Obesity Is Not a Predictor of Complications in Upper Extremity Surgery

HAND
2019, Vol. 14(2) 264–270
© The Author(s) 2017
Article reuse guidelines:
sagepub.com/journals-permissions
DOI: 10.1177/1558944717736825
hand.sagepub.com

Elan J. Golan¹ , Jadie De Tolla¹, Maya Deza Culbertson-Scott¹,
Ryan Krochak¹, and Jack Choueka¹

Abstract

Background: Obesity is an often-cited cause of surgical morbidity. As a result, many institutions have required screening prior to “clearing” obese individuals for surgery. However, it remains unclear whether such testing is warranted for obese patients prior to upper extremity procedures. This study reviews surgical outcomes to determine if obesity does predict operative morbidity following upper extremity surgery. **Methods:** The National Surgical Quality Improvement Program was queried for 18 Current Procedural Terminology codes, representing upper extremity fracture and arthroplasty procedures. Patients’ body mass index (BMI) and medical histories were examined as predictors for postoperative complications. Both individual and combined incidences of complications were compared between patients stratified as normal-weight (BMI < 30); obese (BMI 30–40); and morbidly obese (BMI > 40). **Results:** A total of 8,477 patients were identified over the 5-year study period; 5,303 had a BMI <30, 2,565 a BMI of 30 to 40 and 585 a BMI >40. With the exception of postoperative blood transfusions, there were no significant increases in the incidence rates of any complication event as a function of BMI class. The overall incidence of complications was 2.70 % for BMI <30; 2.74 % for BMI 30 to 40; and 1.54 % for BMI >40. **Conclusions:** Obesity is not a reliable predictor of complications following upper extremity surgery. Thus, requiring preoperative screening for obese patients may constitute an unnecessary burden on medical resources. Further study is needed to identify specific demographics that might serve as more accurate predictors of poor outcomes in obese patients undergoing surgery of the upper extremity.

Keywords: operative risk, NSQIP database, surgical screening, surgical morbidity, fracture care, arthroplasty

Introduction

Obesity has grown to pandemic proportions, with global rates doubling in the past 30 years alone.⁵ In the United States, obesity rates have reached especially high levels, with some estimates postulating that as much as 68% of population being overweight, with 33.8% fitting a diagnosis of clinical obesity.^{15,22}

Obesity has been linked to numerous medical conditions, including diabetes, cardiovascular and pulmonary diseases, chronic pain syndromes, and psychiatric illnesses.¹⁷ These complications translate to additional strain on medical resources and health care expenditures. Medical treatment in obese patients costs as much as much as 42 times more when compared with treatment in patients of normal weight. In the United States, obesity-related complications account for an annual economic burden of approximately \$210 billion dollars, or roughly 10% of total medical spending.²¹

The specific costs of obesity for elective upper extremity procedures are largely unknown. Few studies have

demonstrated an association between obesity and poor outcomes in orthopedics, with most of the existing literature addressing complications following lower extremity procedures such as total joint arthroplasty. Furthermore, existent studies predominantly examine minor sequelae such as infection and delayed healing and seldom address the incidence of severe or life-threatening complications.^{4,6–9}

Though there is little evidence supporting a firm association between obesity and severe postoperative complications, many health care institutions have nonetheless adopted stringent screening protocols that limit access to operative care for “high risk,” obese patients, usually defined by a body mass index (BMI) threshold. These procedures are often applied to all prospective surgical patients, regardless

¹Maimonides Medical Center, Brooklyn, NY, USA

Corresponding Author:

Elan J. Golan, Department of Orthopedic Surgery, Maimonides Medical Center, 927 49th Street, Brooklyn, NY 11219, USA.
Email: ejgolan@gmail.com

of the type of surgery, with BMI used as the sole criterion for additional screening.

As prior studies have found increased complication rates for bony upper extremity procedures when compared with procedures limited to nerve or soft tissue,¹² the present study was limited to the evaluation of arthroplasty and fracture fixation procedures. By exploring the utility of BMI as a predictor of deleterious outcomes following such procedures, this study attempts to determine whether obesity acts as an effective predictor of postoperative complications following upper extremity surgery.

Materials and Methods

Data Query

All patient data used for this study was retrieved from the National Surgical Quality Improvement Program (NSQIP) database. The NSQIP database provides anonymized demographic, preoperative, surgical, and outcome data for individual patients, which can be separated by procedure type.¹ Information collected for each patient includes medical history, surgical procedure performed, and 240 patient-specific medical and intraoperative variables along with all operative outcomes recorded within the immediate 30-day postoperative period. Patient follow-up information is gathered via a combination of chart review and direct patient contact and entered into the NSQIP database by trained clinical data reviewers. NSQIP variable coding has been demonstrated to show high interrater reliability with an incidence of disagreement of less than 2%.²⁰ The NSQIP database has been used extensively for studying postoperative morbidity and complications, including a recent review specific to upper extremity surgery.¹¹

Determination of Complication Incidence Rates

Eighteen Current Procedural Terminology (CPT) codes representing common fracture fixation and arthroplasty procedures of the upper extremity were used to select prospective patients for subsequent analyses (Chart Listing Codes).

The NSQIP database was then queried to return all patients who underwent these procedures during the 5-year period between January 2008 and December 2012. BMI in kg/m² was calculated for each patient based on height and weight information, and patients were then stratified by BMI into “normal” (BMI < 30), “obese” (BMI 30–40), and “morbidly obese” (BMI > 40). A small percentage (5.1%) of patients were classified as “underweight” with a BMI of less than 18.5 (Centers for Disease Control and Prevention)³ and were excluded from subsequent analyses. Age, sex, total anesthesia time for each surgical event were also recorded for each patient along with factors such as diabetes, hypertension, and American Society of Anesthesiologists (ASA)

classification score. In addition, we also looked at a total of 19 complications or adverse events which were collected and recorded in the NSQIP database for the 30-day postoperative interval for each patient. These complications were selected to represent a range of common complications, including superficial wound infection, organ failure, and death. Complications were categorized as being either “localized” (eg, wound infection or dehiscence) or “systemic.” Finally, we also included each patient’s NSQIP “mortality” score,¹ a variable describing surgical complication risk obtained by regression analysis of each patient’s preoperative characteristics.

Statistical Analyses

Normally distributed data (eg, age) were described in terms of mean $\pm$ standard deviation while categorical data (eg, sex) were described in terms of frequency (percent). Univariate analyses were then carried out to compare demographic differences and complication incidences across the BMI groups using either analysis of variance for comparison of continuous variables or chi-squared tests for comparison of categorical variables. Due to the presence of independent risk factors, which may be associated with both BMI and complication risk factors in and of themselves, multivariate logistic regression analysis was performed to test for significant associations of BMI with any of the 19 complications after controlling for possible confounding with other factors. All analyses were carried out using SAS 9.4 (SAS Inc, Cary, North Carolina) with a designated significance threshold of <0.05 used for all analyses. A power analysis indicated that a total sample of 8000 patients would allow for 80% to detect a difference in complication rate of 1.1% with $\alpha = 0.05$.

Results

Between 2008 and 2012, a total of 8026 patients in the NSQIP database underwent one of the 24 upper extremity fracture or arthroplasty procedures. Of these, 4873 patients (61%) had normal BMI, 2568 (32%) were classified as obese, and 585 (7%) were classified as morbidly obese.

Average age was similar among the 3 BMI subgroups, with obese patients (average 62.87 years) noted to be slightly older than either normal-weight (60.34 years) or morbidly obese (60.94 years) individuals. Of note, the normal-weight subgroup contained many more subjects under the age of 55 years, with 19.7% of such younger individuals found to have a BMI of less than 30, when compared with either obese (7.5%) or morbidly obese (1.76%) subjects.

Females represented a slight majority, comprising 53.2% of all patients evaluated. In terms of BMI subgroups, females represented 58.03% of normal-weight individuals, 57.63% of individuals with a BMI of 30 to 40, and 68.21%

Table 1. Demographic and Clinical Characteristics by BMI Classification.

Characteristic	BMI class			P value
	Normal (<30) N = 4873	Obese (30-40) N = 2568	Morbidly obese (>40) N = 585	
Age	60.34 ± 18.25 ^a	62.87 ± 14.49	60.96 ± 12.48	<.001
Age group				
<55	1581 (19.7%) ^b	603 (7.5%)	141 (1.76%)	<.001
55-64	961 (12.0%)	606 (7.6%)	182 (2.3%)	
65-74	1096 (13.7%)	804 (10.0%)	203 (2.5%)	
≥75	1235 (15.4%)	555 (6.9%)	59 (0.74%)	
Female sex	2828 (53.2%)	1480 (18.4%)	399 (5.0%)	<.0001
Preoperative risk factors				
Diabetes	350 (7.18%) #3	477 (18.57%) #2	185 (31.62%) #2	<.0001
Dyspnea	233 (4.78%)	193 (7.52%)	84 (14.36%) #3	<.0001
HTN medication	2001 (41.06%) #1	1575 (61.33%) #1	423 (72.31%) #1	<.0001
Smoking	882 (18.10%) #2	337 (13.12%) #3	60 (10.26%)	<.0001
ETOH	120 (2.46%)	45 (1.75%)	5 (0.85%)	.0114
History CHF	7 (0.14%)	6 (0.23%)	6 (1.03%)	.0002
History MI	6 (0.12%)	3 (0.12%)	1 (0.17%)	.9445
PRVPCS	120 (2.46%)	77 (3.00%)	14 (2.39%)	.3635
Mean ASA score	2.15 (±2.155)	2.40 (±0.63)	2.77 (±0.59)	<.0001
ASA score by age group				
<55	1.69 ± 0.63	1.98 ± 0.64	2.52 ± 0.65	<.001
55-64	2.13 ± 0.63	2.38 ± 0.58	2.81 ± 0.54	
65-74	2.33 ± 0.60	2.53 ± 0.56	2.87 ± 0.55	
≥75	2.62 ± 0.57	2.70 ± 0.52	2.92 ± 0.57	
Estimated morbidity probability	0.018 (±0.016)	0.027 (±0.019)	0.037 (±0.025)	<.0001
Estimated morbidity probability by age group				
<55	0.008 ± 0.008	0.014 ± 0.014	0.020 ± 0.016	<.001
55-64	0.015 ± 0.016	0.024 ± 0.017	0.034 ± 0.019	
65-74	0.022 ± 0.016	0.030 ± 0.017	0.044 ± 0.029	
≥75	0.029 ± 0.017	0.038 ± 0.020	0.053 ± 0.015	
Procedures				
Shoulder arthroplasty	2114 (26.34%)	1599 (19.92%)	374 (4.66%)	<.0001
Fractures of the shoulder	97 (1.21%)	50 (0.62%)	16 (0.20%)	<.4519
Wrist fractures	1755 (21.87%)	669 (8.32%)	160 (1.99%)	<.0001
ORIF forearm fracture	66 (0.82%)	23 (0.29%)	6 (0.07%)	.2059
Arthroplasty of the elbow	841 (10.48%)	228 (2.84%)	29 (0.36%)	<.0001

Note. BMI = body mass index; ASA = American Society of Anesthesiologists; HTN = hypertension; ETOH = alcohol use; CHF = congestive heart failure; MI = myocardial infarction; PRVPCS = previous cardiac surgery; ORIF = open reduction internal fixation.

^aMean ± standard deviation.

^bFrequency (percent).

of those with a BMI greater than 40. Further descriptions of patient demographics are characterized for each BMI subgroup in Table 1.

In terms of medical comorbidities, hypertension represented the most commonly known medical problem across all BMI categories. Among patients who were obese or morbidly obese, diabetes was the second most common comorbid factor, with normal-weight individuals more likely to have a history of smoking. In total, obese and morbidly obese individuals were more likely to have a history one or more of

the examined comorbidities, including hypertension, diabetes, dyspnea, and heart failure. Smoking was the only medical comorbidity that was more common in normal-weight individuals ($P < .001$). These findings were consistent with individual patient assessments based on the NSQIP "mortality" predictive score, which suggested that the obese and morbidly obese individuals analyzed had a significantly higher incidence of overall comorbidity ($P < .001$).

As illustrated in Table 2, despite the significant differences in comorbidity demonstrated by Table 1, there were

Table 2. Operative Outcomes by BMI Class.

Operative outcome	BMI class			P value
	Normal N = 4873	Obese N = 2568	Morbidly obese N = 585	
Any complication	129 (2.65%) ^a	71 (2.76%)	9 (1.54%)	.23
Complication subtype				
Localized	20 (0.41%)	16 (0.62%)	0 (0.00%)	.10
Systemic	49 (1.01%)	23 (0.90%)	4 (0.68%)	.71
Intraoperative transfusions	29 (0.60%)	7 (0.027%)	0 (0.0%)	.14
Postoperative transfusion	157 (3.22%)	76 (2.96%)	17 (2.91%)	.79
All-cause superficial wound complications	17 (0.35%)	10 (0.39%)	0 (0.00%)	.09
Superficial surgical site infection	11 (0.23%)	10 (0.39%)	0 (0.00%)	.1844
Deep surgical site infection	6 (0.12%)	5 (0.19%)	0 (0.00%)	.4734
Wound dehiscence	5 (0.10%)	3 (0.12%)	0 (0.00%)	.7176
Urinary tract infection	26 (0.53%)	24 (0.93%)	5 (0.85%)	.12
Pneumonia	23 (0.47%)	4 (0.16%)	1 (0.17%)	.0668
Pulmonary embolism	9 (0.18%)	7 (0.27%)	0 (0.00%)	.3842
Unplanned intubation	9 (0.18%)	5 (0.19%)	1 (0.17%)	.99
Need for ventilator	6 (0.12%)	2 (0.008%)	0 (0.0%)	.61
Cardiac arrest	6 (0.12%)	2 (0.08%)	1 (0.17%)	.7780
Myocardial infarction	10 (0.21%)	2 (0.08%)	1 (0.17%)	.4297
Sepsis	5 (0.10%)	7 (0.27%)	1 (0.17%)	.2222
Unplanned return to OR	54 (1.11%)	38 (1.48%)	4 (0.68%)	.1858
Unplanned readmission	34 (1.11%)	10 (0.64%)	1 (0.28%)	.1173
Anesthesia time	152.42 ± 68.14	166.77 ± 67.7	171.68 ± 76.2	<.001
30 day mortality	20 (0.21%)	5 (0.19%)	1 (0.17%)	.98

Note. BMI = body mass index; ORIF = open reduction internal fixation; OR = operating room.

^aFrequency (percent).

no significant differences in the incidence of either individual or overall operative complications as a function of BMI. In fact, morbidly obese patients exhibited a lower overall incidence of complication (1.54%) compared with the normal (2.65%) and overweight patients (2.76%), although this result failed to achieve statistical significance ($P = .23$).

Similarly, after subdividing individual complications into “local” and “systemic” subtypes, there were no differences in the incidences of either complication type as a function of BMI. Interestingly, the rate of wound infection was found to be higher in obese individuals as compared with those of normal weight, though this finding again lacked statistical significance. The only outcome that did demonstrate a significant difference in terms of BMI was anesthesia time, with patients of higher BMI requiring a longer total duration of anesthesia. Otherwise, no other complication was identified in which an increased BMI represented a risk for operative complications. Interestingly, as was the case for postoperative transfusion, data from analysis of several factors was actually suggestive of normal-weight individuals incurring a greater incidence of complication.

When comparing complications by procedure type, persons of a normal weight demonstrated significantly higher incidences of operative complication following arthroplasties of both the shoulder and elbow as well as with wrist fracture fixation. There were no significant differences in complication incidences for the remaining procedure subsets examined. None of the results reported here changed substantially after multivariate modeling controlling for procedure type, nor were there changes in individual or overall indicators of comorbidity (Table 3).

Discussion

At many hospitals, including our own institution, patients above a specified BMI threshold are subject to extensive supplemental testing before they can receive surgical treatment. Apart from these tests, which include consultations with various subspecialties, several institutions in our area also mandate that additional staff be on standby to assist in the care of obese patients both during surgery and in the immediate perioperative period. Based on this study's findings, we believe such mandatory additional screening and

Table 3. Any Complication by BMI Class per Procedure Type.

Procedure type	BMI class			P value
	Normal	Obese	Morbidly obese	
Shoulder arthroplasty	68 (3.22%) ^a	45 (2.81%)	6 (1.60%)	.2219
Fractures of the shoulder	10 (10.31%)	2 (4.00%)	3 (18.75%)	.1731
Wrist fractures	28 (1.60%)	18 (2.69%)	0 (0.00%)	.0401
ORIF forearm fracture	0 (0.00%)	0 (0.00%)	0 (0.00%)	
Arthroplasty of the elbow	23 (2.73%)	6 (2.63%)	0 (0.00%)	.6651

Note. BMI = body mass index; ORIF = open reduction internal fixation.

^aFrequency (percent).

support likely represent unnecessary increases in both monetary cost and medical resource allocation. Thus, it is imperative that screening criteria are chosen for their efficacy in predicting deleterious outcomes—especially as unnecessary gating criteria may result in the delay or denial of treatment for patients who are incorrectly labeled *at risk*.

This study was designed to assess whether BMI is an effective predictor of negative outcomes for orthopedic procedures of the upper extremity. With the exception of postoperative blood transfusion, our analyses of surgical outcomes after upper extremity surgery did not demonstrate significant differences in complication incidences between patients of normal weight and obese or morbidly obese patients. These findings differ from other studies examining various orthopedic surgical interventions, which demonstrated increased incidences of postoperative complications in the obese.^{2,4,6,8,18}

One possible explanation for these differences is that most of the prior studies examining the effect of increasing BMI on operative complication rates did not specifically address upper extremity procedures. We believe it is imperative to consider the operative region when attempting to anticipate possible operative complications. Even as a patient gains weight, the amount of adipose tissue in the upper extremities often remains relatively stable in comparison with other regions of the body. In addition, the rates of reported upper extremity wound complications suggest that such complications are relatively rare.^{11,12} Thus, even in morbidly obese individuals, we believe it is unlikely for complications following such procedures to be exacerbated by obesity-related difficulties in surgical exposure or approach, which are commonly reported complications in other regions such as the lower extremity.^{13,14}

Our data also support the previously reported finding of a statistically significant increase in anesthesia time with increasing BMI.¹⁹ This may be attributable to several factors, such as practitioners exercising increased caution in at-risk patients, increased difficulty with anesthetic induction, and additional time for surgical approach and dissection through excess adipose tissue. Interestingly, though mean anesthesia and procedure times increased in patients

with elevated BMI, analyses revealed a pattern toward decreased complication as BMI approaches levels of morbid obesity. However, this finding did not reach statistical significance ($P = .22$).

The phenomenon of elevated BMI conferring protection against negative outcomes for certain procedures has been observed before. The term *obesity paradox* was coined by Mullen et al to describe lower rates of postoperative complications in obese versus nonobese patients. The authors speculated that these counterintuitive effects observed in the obese might be secondary to inadvertent selection bias. They proposed that clinicians may exercise extra caution when carrying out preoperative evaluations on patients they perceive to be “at risk” and that obese patients who received surgical treatment may consist largely of the healthiest subset.¹⁶

With regard to orthopedics, several recent studies characterize correlations between obesity and increased complication rates. However, these studies focus almost exclusively on procedures of the lower extremity, and outcomes vary widely between anatomic regions.^{2,4,6-9,18} In a study of patients undergoing arthroplasty of the knee and hip, Kerkhoffs et al demonstrated higher rates of soft tissue infection and earlier revision in the obese.⁹ Another retrospective study by Cavo et al found similar increases in complication rates for obese patients after ankle fracture fixation. In addition to both increased lengths of stay and costs of hospital expenditure, the obese patients in the study experienced postoperative complications at more than twice the rate of their nonobese counterparts.²

To date, few studies specifically address complications following upper extremity surgery, and none support the use of BMI as a predictor of operative complication in this surgical context. A recent meta-analysis of patients undergoing ambulatory knee and shoulder surgery found no correlation between obesity and postoperative complication rates.¹⁰ Similarly, in a review of 435 obese patients undergoing surgery of the hand, forearm, and elbow, London et al demonstrated no statistical difference in rates of postoperative complication between BMI subgroups.¹²

In this second study, when the authors specifically examined the patients who suffered complications, they found

that the rates increased in a dose-dependent manner within groups with elevated BMIs of 45 or greater.¹² Unfortunately, it is unclear how well this finding can be extrapolated to develop preoperative screening protocols as the complications reviewed—infection, wound healing, and reoperation—were relatively minor and did not include more severe outcomes such as organ failure or death. Furthermore, though the authors noted that bony procedures incurred the highest risks of surgical complication, the study included many soft tissue procedures in their analyses. Including such lower-risk procedures likely reduced the total number of complications, decreasing the chances of finding significant differences in outcomes between BMI subgroups.

Among the strengths of this study's design is the large number of patients included, which greatly increased the chances of finding statistically significant relationships. In addition, the NSQIP database allows for analyses of a variety of outcomes, encompassing a wide range of operative complications, from wound dehiscence to organ failure and even death. Finally, because we limited the scope of our study to bony procedures, our analysis was limited to the subset of upper extremity procedures demonstrated to incur the highest risk of deleterious outcomes.¹² These aspects of the study maximized the chances of detecting differences in complication incidences between BMI subgroups, and increase the confidence that the lack of an observed relationship is not due to an underpowered data set or masking of effects by insufficiently focused subject selection.

However, the current study is not without limitations. As the NSQIP database only records events during the 30-day postoperative interval, our analyses could not detect any complication that occurred more than a month after surgery. Our study also did not control for the quality of care afforded to individual patients. Furthermore, as the NSQIP database does not account for factors such as availability of ancillary resources, or the treatment capabilities of individual hospitals, it is possible that discrepancies in treatment quality may have skewed the measured incidences of postoperative complications. Finally, it must be noted that all of the obese patients reviewed did ultimately undergo surgery. As we have no information as to the number of patients with similar pathologies who were denied surgical treatment, it is possible that our described incidences of complications were biased toward the “healthiest few obese,” possibly offering a biased representation of outcomes in patients with BMIs greater than 30. However, a comparison of the representative proportions of each BMI subgroup in the patient cohort examined for this study revealed larger representation of obese and morbidly obese individuals than would be expected in the general population. Furthermore, these analyses demonstrate equivalent incidences of complication in the obese despite the fact that the elevated BMI groups had a greater propensity for comorbidities than their

normal-weight counterparts. Taken together, we believe these findings suggest that our results were not skewed by an overt selection bias.

This study's data indicate that in patients who undergo upper extremity arthroplasty or fracture fixation, higher BMI does not result in an increased risk of surgical complication. Based on these findings, we recommend that practitioners avoid using BMI as a stand-alone criterion for risk assessment for this subset of patients. Furthermore, we believe our data demonstrating an equivalent incidence of complication between obese and normal-weight individuals suggest that there is no evidentiary basis for the use of BMI as a preoperative screening “gatekeeper” for upper extremity procedures. Based on these findings, we believe it would be more prudent and effectual to customize screening criteria for specific procedure types, as it is quite possible that yet undiscovered factors more faithfully predict increased surgical risks in patients who require upper extremity surgery. Developing such individualized protocols may more effectively shield prospective surgical patients from complication risks, while simultaneously streamlining resource allocation to address factors that are proven to increase patient morbidity and mortality.

Authors' Note

This study was conducted at the Orthopedic Research facilities of Maimonides Medical Center, Brooklyn, NY.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

This article does not contain any studies with human or animal subjects.

Statement of Informed Consent

The authors assert that informed consent is not applicable in this study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

EJ Golan <https://orcid.org/0000-0002-8908-7514>

References

1. American College of Surgeons. *ACS NSQIP Data Users Guide*. Chicago, IL: American College of Surgeons, ed.; 2013.

2. Cavo MJ, Fox JP, Markert R, et al. Association between diabetes, obesity, and short-term outcomes among patients surgically treated for ankle fracture. *J Bone Joint Surg Am*. 2015;97:987-994.
3. Centers for Disease Control and Prevention. About Adult BMI | Healthy Weight | American Center for Disease Control. Date unknown. https://www.cdc.gov/healthyweight/assessing/bmi/adult_bmi/index.html. Accessed September 13, 2016.
4. Dowsey MM, Choong PF. Obesity is a major risk factor for prosthetic infection after primary hip arthroplasty. *Clin Orthop Relat Res*. 2008;466:153-158.
5. Flegal KM, Carroll MD, Kit BK, et al. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *JAMA*. 2012;307:491-497.
6. Foran JR, Mont MA, Etienne G, et al. The outcome of total knee arthroplasty in obese patients. *J Bone Joint Surg Am*. 2004;86-A:1609-1615.
7. Friedman RJ, Hess S, Berkowitz SD, et al. Complication rates after hip or knee arthroplasty in morbidly obese patients. *Clin Orthop Relat Res*. 2013;471:3358-3366.
8. Guss D, Bhattacharyya T. Perioperative management of the obese orthopaedic patient. *J Am Acad Orthop Surg*. 2006;14:425-432.
9. Kerkhoffs GM, Servien E, Dunn W, et al. The influence of obesity on the complication rate and outcome of total knee arthroplasty: a meta-analysis and systematic literature review. *J Bone Joint Surg Am*. 2012;94:1839-1844.
10. Kluczynski MA, Bisson LJ, Marzo JM. Does body mass index affect outcomes of ambulatory knee and shoulder surgery? *Arthroscopy*. 2014;30:856-865.
11. Lipira AB, Sood RF, Tatman PD, et al. Complications within 30 days of hand surgery: an analysis of 10,646 patients. *J Hand Surg Am*. 2015;40:1852-1859.e3.
12. London DA, Stepan JG, Lalchandani GR, et al. The impact of obesity on complications of elbow, forearm, and hand surgeries. *J Hand Surg Am*. 2014;39:1578-1584.
13. McElroy MJ, Pivec R, Issa K, et al. The effects of obesity and morbid obesity on outcomes in TKA. *J Knee Surg*. 2013;26:83-88.
14. Meller MM, Toossi N, Johanson NA, et al. Risk and cost of 90-day complications in morbidly and superobese patients after total knee arthroplasty. *J Arthroplasty*. 2016;31:2091-2098.
15. Mokdad AH, Bowman BA, Ford ES, et al. The continuing epidemics of obesity and diabetes in the United States. *JAMA*. 2001;286:1195-1200.
16. Mullen JT, Moorman DW, Davenport DL. The obesity paradox: body mass index and outcomes in patients undergoing nonbariatric general surgery. *Ann Surg*. 2009;250:166-172.
17. Ogden C, Carroll M, Kit B, et al. *Prevalence of Obesity Among Adults: United States, 2011-2012* (NCHS Data Brief No. 131). Hyattsville, MD: National Center for Health Statistics; 2013.
18. Patel N, Bagan B, Vadera S, et al. Obesity and spine surgery: relation to perioperative complications. *J Neurosurg Spine*. 2007;6:291-297.
19. Perka C, Arnold U, Buttgeriet F. Influencing factors on perioperative morbidity in knee arthroplasty. *Clin Orthop Relat Res*. 2000;(378):183-191.
20. Shiloach M, Frencher SK Jr, Steeger JE, et al. Toward robust information: data quality and inter-rater reliability in the American College of Surgeons National Surgical Quality Improvement Program. *J Am Coll Surg*. 2010;210:6-16.
21. Thompson D, Edelsberg J, Kinsey KL, et al. Estimated economic costs of obesity to U.S. business. *Am J Health Promot*. 1998;13:120-127.
22. Wolf AM, Colditz GA. Current estimates of the economic cost of obesity in the United States. *Obes Res*. 1998;6:97-106.