JSES International 9 (2025) 141–146

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

# High and low body mass index increases the risk of short-term postoperative complications following total shoulder arthroplasty

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ARTICLE INFO

*Keywords:*
Body mass index
Total shoulder arthroplasty
Complications
Risk factors
Orthopedic surgery
Joint replacement

*Level of evidence:* Level III; Retrospective Cohort Comparison Using Large Database; Prognosis Study

**Background:** Several studies have investigated the impact of body mass index (BMI) on total shoulder arthroplasty (TSA) outcomes and reported contrasting results. Therefore, this study aims to better understand the impact of BMI on 30-day post-TSA outcomes by performing a comprehensive risk stratification based on BMI using a large national database.
**Methods:** All patients undergoing TSA, both anatomic and reverse, between 2015 and 2019 were queried from the American College of Surgeons National Surgical Quality Improvement Program database. The study population was stratified into 6 cohorts: BMI < 18.5 kg/m$^2$ (underweight), BMI of 18.5-24.9 kg/m$^2$ (reference cohort), BMI of 25.0-29.9 kg/m$^2$ (overweight), BMI of 30.0-39.9 kg/m$^2$ (obese), BMI of 40.0-49.9 kg/m$^2$ (morbidly obese), and BMI ≥ 50.0 kg/m$^2$ (super-morbidly obese). Postoperative complications within 30 days of surgery were collected. Multivariate logistic regression was conducted to investigate the association between BMI values and postoperative complications. Additionally, to facilitate a direct comparison with existing literature, and further validate our study methodology, a subgroup analysis with multivariate logistic regression was made comparing 2 groups: BMIs > 30 kg/m$^2$ and BMIs < 30 kg/m$^2$. Odds ratios (ORs) were reported with a 95% confidence interval. The level of statistical significance was set at $P < .05$. The analyses were conducted using SPSS 26.0.
**Results:** A total of 22,542 patients undergoing TSA between 2015 and 2019 were reported in the database. Of these, 410 patients did not have reported BMIs, leaving 22,132 patients for the analysis (1.8% attrition bias). The underweight cohort had a greater likelihood of mortality (OR, 6.184; $P = .008$) and nonhome discharge (OR, 1.824; $P = .008$). The morbidly obese cohort had a greater likelihood of developing wound infections (OR, 5.254; $P < .002$). The super-morbidly obese cohort presented a greater likelihood of developing wound infections (OR, 13.431; $P = .002$) and nonhome discharge (OR, 1.525; $P = .035$).
**Conclusion:** Patients with BMI less than 18 and more than 40 were associated with an increased incidence of 30-day postoperative TSA complications such as wound infection, nonhome discharge, and mortality. Based on these findings, preoperative risk stratification based on BMI remains an important part of elective surgery.


In the United States, 104,575 total shoulder arthroplasties (TSAs) have been performed annually since 2017, representing a steep rise from the 51,329 TSAs performed in 2011.[31] This is largely due to the efficacy of TSA in treating advanced glenohumeral arthritis, rotator cuff arthropathy, and proximal humerus fractures.[13] Despite technical advancements and surgeon familiarity, around 12% of patients undergoing TSA still experience short-term and long-term postoperative complications ranging from surgical site infections and cerebrovascular sequelae to rotator cuff tears and periprosthetic humeral fractures.[2] Therefore, it is important for orthopedic surgeons to have a comprehensive understanding of risk factors that contribute to surgical complications.

According to the Centers for Disease Control and Prevention, the prevalence of obesity in the United States has increased from 30.5% in 1999 to 41.9% in 2020, adding $173 billion to the national medical expenditure.[1] On the other side of the spectrum, approximately 30%

Institutional review board approval was not required for this study.

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https://doi.org/10.1016/j.jseint.2024.08.176

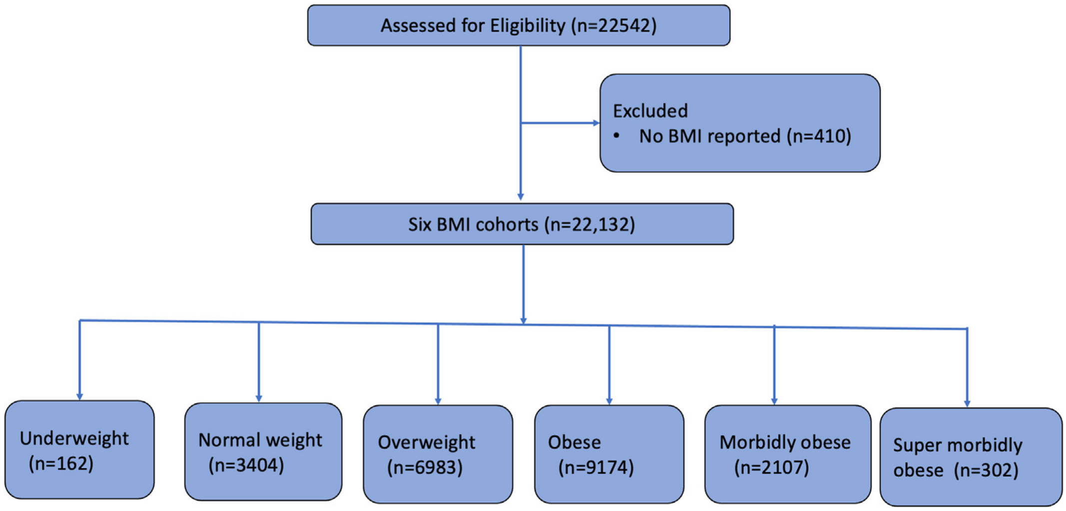


**Figure 1** Patients' enrollment and stratification flowchart. *BMI*, body mass index.

of patients in the hospital are malnourished.[3] Being overweight or underweight has been associated with an increased risk of postoperative complications following total hip and knee arthroplasty including superficial wound infections, deep infections, wound dehiscence, and longer hospital stay.[6,9,23,29] Given the large number of potential TSA patients falling outside of the range of normal body mass index (BMI), BMI may be a helpful preoperative risk factor to assess for postoperative complications.

Several studies have investigated the impact of BMI on TSA outcomes. However, these studies have reported conflicting findings. Some studies suggest that high and low BMIs are risk factors for higher complication rates,[5,10,25,32,33] while others conclude that BMI is not associated with any postoperative complications.[8,14,18,19] For example, Werner et al[33] examined 955 super-obese (BMI $\geq$ 50) patients undergoing TSA and found increased rates of infection, shoulder dislocations, component loosening, and venous thromboembolism. In contrast, Jiang et al[14] and Li et al[19] analyzed more than 2000 patients with BMI $\geq$ 30 and concluded that high BMI was not associated with an increased risk of postoperative complications. These studies, however, did not stratify patients according to the World Health Organization's classification, which may have affected the internal and comparative validity of these studies. Additionally, since extreme BMIs are rare patient populations, these studies may have lacked enough power to detect significant postoperative complications.

Due to the uncertainty regarding the effects of BMI on TSA outcomes, we conducted a large-scale database study. The purpose of our study is to further contribute to the understanding of BMI as a risk factor for 30-day outcomes following TSA. The null hypothesis of the study was that there would be no difference in complications based on the BMI categories. To our knowledge, this is the first study to analyze TSA complications with a comprehensive stratification of BMI using data from a large national database.

## Methods

Patients who underwent TSA, either anatomic or reverse, between 2015 and 2019 were queried from the American College of Surgeons National Surgical Quality Improvement Program database. The BMI of each patient was calculated as follows: weight (kg/height [$m^2$]). Patients who were missing either height or weight measurements were excluded from the analysis. The study population was stratified into 6 cohorts based on categories defined by the World Health Organization: BMI < 18.5 kg/$m^2$ (underweight), BMI of 18.5 to 24.9 kg/$m^2$ (normal weight; reference cohort), BMI of 25.0 to 29.9 kg/$m^2$ (overweight), BMI of 30.0 to 39.9 kg/$m^2$ (obese), BMI of 40.0 to 49.9 kg/$m^2$ (morbidly obese), and BMI $\geq$ 50.0 kg/$m^2$ (super-morbidly obese).

After exclusion criteria, 22,132 were included in the study: 162 (0.7%) had a BMI < 18.5; 3404 (15.1%) had a normal BMI between 18.5 and 24.9; 6983 (31.0%) of patients were overweight with a BMI between 25.0 and 29.9; 9174 (40.7%) of patients were obese with a BMI between 30.0 and 39.9; 2107 (9.3%) of patients were classified as morbidly obese with a BMI between 40.0 and 49.9; finally, 302 (1.3%) patients were in the super-morbidly obese cohort with a BMI $\geq$ 50.0 (Fig. 1).

Patient data were collected from the database including race, gender, BMI, smoking status, functional status, American Society of Anesthesiologists (ASA) classification, steroid use, preoperative laboratory values, preoperative comorbidities, and operative variables. Major and minor complications occurring within 30 days postoperatively were also collected. Major complications included cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, deep vein thrombosis requiring therapy, stroke or cerebrovascular accident, unplanned intubation, pulmonary embolism, the requirement of mechanical ventilation >48 hours, renal failure, sepsis, septic shock, postoperative hospital length of stay >30 days, reoperation, readmission, mortality, and surgical site infection. Minor complications included progressive renal insufficiency, urinary tract infection, pneumonia, and postoperative anemia requiring transfusion.

Binary analysis was initially performed to evaluate significant demographics, comorbidities, and operative variables. After adjusting for these, multivariate logistic regression analysis was performed to study the association between BMI and postoperative complications. Similarly, a subgroup analysis was conducted comparing 2 groups, one of BMI < 30 and the other of BMI < 30. Odds ratios (ORs) were reported with 95% confidence intervals and deemed significant if $P < .05$. SPSS 26.0 (IBM Corp., Armonk, NY, USA) was used for the analysis.

## Results

Of the 22,542 patients undergoing TSA reported in the database, 410 did not have an associated BMI (1.8% attrition bias). After exclusion of these patients, 22,132 patients who underwent TSA between 2015 and 2019 were included in the study (Fig. 1).

**Table I**
Binary logistic regression for demographic and comorbidities.

| | All patients | Weight classification | | | | | |
|---|---|---|---|---|---|---|---|
| | | Nonobese | Underweight | Overweight | Obese | Morbidly obese | Super-morbidly obese |
| Overall | 22,132 | 3404 | 162 | 6983 | 9174 | 2107 | 302 |
| Characteristics | | | | | | | |
| Age | | | $P = .123$ | **$P = .001$** | **$P < .001$** | **$P < .001$** | **$P < .001$** |
| 18-39 | 133 | 31 (0.9%) | 3 (1.9%) | 40 (0.6%) | 44 (0.5%) | 12 (0.6%) | 3 (1.0%) |
| 40-64 | 6196 | 779 (22.9%) | 45 (27.8%) | 1715 (24.6%) | 2761 (30.1%) | 754 (35.8%) | 142 (47.0%) |
| 65-74 | 9135 | 1201 (35.3%) | 53 (32.7%) | 2752 (39.4%) | 3994 (43.5%) | 1008 (47.8%) | 127 (42.1%) |
| ≥75 | 6668 | 1393 (40.9%) | 61 (37.7%) | 2476 (35.5%) | 2375 (25.9%) | 333 (15.8%) | 30 (9.9%) |
| Gender | | | **$P < .001$** | **$P < .001$** | **$P < .001$** | **$P < .007$** | **$P < .001$** |
| Female | 12,323 | 2253 (66.2%) | 129 (79.6%) | 3310 (47.4%) | 4927 (53.7%) | 1468 (69.7%) | 236 (78.1%) |
| Male | 9809 | 1151 (33.8%) | 33 (20.4%) | 3673 (52.6%) | 4247 (46.3%) | 639 (30.3%) | 66 (21.9%) |
| Comorbidities | | | | | | | |
| Functional dependence | | | **$P < .001$** | **$P < .001$** | **$P < .022$** | $P = .449$ | $P = .076$ |
| | 456 | 87 (2.5%) | 15 (9.3%) | 106 (1.5%) | 174 (1.9%) | 61 (2.9%) | 13 (4.3%) |
| Smoker | | | **$P < .001$** | **$P < .001$** | **$P < .001$** | **$P < .001$** | **$P < .001$** |
| | 2356 | 543 (16.0%) | 45 (27.8%) | 736 (10.5%) | 842 (9.2%) | 165 (7.8%) | 25 (8.3%) |
| Diabetes | | | $P = .148$ | **$P < .001$** | **$P < .001$** | **$P < .001$** | **$P < .001$** |
| | 3971 | 251 (7.4%) | 7 (4.3%) | 948 (13.6%) | 1993 (21.7%) | 665 (31.6%) | 107 (35.4%) |
| Hypertensive | | | **$P < .001$** | **$P < .001$** | **$P < .001$** | **$P < .001$** | **$P < .001$** |
| | 14,781 | 1805 (53.0%) | 65 (40.1%) | 4373 (62.6%) | 6618 (72.1%) | 1677 (79.6%) | 243 (80.5%) |
| COPD | | | **$P < .001$** | **$P < .001$** | **$P < .001$** | **$P < .038$** | $P = .174$ |
| | 1503 | 273 (8.0%) | 26 (16%) | 393 (5.6%) | 577 (6.3%) | 203 (9.6%) | 31 (10.3%) |
| Bleeding disorders | | | $P = .619$ | $P = .626$ | $P = .916$ | $P = .498$ | $P = .459$ |
| | 528 | 79 (2.3%) | 6 (3.7%) | 173 (2.5%) | 210 (2.3%) | 55 (2.6%) | 5 (1.7%) |
| Steroid use | | | **$P = .02$** | **$P < .001$** | **$P < .001$** | **$P < .001$** | $P = .207$ |
| | 1078 | 234 (6.9%) | 19 (11.7%) | 319 (4.6%) | 391 (4.3%) | 100 (4.7%) | 15 (5.0%) |
| CHF | | | $P = .929$ | $P = .411$ | $P = .840$ | $P = .058$ | $P = .018$ |
| | 152 | 23 (0.7%) | 1 (0.6%) | 38 (0.5%) | 59 (0.6%) | 25 (1.2%) | 6 (2.0%) |
| ASA classification | | | $P = .051$ | $P = .906$ | **$P < .001$** | **$P < .001$** | **$P < .001$** |
| 1-2 | 9408 | 1739 (51.1%) | 70 (43.2%) | 3576 (51.2%) | 3659 (39.9%) | 330 (15.7%) | 34 (11.3%) |
| ≥3 | 12,724 | 1665 (48.9%) | 92 (56.8%) | 3407 (48.8%) | 5515 (60.1%) | 1777 (84.3%) | 268 (88.7%) |

*COPD*, chronic obstructive pulmonary disease; *CHF*, congestive heart failure; *ASA*, American Society of Anesthesiologists.
Significant *P* values are in bold.

In comparison to the reference BMI cohort, the underweight patients were more likely to be females, functionally dependent, smokers, undergoing steroid therapy, and have chronic obstructive pulmonary disease (COPD) (Table I). After adjusting for significant demographic and comorbidities, a multivariate logistic regression was conducted showing that the underweight cohort had a greater likelihood of nonhome discharge (OR, 1.525; $P = .008$) and mortality (OR, 6.184; $P = .008$) (Tables II and III and, Fig. 2).

In comparison to the reference group, overweight patients were more likely to be male, and to have diabetes and high blood pressure (Table I). After adjusting for significant variables, this group had no significant increase in complication rates (Table II). In comparison to the reference group, the obese cohort was more likely to be diabetic, have high blood pressure, and be assigned to an ASA classification of 3 or more (Table I). After adjusting for significant variables, this group did not show any increased likelihood of postoperative complications (Tables II and III).

Those in the morbidly obese group were likely to be diabetic, hypertensive, have COPD, and score 3 or more on the ASA classification compared to the reference cohort. Additionally, after adjusting for these variables, on multivariate analysis this cohort had a greater likelihood of developing wound infections (OR, 5.254, $P < .002$ and OR, 13.431, $P = .002$, respectively) (Tables II and III, and Fig. 2).

When compared to the reference cohort, the super-morbidly obese patients were more likely to be diabetic, hypertensive, have COPD, and score 3 or more on the ASA classification (Table I). The super-morbidly obese cohort had a greater likelihood of developing wound infections (OR, 13.431; $P = .002$) and nonhome discharge (OR, 1.525; $P = .035$) (Tables II and III and, Fig. 2). Finally, the subgroup analysis demonstrated no significant differences in postoperative complications between BMIs < 30 and BMIs > 30 ($P > .05$, Table IV).

## Discussion

The aim of this study was to determine the association between BMI categories and postoperative TSA complications. We identified significant associations between both low BMI (<18.5 kg/m$^2$) and high BMI (>40 kg/m$^2$) and the likelihood of postoperative complications following TSA. Multivariate analyses found that morbidly obese and super-morbidly obese patients had a higher likelihood of developing wound infections in comparison to the reference group of patients with BMI in the normal range. In addition, super-morbidly obese patients were more likely to have nonhome discharge compared to the reference group. Underweight patients showed a significantly higher likelihood of nonhome discharge and mortality. Overweight and obese patients (BMIs between 25 and 39.9 kg/m$^2$) did not have any significant associations with higher rates of major or minor complications.

Previous studies have shown a correlation between high BMI and increased postoperative complication rates.[5,10,32,33] A national database study investigated 144,239 TSA patients from 2005 to 2012 and concluded that super-morbidly obese patients had higher rates of infections, thrombosis, revision surgery, and dislocation.[33] Similarly, Wagner et al investigated 4567 patients undergoing TSA from 1970 to 2013 and concluded that higher BMI was associated with increased rates of revision surgery and postoperative complications.[32] Our data are consistent with this previous literature analyzing more recent data from a different large national database.

Although high BMI has been associated with a more complex postoperative recovery after total joint arthroplasty,[10,20,21] the literature is still controversial. Jiang et al[14] examined 4796 patients with BMI more than 30.0 kg/m$^2$ and concluded that obese, morbidly obese, and super-morbidly obese patients did not have an

**Table II**
Binary logistic regression for postoperative complications.

| | All patients | Weight classification | | | | | |
|---|---|---|---|---|---|---|---|
| | | Nonobese | Underweight | Overweight | Obese | Morbidly obese | Super-morbidly obese |
| Cardiac arrest | | | $P = .55$ | $P = .472$ | $P = .896$ | $P = .631$ | $P = .999$ |
| | 13 | 2 (0.1%) | 1 (0.6%) | 2 (0.0%) | 6 (0.1%) | 2 (0.1%) | 0 (0.0%) |
| MI | | | $P = .999$ | $P = .728$ | $P = .514$ | $P = .986$ | $P = .746$ |
| | 61 | 8 (0.2%) | 0 (0%) | 19 (0.3%) | 28 (0.3%) | 5 (0.2%) | 1 (0.3%) |
| Cardiac complication | | | $P = .478$ | $P = .951$ | $P = .635$ | $P = .803$ | $P = .909$ |
| | 72 | 10 (0.3%) | 1 (0.6%) | 21 (0.3%) | 32 (0.3%) | 7 (0.3%) | 1 (0.3%) |
| Pulmonary complication | | | $P = .372$ | **$P = .006$** | $P = .382$ | $P = .400$ | $P = .168$ |
| | 189 | 37 (1.1%) | 3 (1.9%) | 41 (0.6%) | 84 (0.9%) | 18 (0.9%) | 6 (2.0%) |
| Renal complication | | | **$P = .048$** | $P = .776$ | $P = .540$ | **$P = .031$** | $P = .251$ |
| | 29 | 3 (0.1%) | 0 (0.0%) | 5 (0.1%) | 12 (0.1%) | 8 (0.4%) | 1 (0.3%) |
| UTI | | | $P = .379$ | $P = .459$ | $P = .495$ | $P = .491$ | $P = .057$ |
| | 153 | 22 (0.6%) | 2 (1.2%) | 37 (0.5%) | 70 (0.8%) | 17 (0.8%) | 5 (1.7%) |
| DVT | | | $P = .064$ | $P = .948$ | $P = .518$ | $P = .414$ | $P = .293$ |
| | 77 | 10 (0.3%) | 2 (1.2%) | 20 (0.3%) | 34 (0.4%) | 9 (0.4%) | 2 (0.7%) |
| PE | | | $P = .421$ | $P = .418$ | $P = .857$ | $P = .308$ | $P = .240$ |
| | 60 | 9 (0.3%) | 1 (0.6%) | 13 (0.2%) | 26 (0.3%) | 9 (0.4%) | 2 (0.7%) |
| Sepsis | | | $P = .999$ | $P = .628$ | $P = .557$ | $P = .294$ | $P = .999$ |
| | 30 | 4 (0.1%) | 0 (0.0%) | 6 (0.1%) | 15 (0.2%) | 5 (0.1%) | 0 (0.0%) |
| Septic shock | | | $P = .999$ | $P = .150$ | $P = .764$ | $P = .986$ | $P = .999$ |
| | 10 | 4 (0.1%) | 0 (0.0%) | 2 (0.0%) | 4 (0.0%) | 0 (0.0%) | 0 (0.0%) |
| Wound infection | | | $P = .999$ | $P = .063$ | $P = .083$ | **$P < .001$** | **$P = .033$** |
| | 106 | 8 (0.2%) | 0 (0.0%) | 34 (0.5%) | 42 (0.5%) | 19 (0.9%) | 3 (1.0%) |
| Surgical site infection | | | $P = .999$ | $P = .461$ | $P = .278$ | $P = .095$ | $P = .072$ |
| | 53 | 5 (0.1%) | 0 (0.0%) | 15 (0.2%) | 23 (0.3%) | 8 (0.4%) | 2 (0.7%) |
| Return to the OR | | | $P = .787$ | $P = .065$ | $P = .841$ | $P = .132$ | $P = .275$ |
| | 311 | 51 (1.5%) | 2 (1.2%) | 75 (1.1%) | 133 (1.4%) | 43 (2.0%) | 7 (2.3%) |
| Readmission | | | $P = .435$ | **$P = .014$** | $P = .491$ | $P = .205$ | $P = .471$ |
| | 647 | 109 (3.2%) | 7 (4.3%) | 166 (2.4%) | 272 (3.0%) | 81 (3.8%) | 12 (4.0%) |
| Nonhome discharge | | | **$P < .001$** | **$P < .001$** | **$P = .002$** | **$P = .046$** | **$P < .001$** |
| | 2100 | 362 (10.6%) | 33 (20.4%) | 582 (8.3%) | 807 (8.8%) | 261 (12.4%) | 55 (18.2%) |
| Any complication | | | **$P = .028$** | **$P = .001$** | **$P = .003$** | $P = .323$ | $P = .941$ |
| | 938 | 177 (5.2%) | 15 (9.3%) | 266 (3.8%) | 367 (4.0%) | 97 (4.6%) | 16 (5.3%) |
| Major complication | | | **$P = .009$** | **$P = .007$** | $P = .459$ | $P = .152$ | $P = .268$ |
| | 933 | 155 (4.6%) | 14 (8.6%) | 242 (3.5%) | 390 (4.3%) | 114 (5.4%) | 18 (6.0%) |
| Minor complication | | | $P = .054$ | **$P < .001$** | **$P < .001$** | **$P = .022$** | $P = .641$ |
| | 677 | 143 (4.2%) | 12 (7.4%) | 200 (2.9%) | 248 (2.7%) | 63 (3.0%) | 11 (3.6%) |
| Mortality | | | **$P = .005$** | $P = .108$ | **$P = .040$*** | $P = .144$ | $P = .000$ |
| | 36 | 10 (0.3%) | 3 (1.9%) | 10 (0.1%) | 11 (0.1%) | 2 (0.1%) | 0 (0.0%) |
| Postoperative transfusion | | | **$P = .027$** | **$P < .001$** | **$P < .001$** | **$P < .001$** | $P = .056$ |
| | 398 | 102 (3.0%) | 10 (6.2%) | 134 (1.9%) | 118 (1.3%) | 31 (1.5%) | 3 (1.0%) |

*MI*, myocardial infarction; *UTI*, urinary tract infection; *DVT*, deep vein thrombosis; *PE*, pulmonary embolism; *OR*, operating room.
Significant *P* values are in bold.

increased incidence of postoperative complications. Similarly, Li et al[19] found no short-term detrimental effects during recovery from TSA in patients with BMI > 30.0 kg/m$^2$. Contrary to these studies, our analysis identified higher BMI (40.0 kg/m$^2$ and higher) as a risk factor for wound infections and nonhome discharge. To facilitate a direct comparison with previous studies, gain deeper insights into the dataset, and assess the strength of our methodology, we conducted further analysis of postoperative complications comparing BMIs less than 30 to BMIs more than 30 as in Li et al[19] and Jiang et al.[14] The analysis demonstrated no differences in postoperative complications between these 2 groups, underscoring the limitations of this approach, which under-represent populations at the extremes of the BMI spectrum such as underweight, morbidly obese, and super-morbidly obese patients. Namely, this methodology may introduce sampling errors and selection bias. On the other hand, a capillary stratification of the BMIs in multiple groups, as employed in this study, ensures a comprehensive representation of each subgroup within the population, thus minimizing statistical errors.

Additionally, the use of a large national database allowed us to strengthen our statistical analysis. The inclusion of 22,132 patients, comprising 11,281 patients with a BMI of 30.0 kg/m$^2$ and more, afforded us enough statistical power to identify postoperative complications in patient populations with less common characteristics. In contrast, the aforementioned studies had only 2131 patients classified as obese and above.[14,19]

Although morbidly obese and super-morbidly obese patients showed an increase in postoperative complication rates, overweight and obese patients (BMI between 25 and 39.9 kg/m$^2$) were not at significant risk for major and minor complications. This agrees with some of the existing literature. A retrospective cohort study by Garcia et al[8] analyzed TSA postoperative outcomes in 4751 patients with BMI > 30.0 kg/m$^2$. The study did not find a significant association between postoperative complications and BMI between 30 and 40.0 kg/m$^2$.

On the other end of the BMI scale, Ottesen et al[25] analyzed 15,717 patients from 2005 to 2016 and found that underweight patients had a higher probability of experiencing serious adverse events such as deep infections, renal failures, cerebrovascular events, and postoperative infections. Our study identified underweight patients as having increased odds of major complications, mortality, and nonhome discharge on bivariate analysis. After adjusting for comorbidities, underweight patients were associated with increased odds of nonhome discharge and mortality. Therefore, underweight patients may face a more complex postoperative course and serious consequences even leading up to death.

Overall, the current findings reinforce the importance of optimal nutritional management in patients undergoing TSA. With the

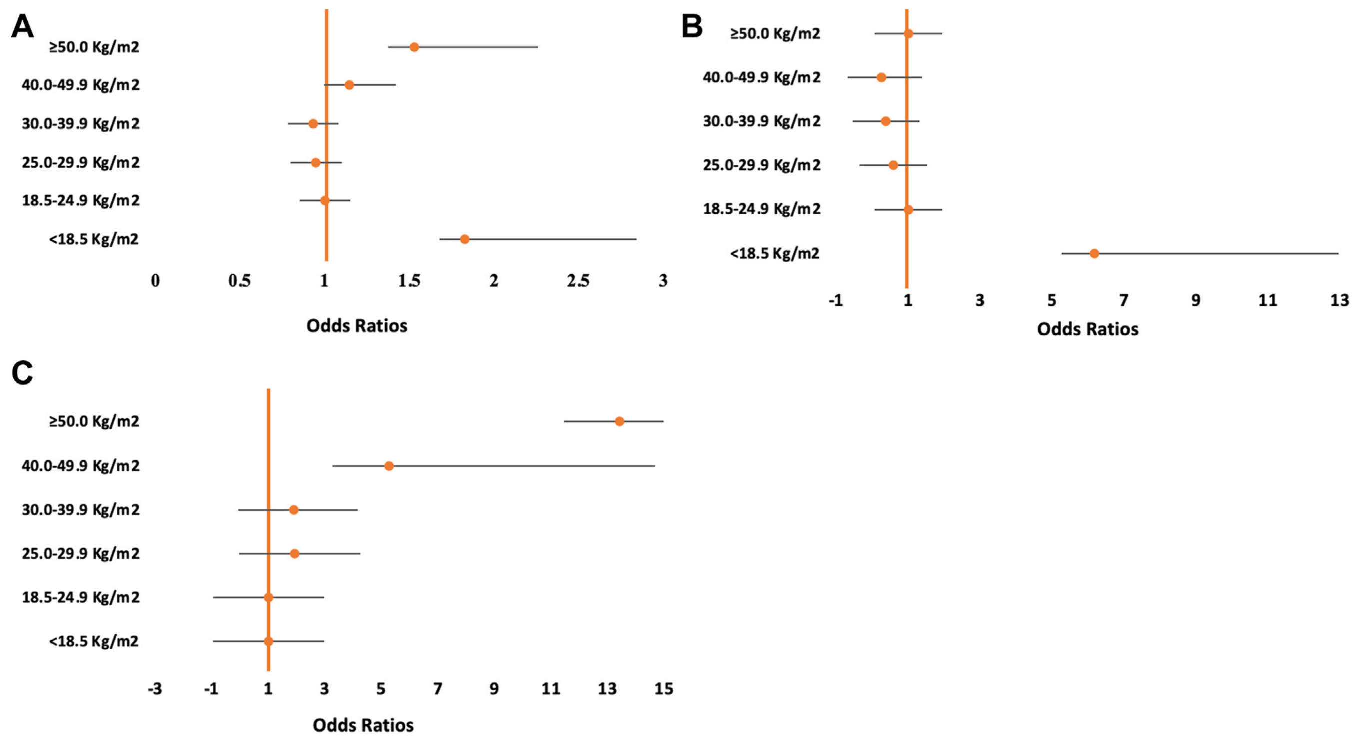


**Figure 2** Forest plots showing that (**A**) nonhome discharge was more likely in the underweight and super-morbidly obese patients, (**B**) mortality was more likely in the underweight cohort, and (**C**) wound infections were more likely in the morbidly and super-morbidly obese patients.

increased evidence of detrimental postoperative outcomes in patients with high BMI, some surgeons already require weight loss and the use of a cutoff BMI of 40 kg/m$^2$ before performing surgery. To accomplish these goals, new effective weight loss programs are to be completed before joint surgeries.[7,15,26] In a retrospective study, Keeney et al[15] showed that a 20-pound preoperative weight loss in morbidly obese patients resulted in a shorter length of stay and a lower risk of nonhome discharge.

Optimizing perioperative care in patients with high BMI involves a multidisciplinary approach. Additionally, pharmacokinetics and pharmacodynamics are strongly influenced by the adipose composition of patients.[4] Therefore, for both obese and underweight patients, optimal communication with the anesthesiologists and the medical team should be promoted to stress the importance of calculations of lean, ideal, and adjusted body weight to decide the most appropriate pharmacological treatment and optimize perioperative care.[12]

Although obesity has been shown to negatively affect surgical outcomes,[17,28] the correlation between low BMI and increased postoperative complications after TSA is not yet fully understood.[25]

**Table III**
Multivariate logistic regression of postoperative complications adjusted for significant demographics and comorbidities.

| Weight classification | Statistical significance | |
|---|---|---|
| | OR (95% CI) | *P* value |
| Underweight | | |
| Nonhome discharge | 1.824 (1.172-2.839) | **.008** |
| Mortality | 6.184 (1.598-23.926) | **.008** |
| Morbidly obese | | |
| Wound infection | 5.254 (1.878-14.700) | **<.002** |
| Super-morbidly obese | | |
| Wound infection | 13.431 (2.603-69.300) | **.002** |
| Nonhome discharge | 1.525 (1.030-2.258) | **.035** |

*OR*, odds ratio; *CI*, confidence interval.
Significant *P* values are in bold.

Malnutrition may play a role in decreased wound healing and capacity to prevent infections. This seriously impacts the body's physiological recovery from trauma, surgery, and disease.[24,27] Additionally, malnutrition induces a state of chronic fatigue and inability to react to major stressors, leading to poor postoperative outcomes.[22] To quickly identify malnourished patients, a subjective global assessment can be performed and objective data measured.[11] The subjective assessment includes the patient history and physical examination, while the objective data include levels of creatinine, albumin, cholesterol, cholinesterase, transferrin, nitrogen balance, and blood lymphocyte count.[30]

Limitations of this study include that postoperative data within the National Surgical Quality Improvement Program database are limited to the 30-day postoperative period. Therefore, we could not consider long-term postoperative adverse outcomes that may occur following TSA, such as loosening and instability. Additionally, this is a retrospective cohort study, so while we were able to calculate the likelihood of certain events, we could not determine causality. Finally, the database coding does not distinguish between anatomic and reverse TSA, nor does it account for the indications of TSA (such as proximal humerus fracture, rotator cuff arthropathy, or osteoarthritis). Although Kirsch et al[16] found no significant differences in medical complications between patients undergoing

**Table IV**
Subanalysis of BMIs < 30 kg/m$^2$ and BMI > 30 kg/m$^2$.

| Weight classification | Statistical significance | |
|---|---|---|
| | OR (95% CI) | *P* value |
| Less than 30 kg/m$^2$ | | |
| Mortality | 0.531 (0.261-1.081) | .081 |
| More than 30 kg/m$^2$ | | |
| Wound infection | 1.388 (0.920-2.095) | .118 |
| Nonhome discharge | 1.052 (0.954-1.160) | .310 |

*BMI*, body mass index; *OR*, odds ratio; *CI*, confidence interval.

anatomic TSA and reverse TSA, the inability to stratify by surgical technique remains a significant factor that could impact our outcomes. Readers should take this into consideration.

Despite these limitations, the use of a large validated national database, the application of a multivariate logistic regression, and a comprehensive stratification of BMI categories afforded us a robust methodology and enough power to detect postoperative complications in relatively uncommon patient populations and strengthened the internal and external validity of the study.

## Conclusion

Overall, the present study found that patients with BMI $\geq$ 40 kg/m$^2$ had a higher likelihood of developing wound infections, while those with BMIs $\leq$ 18.5 kg/m$^2$ had a higher likelihood of nonhome discharge and mortality. Additionally, super-morbidly obese patients were more likely to not be discharged at home. These patients would benefit from a holistic multidisciplinary approach to care, which would include nutritional plans, weight loss programs, and subjective and objective evaluations.

## Disclaimers:

Funding: No funding was disclosed by the authors.
Conflicts of interest: The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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