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The Impact of Obesity on Complications of Elbow, Forearm, and Hand Surgeries

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Abstract

Purpose: To compare the rates of postoperative complications in obese and non-obese patients following elbow, forearm, and hand surgeries.

Methods: This case-control study examined 436 patients whose body mass index (BMI) was over 35 and who underwent hand, wrist, forearm, or elbow surgery between 2009-2013. Controls were patients (n=433) with a BMI<30 who had similar surgeries over the same period, and frequency-matched by type of surgery (i.e., bony, soft tissue, or nerve), age, and sex. Postoperative complications were defined as infection requiring antibiotic or reoperation, delayed incision healing, nerve dysfunction, wound dehiscence, hematoma, and other reoperation. Medical comorbidities (e.g., hypertension, diabetes, stroke, vascular disease, kidney disease, and liver disease) were recorded. Chi-square analyses were performed to explore the association between obesity and postoperative complications. Similar analyses were performed stratified by surgery type and BMI classification. Logistic regression modeling was performed to identify predictors of postoperative complications accounting for surgery type, BMI, the presence of comorbidities, patient age, and patient sex. This same model was also run separately for case and control patients.

Results: The overall complication rate was 8.7% with similar rates between obese and non-obese patients (8.5% vs 9.0%). Bony procedures resulted in the greatest risk of complication in both groups (15% each group). Multivariate analysis confirmed surgery type as the only significant predictor of complications for non-obese patients. However, among obese patients, both bony surgery and increasing BMI were associated with greater complication rates.

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Discussion: Not all obese patients appear to be at any higher risk for complications after elbow, forearm, and hand surgery compared to non-obese patients. However, there appears to be a dose-dependent effect of BMI among obese patients such that increasing-obesity heightens the risk of complications, especially for those with a BMI greater than 45.

Level of Evidence: Prognostic, Level II

Keywords

Obesity; Surgery; Complications; BMI

INTRODUCTION

Obesity is an emerging epidemic in the United States. Currently, over 35% of adults nationwide are considered obese (body mass index [BMI] ≥ 30), and the national prevalence of obesity has been climbing steadily since 1980.(1) Due to the increasing prevalence of marked obesity, the World Health Organization and the National Institutes of Health have stratified obesity by BMI, and others have further differentiated class III obesity (originally BMI ≥ 40) to now specifically include extreme obesity (45-49.9) and super obesity (≥ 50). (2) In 2008, data indicated that the medical costs to treat obesity reached \$147 billion in the United States.(3) Obesity has been linked to increased predisposition to multiple orthopedic disorders, including hip and knee osteoarthritis, low back pain, and carpal tunnel syndrome and to complications following orthopedic procedures.(4,5)

This includes greater rates of infection, more frequent need for revision surgery after total knee arthroplasty and acetabular fracture fixation, and difficulty achieving fracture union. (6-8) Obesity is also associated with negative functional outcomes and longer hospital stays following arthroscopic rotator cuff repairs.(9)

Despite this evidence of adverse outcomes and increased complication rates among obese orthopedic patients, the risk of postoperative complications following surgery for elbow, forearm, and hand conditions is unknown.(10) Considering the unique characteristics of these surgeries including immediate ambulation, short duration of common procedures, and limited subcutaneous fat in these areas, we questioned if complications following these surgeries would differ from other orthopedic surgeries in obese individuals. The purpose of this case-control investigation was to compare the rates of postoperative complications experienced by obese and non-obese hand, wrist, forearm, and elbow surgical patients. We tested the null hypothesis that obese patients would experience similar complication rates compared to non-obese patients following operations on the elbow and distally.

MATERIALS AND METHODS

This case-control study compared severely obese (BMI ≥ 35) hand, forearm, and elbow surgical patients to a non-obese (BMI < 30) surgery patient control group undergoing similar surgeries. After receiving approval from our institutional review board, cases were identified using electronic anesthesia records from preoperative assessments in our institution from 2009 to 2013. All procedures were performed by 1 of 5 fellowship-trained orthopedic hand

surgeons. Our patient groups excluded patients with BMI over 30 but less than 35. This was chosen *a priori* to increase the differentiation between the groups based on the presumption that BMI in each group would skew toward normal away from the high and low extremes and minimize the chance of misclassification of patients due to minor weight fluctuation around a BMI of 30 (Figure 1). Other exclusion criteria were patients younger than 18 years, patients undergoing surgery proximal to the elbow, patients concurrently undergoing more than 1 type of surgery (bony, soft tissue, or nerve), and any patient without postoperative care at our institution. Surgeries coded with a primary procedure of irrigation and debridements were also excluded due to difficulty in determining if sequential trips to the operating room or persistent infection was expected or represented a complication. A total of 435 hand, wrist, forearm, and elbow procedures on patients with a BMI ≥ 35 were included. The control group comprised 433 patients with BMI < 30 who had a hand, wrist, forearm, or elbow surgery over the same time period and were frequency-matched to the obese group by type of surgery (i.e., bony, soft tissue, and nerve), age, and sex in decreasing order of priority.

The medical records of both groups were reviewed to document the incidence and type of postoperative complications. Reviews were performed by 4 researchers, none of whom were the surgeon of record, after *a priori* agreement on the definition of a complication. For confirmation, a second member of the research team reviewed the record of any patient experiencing a complication. Complications were defined as clinical signs of infection requiring antibiotic prescription (by the operating surgeon or primary care physician), delayed incision healing, nerve symptoms, wound dehiscence, hematoma, and reoperations for these or other reasons. Patient-reported medical comorbidities (e.g., hypertension, diabetes, stroke, vascular disease, kidney disease, and liver disease) were also recorded.

Data Analysis

There were a fixed number of patients in the obese cohort ($n=435$). An *a priori* sample size analysis was performed during the design of this study to determine if we would need to increase our number of control patients beyond a 1:1 ratio to adequately power our study. Assuming complications to be a rare event (2% estimated), we determined that 376 patients in each group (1:1) was sufficient to provide 80% power to detect what we estimated *ad hoc* to be a clinically relevant increase in complications to 6% (4% absolute increase) with an alpha of 0.05 using an independent chi-square test. Such numbers also provided us with enough power to perform our logistic regression modeling.

Descriptive statistics were produced to characterize each patient group, the procedures performed, and the postoperative complications encountered. Surgeries were also detailed according to procedures performed. Equivalence of group demographic data and surgery types was tested with chi-square analyses and Mann-Whitney tests. The incidence of complications was compared between patient groups by chi-square analysis. Similar analyses were performed stratified on surgery type and BMI classification. Bonferroni corrections were made for multiple comparisons.

Binary logistic regression modeling was performed to analyze the relationship between postoperative complications and patient sex, age, BMI, surgery type, and the number of

comorbidities. A forced entry procedure was used. Model explanatory power was assessed with the c-statistic. All P-values were unadjusted. This statistical model was built on univariate associations with the occurrence of complications. The BMI was included in the multivariate model based on our study hypothesis. Subgroup models were repeated for the obese and non-obese patients separately using a forced entry regression procedure. For all statistical tests, significance was defined as $P < 0.05$.

RESULTS

Demographic data of the obese and non-obese patient groups are presented in Table 1. There were no statistically significant differences between the 2 groups based on age, type of surgery, anesthesia type, or duration of surgery. Greater surgical detail is presented in Table 2. The obese group had a significantly higher percentage of females and patients whose health was complicated by one or more comorbidities.

Thirty-seven obese patients (9%) and 39 non-obese patients (9%) experienced postoperative complications ($P = 0.79$). The same pattern of similar complication incidence held true when the 2 groups were stratified based on surgical procedure (Table 3). Patients within the non-obese group underwent more reoperations (19) compared to patients in the obese group (8) (Table 4). For the entire study population, complications were more common after bony procedures compared to soft tissue and nerve conditions ($P < 0.01$). Bony procedures required significantly longer anesthesia time compared to nerve (51 minutes less) and soft tissue surgeries (49 minutes less) ($P < 0.01$), however, the amount of time under anesthesia did not differ between procedure categories when stratified by whether or not a complication occurred ($P = 0.3$). There was a significant ($P = .03$) increase in the percentage of complications for patients with a BMI ≥ 45 (15/113 patients, 13%) versus those obese patients with a BMI less than 45 (22/323 patients, 7%).

For the entire study population, the regression model for postoperative complications was significant when accounting for patients' BMI, procedure category, age, sex, and comorbidities (LR chi-square=18.5, $df=6$, $p=0.005$), with a c-statistic of 0.65. The only significant predictor was procedure category, indicating that when controlling for all other variables patients that underwent bony procedures had 3.8 times greater odds of having a complication compared to nerve procedures and 2.0 times greater odds of having a complication compared to soft tissue procedures (Table 5). Thus, when modeling included all participants, BMI did not significantly alter the risk of complication after bony procedures.

When modeling only obese patients, the model for postoperative complications remained significant when accounting for patients' BMI, procedure category, age, sex, and having comorbidities (LR chi-square=14.9, $df=6$, $P=0.02$), with a c-statistic of 0.68. Among obese patients, both procedure category and BMI were significant predictors (Table 6). Obese patients undergoing bony procedures have 2.9 times greater odds and 2.6 times greater odds of having a postoperative complication compared to both nerve and soft tissues procedures, respectively. Additionally, for every 1-point increase in BMI above 35, these patient's odds of having a complication increase 1.1 times in logistic fashion. For example, a patient with a

BMI of 50 had 4.2 times the odds of experiencing a postoperative complication than a patient with BMI=35.

Finally, in non-obese patients, the model for postoperative complications remained significant when accounting for patients' BMI, procedure category, age, sex, and having comorbidities (LR chi-square=12.4, df=6, P=0.05), with a c-statistic of 0.67, but only procedure category remained as a significant predictor and only for comparisons of bony procedures to nerve procedures. (OR 4.2 95% CI 1.7-10.5).

DISCUSSION

Our data did not demonstrate greater risks of complications following hand, wrist, forearm, and elbow surgery for all patients categorized as obese (BMI ≥ 35). However, we found a dose-dependent effect of advancing BMI trending with heightened complications rates, such that extreme obese and super obese patients (BMI ≥ 45) may be at the greatest risk for surgical complications.

Our data contrast previous studies on how obese patients fare after other joint procedures, which have found higher complication rates in obese groups. Using a meta-analysis of studies on total knee arthroplasties in obese patients, Kerkhoffs et al reported that obesity had an overall negative impact on outcomes.⁽⁶⁾ Based on 14 studies of total knee arthroplasties in 15,276 patients, infection occurred more frequently in obese patients, with an odds ratio of 1.90 (95% CI, 1.46 to 2.47), a finding that was not mirrored in hand surgery.

Karunakar et al performed a retrospective chart review of open reduction and internal fixation of acetabular fractures to evaluate the risk that obese patients have for postoperative complications.⁽¹¹⁾ The authors found BMI had a significant relationship with blood loss, prevalence of wound infection, and prevalence of deep venous thrombosis. No association was found between BMI and nerve palsy, heterotopic ossification, or pulmonary embolism. Although the study assessed several complication types that were not considered in our study due to their rarity in hand surgery, overall (none occurred in our entire study population) there was a higher rate of infection among obese patients in lower extremity surgery that we did not identify in our study.

The discrepancy between our data and that following lower extremity surgery may have several explanations. First, despite increased risk of thromboembolic complications in obese patients following lower extremity surgery, most operations from the elbow distally are relatively short in duration, often performed under regional block, and are not expected to affect patient mobility or ambulation that may lead to a thromboembolic event. Second, the data indicate that for surgeries included in our study, obese and non-obese patients did not differ in the length of surgery or in the type of anesthesia used as was the case for lower extremity arthroplasty. Third, local wound complications are often related to extensive subcutaneous fat that is prone to seroma formation, necrosis, and infection secondary to large incisions and difficult, deep exposures. Extensive subcutaneous fat is likely a greater impediment to effective surgery in the chest, abdomen, and lower extremity. Even in

morbidly obese individuals, we often encounter limited subcutaneous fat from the elbow distally.

For arthroscopic rotator cuff repairs, obese patients often require longer operative times and report worse functional outcomes.⁽⁹⁾ These findings further support the idea that increased fat around a joint makes surgical repair of the joint more challenging, an issue that does appear to be mitigated when operating more distally on the upper extremity. That study also reported no significant difference in revision rates of rotator cuff repairs between non-obese and obese groups (BMI 30), but the difference was significant when comparing class III and above obese groups (BMI 40) to non-obese groups. This result parallels the association between BMI and complication rates in the obese patients in our study. Both of these findings imply that extremely high BMIs may raise complication rates in hand and upper extremity surgery.

Treatment of the obese surgical patient is challenging secondary to increased adipose tissue, depth of dissection, and the frequency and number of comorbid medical conditions that can complicate surgical healing. Although we considered that this overall health impact of obesity could produce more complications following hand surgery, our data did not support this. Despite a greater number of medical comorbidities in obese individuals, complication rates mirrored the healthier non-obese cohort. It may be that the well-vascularized upper extremity with robust soft tissues provides enough healing potential to avoid complications in most patients even in the face of poorer general health states. Alternatively, elevation of the distal upper extremity may reduce hematoma, seroma, and edema.

The primary limitation of our investigation is inherent with any case-control study. By relying on medical records to quantify complications, we were dependent on the completeness of the surgeons' notes. While omissions in the record were a source for concern, we expected that the 2 groups would be affected similarly, so it is unlikely that this systematically biased our results. Secondly, we determined a patient's comorbidity status based on patient self-report via patient intake forms, which may be imperfect. While this introduced potential recall bias or a tendency to hide such information from one's provider, there was no reason to believe this affected 1 group preferentially over the other. Although our study population underwent a wide variety of procedures, the procedures were not all inclusive. The use of anesthesia preoperative assessment records and the exclusion of surgeries combining bony and soft tissue or nerve procedures eliminated all acute injuries treated emergently. Therefore, our data may not generalize to patients with upper extremity open fractures or mangled injuries. Finally, as our study focused on perioperative complications and not surgical results, we could not assess any inequality in operative outcomes or patient satisfaction between the patient groups.

Our management of hand, wrist, forearm, and elbow conditions is similar for the obese and non-obese patient. Without a differential incidence of postoperative complications, our preoperative counseling regarding risk of complications is largely unaffected by obesity, except in patients with BMIs 45 or greater, whom we expect to be at a heightened risk for surgical complications. Thus, in a patient with BMI 45, our counseling includes the fact that the patient's weight increases the risk of surgical complication. Although we have not

refused to perform surgery on patients with extremely high BMIs, preoperative weight loss may increase operative safety for elective surgical procedures in the distal upper extremity when postponement would not compromise outcome.

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Figure 1.

A) Distribution of patient's BMIs for the non-obese group. B) Distribution of patient's BMIs for the obese group.

Table 1

Demographic data for the study population according to patient group.

Variable		Obese Group	Non-obese Group	P value
N		435	433	---
Age (Interquartile range - IQR)		54 (16)	53 (18)	0.73
Male (%)		118 (27%)	172 (40%)	<0.01
Surgery Type (%)	Bony	115 (26%)	118 (27%)	0.96
	Nerve	181 (42%)	174 (40%)	
	Soft tissue	140 (32%)	141 (33%)	
Anesthesia Type(%)	Block	102 (23%)	125 (29%)	0.72
	General	164 (38%)	155 (36%)	
	MAC	66 (15%)	48 (11%)	
	Combination	104 (24%)	105 (24%)	
Surgery Length in Minutes (IQR)		62 (52)	67 (53)	0.51
Comorbidities (%)	0	148 (34%)	271 (63%)	<0.01
	1	140 (34%)	115 (27%)	
	2	99 (23%)	33 (8%)	
	3	41 (9%)	9 (2%)	
	4	7 (2%)	5 (1%)	
	5	1 (0%)	0 (0%)	
BMI (IQR) *		40 (8)	25 (5)	<0.01

* Patient's BMI in both groups were not normally distributed with each group skewed toward the central range and away from the extremes.

Table 2

Procedure details according to patient group. Note that each surgery contributing data may have included multiple procedures within a category.

Procedure		Obese (N=500)	Non-obese (N=478)
Nerve Surgery	Nerve releases at the wrist	172 (86)	144 (76)
	Nerve releases at the elbow	23 (12)	29 (15)
	Nerve repairs	5 (3)	16 (8)
Soft Tissue Surgery	First dorsal compartment and trigger finger releases	66 (47)	49 (37)
	Mass/ganglion excision or biopsy	58 (41)	61 (46)
	Flexor/extensor tendon repair	17 (12)	24 (18)
Bony Surgery	Finger/hand/wrist fractures	64 (52)	85 (71)
	Trapeziometacarpal arthroplasty	1 (1)	1 (1)
	Digital arthrodesis/arthroplasty	17 (14)	24 (20)
	Wrist arthrodesis/arthroplasty	28 (23)	7 (6)
	Forearm/Elbow fractures	13 (11)	2 (2)
Other (from all categories)	Other	36	36

• () represent percentage within surgical category

Table 3

Procedure categories and the number and description of complications that occurred in both the obese and non-obese groups. **

Procedure Category	Number of complications in the obese group (%)	Number of complications in the non-obese group (%)	P value *
Bony	17 (15%) Antibiotics for infection: 9 Delayed incision healing: 2 Nerve injury: 2 Wound dehiscence: 2 Hematoma: 2 Reoperation: 6	18 (15%) Antibiotics for infection: 6 Delayed incision healing: 1 Nerve injury: 2 Wound dehiscence: 0 Hematoma: 1 Reoperation: 12	0.92
Nerve	10 (6%) Antibiotics for infection: 6 Delayed incision healing: 3 Nerve injury: 0 Wound dehiscence: 3 Hematoma: 2 Reoperation: 1	7 (4%) Antibiotics for infection: 4 Delayed incision healing: 1 Nerve injury: 0 Wound dehiscence: 2 Hematoma: 1 Reoperation: 1	0.38
Soft tissue	9 (6%) Antibiotics for infection: 8 Delayed incision healing: 5 Nerve injury: 3 Wound dehiscence: 2 Hematoma: 2 Reoperation: 1	14 (10%) Antibiotics for infection: 6 Delayed incision healing: 3 Nerve injury: 0 Wound dehiscence: 2 Hematoma: 1 Reoperation: 6	0.29

* P value from chi-square analyses

** Total numbers (%) for each procedure category is number of patients. Individual patients may have experienced multiple types of complications.

Table 4

Reasons for reoperations.

Reason for reoperation	Obese	Non-obese	Total
Nonunion/malunion	5	2	7
Symptomatic hardware	1	5	6
Infection/dehiscence/hematoma	2	3	5
Nerve compression	0	3	3
Failure of index procedure	0	2	2
Contracture/tendon irritation	0	4	4

Table 5

Variables in the logistic regression modeling for prediction of post-operative complication combining both study cohorts.

Variable	Beta	P-value	Odds Ratio (95% CI)
Constant	-2.3	---	---
Male sex vs. female sex	0.07	0.78	1.1 (0.65 to 1.8)
Age	-0.01	0.41	1.0 (0.97 to 1.0)
Bony procedure vs. soft tissue procedure	0.7	0.01	2.0 (1.2 to 3.6)
Bony procedure vs. nerve procedure	- 1.2	<0.001	3.8 (1.8 to 6.1)
Number of comorbidities	0.07	0.60	1.1 (0.82 to 1.4)
BMI	0.01	0.50	1.0 (0.98 to 1.0)

Table 6

Variables included in the logistic regression modeling for prediction of post-operative complications for patients with a BMI >35.

Variable	Beta	P-value	Odds Ratio (95% CI)
Constant	-3.6	---	---
Male sex vs. female sex	0.36	0.35	1.4 (0.68 to 3.0)
Age	-0.01	0.48	0.99 (0.96 to 1.0)
Bony procedure vs. soft tissue procedure	- 1.0	0.03	2.6 (1.1 to 6.3)
Bony procedure vs. nerve procedure	- 1.1	0.01	2.9 (1.3 to 6.8)
Number of comorbidities	0.06	0.75	1.1 (0.73 to 1.5)
BMI	0.05	0.03	1.1 (1.0 to 1.1)