlebitis, and sepsis did not significantly differ between AGE70+ and U70 patients.

When stratified by procedure, as shown in Table 7, rates of organ-space SSI, acute renal failure, urinary tract infection, myocardial infarction, DVT/thrombophlebitis, and

Table 5
Patient demographic characteristics, categorical variables by procedure type

| | AGE70+ (n = 1498) | | U70 (n = 161,897) | | *P* value |
|---|---|---|---|---|---|
| | n | % of cohort | n | % of cohort | |
| Male | | | | | |
| SG | 257 | 34.3 | 14,253 | 21.2 | <.001 |
| RYGB | 247 | 33.1 | 18,636 | 20 | <.001 |
| Minority | | | | | |
| SG | 92 | 12.3 | 20,550 | 30.2 | <.001 |
| RYGB | 67 | 9.8 | 18,555 | 23.6 | <.001 |
| ASA 1 | | | | | |
| SG | 0 | 0 | 338 | .5 | .057 |
| RYGB | 1 | .1 | 329 | .4 | .315 |
| ASA 2 | | | | | |
| SG | 88 | 11.7 | 20,491 | 29.9 | <.001 |
| RYGB | 75 | 10 | 26,402 | 28.3 | <.001 |
| ASA 3 | | | | | |
| SG | 614 | 81.8 | 46,004 | 67.2 | <.001 |
| RYGB | 611 | 81.8 | 64,157 | 68.7 | <.001 |
| ASA 4 | | | | | |
| SG | 48 | 6.4 | 1560 | 2.3 | <.001 |
| RYGB | 60 | 8 | 2457 | 2.6 | <.001 |
| ASA 5 | | | | | |
| SG | 1 | .1 | 1 | 0 | .02 |
| RYGB | 0 | 0 | 8 | 0 | .8 |
| Not documented | 0 | 0 | 135 | 0.1 | |
| Functional status - independent | | | | | |
| SG | 727 | 96.8 | 68,050 | 99.4 | <.001 |
| RYGB | 719 | 96.3 | 92,747 | 99.3 | <.001 |
| Functional status - partially dependent | | | | | |
| SG | 17 | 2.3 | 261 | .4 | <.001 |
| RYGB | 20 | 2.7 | 438 | .5 | <.001 |
| Functional status - totally dependent | | | | | |
| SG | 1 | .1 | 19 | .0 | .091 |
| RYGB | 3 | .4 | 17 | .0 | <.001 |
| Not documented | 11 | .7 | 365 | .2 | |
| Hypertension | | | | | |
| SG | 631 | 84 | 32,027 | 46.8 | <.001 |
| RYGB | 620 | 83 | 49,577 | 53.1 | <.001 |
| Diabetes | | | | | |
| SG | 323 | 43 | 15,521 | 22.7 | <.001 |
| RYGB | 395 | 52.9 | 29,122 | 31.2 | <.001 |
| Dyspnea | | | | | |
| At rest | | | | | |
| SG | 5 | .7 | 164 | .2 | <.001 |
| RYGB | 5 | .7 | 336 | .4 | .04 |
| Moderate exertion | | | | | |
| SG | 140 | 18.6 | 8158 | 11.9 | <.001 |
| RYGB | 193 | 25.8 | 18078 | 19.3 | <.001 |
| Ascites | | | | | |
| SG | 1 | .1 | 5 | 0 | .063 |
| RYGB | 4 | .5 | 10 | 0 | <.001 |
| COPD | | | | | |
| SG | 45 | 6 | 1061 | 1.5 | <.001 |
| RYGB | 47 | 6.3 | 1717 | 1.8 | <.001 |
| Smoke | | | | | |
| SG | 28 | 3.7 | 6709 | 9.8 | <.001 |
| RYGB | 26 | 3.5 | 10,203 | 10.9 | <.001 |
| Steroid | | | | | |
| SG | 22 | 2.9 | 1227 | 1.8 | .2 |
| RYGB | 12 | 1.6 | 1076 | 1.2 | .247 |

(*continued on next page*)

Table 5 (*continued*)

| | AGE70+ (n = 1498) | | U70 (n = 161,897) | | *P* value |
|---|---|---|---|---|---|
| | n | % of cohort | n | % of cohort | |
| CHF | | | | | |
| SG | 5 | .7 | 188 | .3 | .043 |
| RYGB | 4 | .5 | 180 | .2 | .035 |
| Renal failure | | | | | |
| SG | 2 | .3 | 32 | 0 | .052 |
| RYGB | 0 | 0 | 23 | 0 | .668 |
| Dialysis | | | | | |
| SG | 5 | .7 | 295 | .4 | .33 |
| RYGB | 1 | .1 | 157 | .2 | .82 |
| Cancer | | | | | |
| SG | 2 | .3 | 10 | 0 | .007 |
| RYGB | 11 | 1.5 | 23 | 0 | <.001 |
| Transfusion | | | | | |
| SG | 3 | .4 | 16 | 0 | .001 |
| RYGB | 1 | .1 | 15 | 0 | .014 |

AGE70+ = cohort includes patients age ≥70; U70 = patients under age 70; SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass; ASA = American Society of Anesthesiologists classification; COPD = chronic obstructive pulmonary disease; CHF = congestive heart failure.

septic shock were significantly increased in AGE70+ patients undergoing RYGB but not SG. Operative time for both SG and RYGB was similar between groups.

Subgroup analysis stratified by functional status is displayed in Table 8. Impaired functional status was associated with increased rates of morbidity and mortality for

Table 6
Intraoperative variables and 30-day morbidity and mortality

| | AGE70+ (n = 1498) | | U70 (n = 161,897) | | *P* value | | |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | | |
| Operative time, min | 113.5 | 60.0 | 114.7 | 56.4 | .011 | | |
| Days from OR until discharge | 2.9 | 4.8 | 2.2 | 2.4 | <.001 | | |
| | n | Frequency | n | Frequency | | Odds Ratio | 95%CI |
| Mortality | 15 | 1.0% | 179 | .1% | <.001 | 10.2 | 6.188–16.811 |
| Morbidity | 120 | 8.0% | 7954 | 4.9% | <.001 | 1.7 | 1.397–2.034 |
| Major morbidity | 38 | 2.5% | 1354 | .8% | <.001 | 3.1 | 2.226–4.277 |
| Superficial-incisional SSI | 17 | 1.1% | 1912 | 1.2% | .869 | 1.0 | .594–1.553 |
| Deep-incisional SSI | 1 | .1% | 225 | .1% | .454 | .5 | .067–3.425 |
| Organ-space SSI | 14 | .9% | 935 | .6% | .07 | 1.6 | .956–2.760 |
| Pneumonia | 16 | 1.1% | 641 | .4% | <.001 | 2.7 | 1.649–4.472 |
| Unplanned intubation | 14 | .9% | 468 | .3% | <.001 | 3.3 | 1.908–5.551 |
| Pulmonary embolism | 3 | .2% | 307 | .2% | 0.925 | 1.1 | .338–3.297 |
| Failure to wean from ventilator >48 hr | 14 | .9% | 386 | .2% | <.001 | 3.9 | 2.310–6.745 |
| Progressive renal insufficiency | 9 | .6% | 231 | .1% | <.001 | 4.2 | 2.169–8.249 |
| Acute renal failure | 3 | .2% | 149 | .1% | .171 | 2.2 | .694–6.839 |
| Urinary tract infection | 17 | 1.1% | 1129 | .7% | .043 | 1.6 | 1.010–2.646 |
| Stroke/CVA | 3 | .2% | 34 | .0% | <.001 | 9.6 | 2.931–31.138 |
| Cardiac arrest requiring CPR | 5 | .3% | 117 | .1% | <.001 | 4.6 | 1.889–11.350 |
| Myocardial infarction | 7 | .5% | 114 | .1% | <.001 | 6.7 | 3.101–14.317 |
| Transfusion required intraoperatively or postoperatively | 40 | 2.7% | 1513 | .9% | <.001 | 2.7 | 1.995–3.768 |
| DVT/thrombophlebitis | 5 | .3% | 372 | .2% | .404 | 1.3 | .599–3.005 |
| Sepsis | 10 | .7% | 709 | .4% | .181 | 1.5 | .817–2.858 |
| Septic shock | 9 | .6% | 269 | .2% | <.001 | 3.3 | 1.697–6.418 |
| Return to OR | 45 | 3.0% | 3278 | 2.0% | .008 | 1.5 | 1.112–2.020 |

AGE70+ = cohort includes patients age ≥70; U70 = patients under age 70; SD = standard deviation; OR = operating room; CI = confidence interval; SSI = surgical site infection; CVA = cerebrovascular accident; CPR = cardiopulmonary resuscitation; DVT = deep vein thrombosis.

Table 7
Intraoperative variables and 30-day morbidity and mortality, by procedure type

| | AGE70+ (n = 1498) | | U70 (n = 161,897) | | *P* value | | |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | | | |
| Operative time, min | | | | | | | |
| SG | 90.2 | 47.2 | 87.9 | 43.1 | .145 | | |
| RYGB | 136.9 | 62.3 | 134.4 | 56.8 | .224 | | |
| Days from OR until discharge | | | | | | | |
| SG | 2.4 | 2.4 | 1.9 | 2 | <.001 | | |
| RYGB | 3.5 | 6.3 | 2.4 | 2.6 | <.001 | | |
| | n | Frequency | n | Frequency | | Odds ratio | 95%CI |
| Mortality | | | | | | | |
| SG | 5 | .7% | 52 | .1% | <.001 | 10.2 | 4.376–23.789 |
| RYGB | 10 | 1.3% | 127 | .1% | <.001 | 10.9 | 5.860–20.253 |
| Morbidity | | | | | | | |
| SG | 48 | 6.4% | 2179 | 3.2% | <.001 | 2.1 | 1.546–2.791 |
| RYGB | 72 | 9.6% | 5775 | 6.2% | <.001 | 1.6 | 1.268–2.067 |
| Major morbidity | | | | | | | |
| SG | 16 | 2.1% | 735 | .6% | <.001 | 3.5 | 2.095–5.744 |
| RYGB | 22 | 2.9% | 927 | 1.0% | <.001 | 3.0 | 1.972–4.651 |
| Superficial-incisional SSI | | | | | | | |
| SG | 5 | .7% | 392 | .6% | .736 | 1.2 | .480–2.820 |
| RYGB | 12 | 1.6% | 1520 | 1.6% | .965 | 1.0 | .557–1.750 |
| Deep-incisional SSI | | | | | | | |
| SG | 1 | .1% | 36 | .1% | .342 | 2.5 | .347–18.509 |
| RYGB | 0 | .0% | 189 | .2% | .219 | .0 | 0.0 |
| Organ-space SSI | | | | | | | |
| SG | 4 | .5% | 291 | .4% | .653 | 1.3 | .466–3.374 |
| RYGB | 10 | 1.3% | 644 | .7% | .033 | 2.0 | 1.042–3.666 |
| Pneumonia | | | | | | | |
| SG | 5 | .7% | 165 | .2% | .019 | 2.7 | 1.136–6.774 |
| RYGB | 11 | 1.5% | 476 | .5% | <.001 | 2.9 | 1.598–5.329 |
| Unplanned intubation | | | | | | | |
| SG | 6 | .8% | 120 | .2% | <.001 | 4.6 | 2.014–10.447 |
| RYGB | 8 | 1.1% | 348 | .4% | .002 | 2.9 | 1.431–5.858 |
| Pulmonary embolism | | | | | | | |
| SG | 0 | .0% | 108 | .2% | .276 | .0 | .0 |
| RYGB | 3 | .4% | 199 | .2% | .276 | 1.9 | .603–5.921 |
| Failure to wean from ventilator >48 hr | | | | | | | |
| SG | 5 | .7% | 86 | .1% | <.001 | 5.3 | 2.157–13.167 |
| RYGB | 9 | 1.2% | 300 | .3% | <.001 | 3.8 | 1.943–7.376 |
| Progressive renal insufficiency | | | | | | | |
| SG | 5 | .7% | 87 | .1% | <.001 | 5.3 | 2.133–13.012 |
| RYGB | 4 | .5% | 144 | .2% | .009 | 3.5 | 1.288–9.444 |
| Acute renal failure | | | | | | | |
| SG | 0 | .0% | 46 | .1% | .477 | .0 | .0 |
| RYGB | 3 | .4% | 103 | .1% | .018 | 3.7 | 1.157–11.541 |
| Urinary tract infection | | | | | | | |
| SG | 3 | .4% | 338 | .5% | .714 | .8 | .259–2.525 |
| RYGB | 14 | 1.9% | 791 | .8% | 0.002 | 2.2 | 1.312–3.813 |
| Stroke/CVA | | | | | | | |
| SG | 1 | .1% | 13 | .0% | .029 | 7.0 | .917–53.737 |
| RYGB | 2 | .3% | 21 | .0% | <.001 | 11.9 | 2.795–51.018 |
| Cardiac arrest requiring CPR | | | | | | | |
| SG | 2 | .3% | 37 | .1% | .015 | 4.9 | 1.188–20.527 |
| RYGB | 3 | .4% | 80 | .1% | .004 | 4.7 | 1.483–14.932 |
| Myocardial infarction | | | | | | | |
| SG | 1 | .1% | 52 | .1% | .573 | 1.8 | .242–12.706 |
| RYGB | 6 | .8% | 62 | .1% | <.001 | 12.2 | 5.529–28.276 |

(*continued on next page*)

Table 7 (*continued*)

| | n | Frequency | n | Frequency | | Odds ratio | 95%CI |
|---|---|---|---|---|---|---|---|
| Transfusion required intraoperatively or postoperatively | | | | | | | |
| SG | 19 | 2.5% | 534 | .8% | <.001 | 3.3 | 2.078–5.248 |
| RYGB | 21 | 2.8% | 979 | 1.0% | <.001 | 2.5 | 1.611–3.869 |
| DVT/Thrombophlebitis | | | | | | | |
| SG | 0 | .0% | 184 | .3% | .155 | .3 | .041–2.090 |
| RYGB | 5 | .7% | 188 | .2% | .005 | 1.5 | .633–3.713 |
| Sepsis | | | | | | | |
| SG | 4 | .5% | 179 | .3% | .15 | 2.0 | .756–5.517 |
| RYGB | 6 | .8% | 530 | .6% | .393 | 1.4 | .633–3.184 |
| Septic shock | | | | | | | |
| SG | 3 | .4% | 71 | .1% | .14 | 3.9 | 1.214–12.294 |
| RYGB | 6 | .8% | 225 | .2% | .002 | 3.4 | 1.486–7.570 |
| Return to OR | | | | | | | |
| SG | 16 | 2.1% | 780 | 1.1% | .011 | 1.9 | 1.145–3.115 |
| RYGB | 29 | 3.9% | 2498 | 2.7% | .042 | 1.5 | 1.012–2.316 |

AGE70+ = cohort includes patients age ≥70; U70 = patients under age 70; SD = standard deviation; SG = sleeve gastrectomy; RYGB = Roux-en-Y gastric bypass; OR = operating room; CI = confidence interval; SSI = surgical site infection; CVA = cerebrovascular accident; CPR = cardiopulmonary resuscitation; DVT = deep vein thrombosis.

Table 8
Intraoperative variables and 30-day morbidity and mortality, by functional status

| | AGE70+ (n = 1498) | | U70 (n = 161,897) | | *P* value |
|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | |
| Days from OR until discharge | | | | | |
| Independent | 2.9 | 4.7 | 2.2 | 2.4 | <.001 |
| Partially dependent | 5.6 | 7.1 | 3.8 | 5.5 | .05 |
| Totally dependent | 5.3 | 3.9 | 8.3 | 14.7 | .687 |
| | n | Frequency | n | Frequency | |
| Mortality | | | | | |
| Independent | 12 | .8% | 176 | .1% | <.001 |
| Partially dependent | 2 | 5.4% | 3 | .4% | .022 |
| Totally dependent | 1 | 25.0% | 0 | .0% | .1 |
| Pneumonia | | | | | |
| Independent | 14 | 1.0% | 630 | .4% | .001 |
| Partially dependent | 2 | 5.4% | 10 | 1.4% | .118 |
| Totally dependent | 0 | .0% | 0 | .0% | |
| Unplanned intubation | | | | | |
| Independent | 12 | .8% | 451 | .3% | <.001 |
| Partially dependent | 2 | 5.4% | 15 | 2.1% | .209 |
| Totally dependent | 0 | .0% | 1 | 2.8% | .736 |
| Failure to wean from ventilator >48 hr | | | | | |
| Independent | 12 | .8% | 363 | .2% | <.001 |
| Partially dependent | 2 | 5.4% | 20 | 2.9% | .376 |
| Totally dependent | 0 | .0% | 3 | 8.3% | .548 |
| Progressive renal insufficiency | | | | | |
| Independent | 7 | .5% | 225 | .1% | .001 |
| Partially dependent | 1 | 2.7% | 3 | .4% | .187 |
| Totally dependent | 1 | 25.0% | 1 | 2.8% | .192 |
| Urinary tract infection | | | | | |
| Independent | 16 | 1.1% | 1099 | .7% | .053 |
| Partially dependent | 1 | 2.7% | 22 | 3.1% | >.999 |
| Totally dependent | 0 | .0% | 1 | 2.8% | >.999 |
| Stroke/CVA | | | | | |
| Independent | 3 | .2% | 34 | .0% | .004 |
| Partially dependent | 0 | .0% | 0 | .0% | |
| Totally dependent | 0 | .0% | 0 | .0% | |

(*continued on next page*)

Table 8 (*continued*)

| | n | Frequency | n | Frequency | |
|---|---|---|---|---|---|
| Cardiac arrest requiring CPR | | | | | |
| Independent | 5 | .3% | 114 | .1% | <.001 |
| Partially dependent | 0 | .0% | 3 | .4% | >.999 |
| Totally dependent | 0 | .0% | 0 | .0% | |
| Myocardial infarction | | | | | |
| Independent | 7 | .5% | 108 | .1% | <.001 |
| Partially dependent | 0 | .0% | 5 | .7% | >.999 |
| Totally dependent | 0 | .0% | 0 | .0% | |
| Transfusion required intraoperatively or postoperatively | | | | | |
| Independent | 38 | 2.6% | 1491 | .9% | <.001 |
| Partially dependent | 1 | 2.7% | 15 | 2.1% | .566 |
| Totally dependent | 1 | 25.0% | 3 | 8.6% | .363 |
| Septic shock | | | | | |
| Independent | 6 | .4% | 288 | .2% | .036 |
| Partially dependent | 2 | 5.4% | 8 | 1.1% | .086 |
| Totally dependent | 1 | 25.0% | 0 | .0% | .1 |
| Return to OR | | | | | |
| Independent | 42 | 2.9% | 3229 | 2.0% | .016 |
| Partially dependent | 3 | 8.1% | 31 | 4.4% | .241 |
| Totally dependent | 0 | .0% | 5 | 13.9% | >.999 |

AGE70+ = cohort includes patients age ≥70; U70 = patients under age 70; SD = standard deviation; OR = operating room; CVA = cerebrovascular accident; CPR = cardiopulmonary resuscitation.

AGE70+ patients and for U70 patients, although the small number of patients within each category limited statistical analysis.

This study is limited by its retrospective nature and the potential for selection bias in both cohorts. In addition, the ACS-NSQIP database only tracks 30-day outcomes so morbidity and mortality data beyond this time period are not included in our analysis.

## Discussion

Bariatric surgery can improve the health status and quality of life for patients with morbid obesity and related diseases, such as metabolic syndrome, cardiopulmonary disease, and joint disease. Evaluation of risk and benefit is performed on a case-by-case basis, but evidence-based medicine is critical in empowering surgeons and patients to make informed decisions.

In this study, overall morbidity, major morbidity, and mortality were increased for AGE70+ patients undergoing both SG and RYGB relative to U70 patients. Rates of several adverse events, namely acute renal failure, myocardial infarction, and DVT/thrombophlebitis were increased in AGE70+ patients undergoing RYGB but not SG. These observed differences may suggest that SG is the preferred procedure for elderly patients with organ-specific risk factors. The increased rates of morbidity and mortality observed for patients with impaired functional status supports consideration of functional status when evaluating preoperative risk.

## Conclusion

Further study assessing the safety and long-term outcomes of bariatric surgery in elderly patients is warranted. We plan to use the extended follow-up MBSAQIP data when it is available to assess long-term outcomes, weight loss, and resolution of co-morbid disease to more completely assess risk versus benefit for bariatric surgery in elderly patients.

## Disclosures

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

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