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Morbid Obesity Independently Impacts Complications, Mortality, and Resource Use After TKA

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Abstract

Background The importance of morbid obesity as a risk factor for complications after total knee arthroplasty (TKA) continues to be debated. Obesity is rarely an isolated diagnosis and tends to cluster with other comorbidities that may independently lead to increased risk and confound outcomes. It is unknown whether morbid obesity independently affects postoperative complications and resource use after TKA.

Questions/purposes The purpose of this study was to determine whether morbid obesity is an independent risk factor for inpatient postoperative complications, mortality, and increased resource use in patients undergoing primary TKA.

Methods The Healthcare Cost and Utilization Project Nationwide Inpatient Sample (NIS) database was used to identify patients undergoing primary TKA from October 2005 to December 2008. Morbid obesity (body mass index $\geq$ 40 kg/m^2) was determined using International Classification of Diseases, 9th Revision, Clinical Modification codes. In-hospital postoperative complications, mortality, costs, and disposition for morbidly obese patients were compared with nonobese patients. To control for potential confounders and comorbid conditions, each morbidly obese patient was matched to a nonobese patient using age, sex, and all 28 comorbid-defined elements in the NIS database based on the Elixhauser Comorbidity Index. Of 1,777,068 primary TKAs, 98,410 (5.5%) patients were categorized as morbidly obese. Of these, 90,045 patients (91%) were able to be matched one-to-one to a nonobese patient for the adjusted analysis.

Results Morbidly obese patients had a higher risk of postoperative in-hospital infection (0.24% versus 0.17%; odds ratio [OR], 1.3; 95% confidence interval [CI], 1.1–1.7; $p = 0.001$), wound dehiscence (0.11% versus 0.08%; OR, 1.3; 95% CI, 1.0–1.7; $p = 0.28$), and genitourinary-related complications (0.60% versus 0.44%; OR, 1.3; 95% CI, 1.1–1.5; $p < 0.001$). There was no increase in the prevalence of cardiovascular or thromboembolic-related complications. Morbidly obese patients were at higher risk of in-hospital death after primary TKA compared with nonobese patients (0.08% versus 0.02%; OR, 3.2; 95% CI, 2.0–5.2; $p < 0.001$). Total hospital costs (USD 15,174 versus USD 14,715, $p < 0.001$), length of stay (3.6 days versus 3.5 days, $p < 0.001$), and rate of discharge to a facility (40% versus 30%, $p < 0.001$) were all higher in morbidly obese patients.

Conclusions Morbid obesity appears to be independently associated with a higher risk for a small number of select in-hospital postoperative complications and mortality after matching for comorbid medical conditions linked to obesity. However, the independent impact of morbid obesity appears to be fairly modest, and morbid obesity did not appear to be an independent risk factor for many systemic complications. Continued research is necessary to identify the influence of associated comorbidities on early

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postoperative complications in morbidly obese patients after TKA.

Level of Evidence Level II, prognostic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

The age-adjusted prevalence of obesity (body mass index [BMI] $\geq$ 30 kg/m^2) in the United States is 35% with approximately 6% of the population being considered morbidly obese (BMI $\geq$ 40 kg/m^2) [15]. The prevalence of obesity in patients undergoing TKA is 20% at the national level [31] and as high as 52% in some single-center reports [14]. As the number of primary and revision knee arthroplasties [7, 24] as well as the number of obese patients undergoing TKA [14] continues to increase, there has been more interest in the role of obesity as a risk factor for complications and poor outcomes after TKA.

Previous studies have reported conflicting results regarding the association of obesity and postoperative complications with some investigations reporting obesity as a significant risk factor [2, 12, 17, 21, 22, 24, 26–28, 30, 33, 35, 38] and others finding no such association [5, 9, 11, 16, 23, 29, 32]. There are several potential explanations for these divergent results including a heterogeneous definition of obesity, small sample sizes, and the association of obesity with other comorbidities. A recent literature review by the American Association of Hip and Knee Surgeons on this topic pointed out that obesity is rarely an isolated diagnosis and tends to cluster with other comorbidities that may independently lead to increased risk of complications [35]. A BMI $\geq$ 40 kg/m^2 seems to be a threshold for which the majority of perioperative complications and revision rates appear to increase considerably in patients having TKA [39]; however, data on mortality and resource consumption are limited [3, 12, 25].

The objectives of our study were to determine if morbid obesity is an independent risk factor for (1) inpatient postoperative complications; (2) mortality; and (3) increased resource use after primary TKA using a large, nationally representative database. A matching study design was used to attempt to control for potential confounders and comorbid conditions.

Patients and Methods

Our data were obtained from the Nationwide Inpatient Sample (NIS) database from October 2005 to December 2008. The NIS is a stratified, statistically valid survey of hospitals conducted by the federal Healthcare Cost and Utilization Project [19], in which hospitals are selected to approximate a 20% stratified sample of US community hospitals with discharge weights provided to produce national estimates. Because of the large size of the database, the NIS is particularly well suited for epidemiological studies related to specific procedures or diseases in the national population [7, 8].

Using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) procedure codes, we identified 1,777,068 patients who underwent primary TKA (81.54) during the study period. Of this group, we identified a total of 98,410 (5.5%) patients who were morbidly obese (278.01, v85.4, v85.41, v85.42, v85.43, v85.44, v85.54, v85.5, v85.50, v85.51, v85.52, v85.53, v85.54). We then created a final comparison cohort using a one-to-one matching process with each morbidly obese patient paired with a patient not carrying any obesity or morbid obesity code (nonobese group, BMI $<$ 30 kg/m^2). We matched the patients using age, sex, and all 28 comorbid-defined elements in the NIS database based on the Elixhauser Comorbidity Index [13] with the exception of obesity. Because of the high prevalence of obstructive sleep apnea in obese patients [34, 37] and its association with postoperative complications in patients undergoing total joint arthroplasty [10, 18], this comorbidity was also added to the matching model (327.2, 327.20, 327.21, 327.23, 327.27, 327.29, 780.51, 780.53, 780.57). We used the coarsened exact matching algorithm to perform the matching process [4, 20]. Morbidly obese patients who could not be matched were discarded from the matched cohort (9%). A comparison of these variables was performed to confirm that both groups had comparable characteristics at baseline (Table 1). There were no statistical differences at baseline between nonobese and morbidly obese patients in terms of age, sex, and comorbidities, confirming adequate matching and reducing the effect of these variables in further analyses (Table 1). Of the 98,410 patients identified in the database as morbidly obese, 90,045 patients (91%) were able to be matched one-to-one to a nonobese patient for the adjusted analysis.

To identify in-hospital postoperative complications, ICD-9-CM diagnosis codes were used in any of the 14 secondary diagnosis fields. Postoperative complications included central nervous system (997.0, 997.00, 997.01, 997.02, 997.09), cardiac (997.1), peripheral vascular (9972), respiratory (997.3, 997.31, 997.39), gastrointestinal (997.4), genitourinary (997.5), hematoma or seroma (998.1, 998.11, 998.12, 998.13), wound dehiscence (998.3, 998.0, 998.31, 998.32, 998.33), postoperative infection (998.5, 998.51, 998.59), deep vein thrombosis (453.4, 453.40, 453.41, 453.42), pulmonary embolism (415.1, 415.11, 415.19), postoperative anemia (285.1), and mortality (coded within the NIS).

As direct measures for resource consumption, we converted total hospital charges into costs using cost-to-charge

Table 1. Comparison of baseline characteristics between matched nonobese and morbidly obese patients

Baseline characteristics	Nonobese (n = 90,442) Number (%)	Morbidly obese (n = 90,143) Number (%)	p value*
Age (years; mean; range)	61 (22–90)	61 (22–90)	NA
Female	67,859 (75)	67,682 (75)	0.79
Comorbidities			
Obstructive sleep apnea	19,249 (21)	19,147 (21)	0.82
AIDS	0 (NA)	0 (NA)	NA
Alcohol abuse	223 (0.2)	228 (0.2)	0.78
Deficiency anemia	11,708 (13)	11,697 (13)	0.84
Rheumatoid arthritis/collagen vascular disease	2528 (2.8)	2525 (2.8)	0.93
Chronic blood loss anemia	1664 (1.8)	1630 (1.8)	0.61
Congestive heart failure	2324 (2.6)	2322 (2.6)	0.93
Chronic pulmonary disease	17,765 (19)	17,670 (19)	0.82
Coagulopathy	654 (0.7)	641 (0.7)	0.76
Depression	13,714 (15)	13,680 (15)	0.94
Diabetes uncomplicated	28,468 (31)	28,340 (31)	0.86
Diabetes with chronic complications	1950 (2.2)	1929 (2.1)	0.81
Drug abuse	139 (0.2)	145 (0.2)	0.70
Hypertension (uncomplicated and complicated)	69,738 (77)	69,580 (77)	0.68
Hypothyroidism	13,520 (15)	13,513 (15)	0.80
Liver disease	428 (0.5)	429 (0.5)	0.93
Lymphoma	56 (0.1)	57 (0.1)	0.91
Fluid and electrolyte disorder	6367 (7)	6,353 (7)	0.94
Metastatic cancer	10 (< 0.1)	10 (< 0.1)	0.99
Other neurological disorders	2122 (2.3)	2078 (2.3)	0.56
Paralysis	74 (0.1)	77 (0.1)	0.79
Peripheral vascular disease	851 (0.9)	845 (0.9)	0.93
Psychoses	1257 (1.4)	1232 (1.4)	0.67
Pulmonary circulation disorders	538 (0.6)	539 (0.6)	0.93
Renal failure	1995 (2.2)	1977 (2.2)	0.85
Solid tumor without metastasis	111 (0.1)	108 (0.1)	0.85
Peptic ulcer disease excluding bleeding	<10 (< 0.1)	<10 (< 0.1)	0.99
Valvular heart disease	2170 (2.4)	2185 (2.4)	0.73
Weight loss	20 (< 0.1)	19 (< 0.1)	0.88

* Pearson chi square; NA = not applicable.

ratios provided with the NIS database and were reported as total costs and cost/day by dividing total cost by length of stay. Cost-to-charge ratios are hospital-specific and based on all-payer inpatient cost for every hospital in the NIS database. Discharge disposition (home versus rehabilitation facility) was used as an indirect measure of postdischarge resource consumption.

All statistical analyses were performed using SPSS Version 20 for Windows (IBM Corp, Armonk, NY, USA). Matching was performed using Coarsened Exact Matching add-on for SPSS. Descriptive statistics were obtained for all variables used within the study. Missing values were excluded for the purpose of this analysis. Independent sample t-tests and Pearson chi-square analysis were used for bivariate comparisons. Multivariate modeling with logarithmic transformation was used to examine the risk-adjusted association between nonobese and morbidly obese patients. Odds ratios were calculated with their respective 95% confidence intervals and statistical significance was assigned at the $p < 0.05$ level.

Results

Morbidly obese patients undergoing primary TKA had a higher risk of select postoperative in-hospital complications

compared with nonobese patients (Table 2). These complications included wound dehiscence (0.11% versus 0.08%; odds ratio [OR], 1.3; 95% confidence interval [CI], 1.0–1.7; p = 0.28), infection (0.24% versus 0.17%; OR, 1.3; 95% CI, 1.1–1.7; p = 0.001), genitourinary-related complications (0.60% versus 0.44%; OR, 1.3; 95% CI, 1.1–1.5; p < 0.001), and postoperative anemia (16% versus 15%; OR, 1.0; 95% CI, 1.0–1.1; p < 0.001). Postoperative anemia, although statistically significant, was not markedly different between groups (15% versus 16%) and was not considered clinically important. Morbid obesity was not an independent risk factor for increased systemic complications such as cardiac, respiratory, thromboembolic disease, or other local complications like hematomas and seromas (Table 3).

From the morbidly obese cohort, 76 patients (0.08%) died while in the hospital compared with 23 patients (0.02%) in the nonobese group (OR, 3.2; 95% CI, 2.0–5.2; p < 0.001).

Total hospital costs were greater among patients with morbid obesity (USD 15,174 versus USD 14,715, p < 0.001) with an absolute difference of USD 459, or 3% (Table 4). Length of stay was slightly higher in patients with morbid obesity (3.6 days versus 3.5 days, p < 0.001). Indirect measures of resource consumption were also higher for the morbidly obese with discharge from the hospital to rehabilitation facilities more commonly seen with morbidly obese patients (40% versus 30%, p < 0.001).

Table 2. Comparison of in-hospital postoperative complications that were increased after primary knee arthroplasty between morbidly obese and nonobese patients

Postoperative complications	Primary TKA		
	Nonobese (n = 90,442)	Morbidly obese (n = 90,143)	OR (95% CI)
Genitourinary	406 (0.44%)	549 (0.60%)	1.3 (1.1–1.5)*
Wound dehiscence	74 (0.08%)	103 (0.11%)	1.3 (1.0–1.8)*
Infection	162 (0.17%)	225 (0.24%)	1.3 (1.1–1.7)*
Anemia	13,843 (15%)	14,422 (16%)	1.0 (1.0–1.1)*

* p < 0.05; OR = odds ratio; CI = confidence interval.

Table 3. Comparison of in-hospital postoperative complications that were not increased after primary knee arthroplasty between morbidly obese and nonobese patients

Postoperative complications	Primary TKA		
	Nonobese (n = 90,442)	Morbidly obese (n = 90,143)	OR (95% CI)
Cardiac	642 (0.70%)	683 (0.75%)	1.0 (0.9–1.1)
Peripheral vascular	197 (0.21%)	154 (0.17%)	0.7 (0.6–0.9)*
Respiratory	721 (0.79%)	515 (0.57%)	0.7 (0.6–0.8)*
Gastrointestinal	377 (0.41%)	374 (0.41%)	0.9 (0.8–1.1)
Central nervous system	60 (0.06%)	60 (0.06%)	1.0 (0.7–1.4)
Hematoma/ seroma	701 (0.77%)	664 (0.73%)	0.9 (0.8–1.0)
Deep vein thrombosis	404 (0.44%)	349 (0.38%)	0.8 (0.7–1.0)
Pulmonary embolism	407 (0.45%)	357 (0.39%)	0.8 (0.7–1.0)

* p < 0.05; OR = odds ratio; CI = confidence interval.

Discussion

The increasing number of morbidly obese patients undergoing primary TKA is a growing concern given the potentially increased risk for postoperative complications in this group. However, obesity is rarely an isolated diagnosis and tends to cluster with other comorbidities that may independently lead to increased risk of complications [17, 29, 33, 39]. Published studies have not always agreed in the reported influence of obesity on different complications such as infection [21, 26, 27, 30, 35], thromboembolism [16, 28] and cardiovascular disease [5, 17]. The results of our matching study using a large administrative database suggest that morbid obesity is an independent risk factor for inpatient postoperative

Table 4. Financial resource consumption after primary knee arthroplasty between morbidly obese and nonobese patients

Financial resource consumption	Primary TKA		
	Nonobese (n = 90,442)	Morbidly obese (n = 90,143)	p value
Total cost (range)	USD 14,715 (USD 31 to USD 305,526)	USD 15,174 (USD 24 to USD 121,202)	< 0.001
Cost/day (range)	USD 4532 (USD 10 to USD 46,416)	USD 4528 (USD 8 to USD 30,832)	0.73
Length of stay (days)	3.5	3.6	<0.001
Disposition–home	62,367 (69%)	53,962 (59%)	< 0.001
Disposition–rehabilitation facility	27,879 (30%)	35,966 (40%)	< 0.001

complications, mortality, and increased resource use after primary TKA.

Many of the limitations of our study are inherent to the analysis of large administrative databases such as the NIS. Incomplete data collection, uncertain compliance and accuracy of coding related to diagnosis and procedures performed, and lack of detailed clinical information are all valid concerns. However, administratively coded comorbidities and complications have been shown to correlate reasonably well with the clinical medical record with acceptable accuracy [6]. Certain events such as postoperative hematoma, infection, and wound dehiscence are also open to a certain amount of subjective interpretation and potential for observer bias. We are also limited in what data are available for analysis; for example, we are unable to determine the duration of the surgical procedure or the method of deep vein thrombosis prophylaxis used for each patient. Cause of death is also not available, which may underestimate the true prevalence of cardiac complications and thromboembolic events such as pulmonary embolism. These recognized limitations are inherent to all studies using this database design and could potentially be improved through prospective data collection.

Certain aspects of our study methodology require emphasis. First, we are examining postoperative in-hospital events only. The NIS collects data only on events and care within the period of hospitalization. Many of the potential perioperative complications may occur after discharge from the hospital, and our study cannot capture these events. For example, venous thromboembolism and infection often present days or weeks after hospital discharge and thus would not be reflected in the NIS data set. We cannot determine whether these postdischarge events occur with higher, lower, or the same frequency in our study groups. Second, we are matching morbidly obese patients with nonobese patients who have the same comorbidity profile. By matching comorbidities, the nonobese group is likely to be less healthy than the general population. Our results should not be used to compare the morbidly obese patient with the nonobese general population, because our findings likely underestimate the true difference in perioperative risk between these groups. Furthermore, although we used the well-established Elixhauser Comorbidity Index in combination with sleep apnea to match our patients, we acknowledge that all potential comorbid conditions relevant to morbid obesity may not be contained in this comorbidity system. Finally, length of stay and discharge destination do not necessarily reflect either the intensity or cost of inpatient care, because many hospitals use aggressive care pathways with a view to early discharge. In addition, our groups were not matched by insurance status; several private and government insurers require a minimum hospital stay before discharge to rehabilitation facilities. Thus, the cost and length of care for patients being transferred to skilled nursing settings would necessarily be higher.

Only a few in-hospital postoperative complications were increased among patients with morbid obesity (Table 2). The association between morbid obesity and postoperative infection is strongly supported in the literature by multiple studies [12, 21, 25, 27, 35, 36] with many of them also controlling for multiple associated comorbidities such as diabetes. A recent meta-analysis [24] pulling data from 20 studies and 15,276 patients showed an increased risk for superficial infection (OR, 2.1) and deep infection (OR, 2.3) in obese patients. Our study also suggests an increased prevalence of urinary complications in patients who were morbidly obese. This is consistent with one recent study of 4718 patients undergoing TKA that found an association between obesity and postoperative urinary tract infections [1]. However, contrary to these findings, one large study of 9735 patients undergoing TKA [5] found no increase in urinary infections in the morbidly obese group. Although the incidence of urinary complications was still low (0.6%) in morbidly obese patients in our study, there is evidence that this complication can contribute to postoperative infection [35]. Interestingly, we did not find any increase in systemic postoperative complications between nonobese and morbidly obese patients (Table 3). Previous studies have suggested a link between obesity and postoperative thromboembolic disease and cardiovascular complications [17, 28]. Our data suggest that the multiple comorbidities that associate with morbid obesity are important confounders in this regard and that morbid obesity itself is not an independent risk factor for these in-hospital events. This highlights the importance of preoperatively assessing other comorbidities that are often present with morbid obesity in attempting to assess postoperative in-hospital patient risk.

To our knowledge, this is the first study to show that morbid obesity is an independent risk factor for in-hospital mortality (0.08%) after primary TKA with three times the risk after controlling for multiple patient characteristics. As far as we are aware, the only previous study examining this issue is the article by Bordini et al. [5], which reported a prevalence of death of 0.58% in morbidly obese patients without an increased risk after controlling for age, sex, and BMI. Given the lack of systemic complications seen in the morbidly obese cohort in our data, the reason for this finding is unclear. We acknowledge that the inability to analyze the etiology of the patient deaths is a limitation of this study and that further study will be needed to effectively address and clarify this finding.

Total hospital costs, length of stay, and indirect measures of resource consumption were higher in the morbidly obese cohort. Previous literature is mixed and inconsistent on this issue. Batsis et al. [3] similarly did not find substantial differences in resource use in patients with morbid

obesity; the average total hospital costs of USD 15,752 were very similar to our results. Kim [25] on the other hand using the same NIS database and controlling for age, sex, race, and primary payer found significant differences with a 7% (USD 1432) increase in total hospital cost in morbidly obese patients. These data were not controlled for comorbidities and may explain the discrepancy with our study. Importantly, we did note a higher proportion of morbidly obese patients being discharged to rehabilitation facilities versus home (10% higher in the morbid obesity cohort). When considering the higher in-hospital total cost with the higher rate of discharge to a facility, it appears that overall costs for TKA are higher in patients who are morbidly obese.

Although studies on large databases have their limitations, the large number of patients with controlled variables such as age, sex, and comorbidities included in our analysis and our ability to perform a detailed matching study provide unique and previously unavailable insight into the impact of morbid obesity after primary knee arthroplasty throughout the United States. Morbidly obese patients have a statistically higher risk for select postoperative complications, particularly related to wound healing, and experience a higher risk for postoperative inpatient mortality. Morbid obesity is also independently associated with increased resource use after TKA. However, the independent impact of morbid obesity on postoperative in-hospital complications appears fairly modest after controlling for age, sex, and baseline comorbidities often associated with morbid obesity. Furthermore, other postoperative in-hospital systemic complications such as cardiovascular or thromboembolic events do not seem to be explained by morbid obesity alone. Our study suggests that using BMI $\geq$ 40 kg/m^2 is not likely to be a perfect single predictor for postoperative complications after primary TKA. Further research is necessary to identify the influence of other comorbidities or factors on postoperative complications in morbidly obese patients after TKA.

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