Obesity, Comorbidities, and the Associated Risk among Patients Who Underwent Total Knee Arthroplasty in Alberta

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Abstract

Obesity, a common risk factor for osteoarthritis (OA), accelerates joint deterioration resulting in the need for early total knee arthroplasty (TKA). The role of obesity in the management of OA remains a controversial topic. In this study, we examined whether obesity along with other comorbidities is associated with peri/postoperative complications in patients who underwent primary unilateral TKA in Alberta, Canada. A retrospective secondary analysis was performed on data extracted from data repository of patients ($n = 15,151$) who underwent TKA between 2012 and 2016. The sample was divided into five groups based on body mass index (BMI) classification developed by the World Health Organization. The associations between dependent variable (presence or absence of a complication or comorbidity) with the independent variables (year of surgery, age, sex, length of surgery, and BMI groups) were examined using binomial logistic regression. Results showed that obese classes I, II, and III, irrespective of other covariates, were more likely to have diabetes and pulmonary embolism ($p < 0.001$) compared with the normal BMI group. Patients with obese class III compared with the patients in normal BMI group were more likely to have deep wound infection ($p = 0.04$). Patients with comorbidities were more likely to have a blood transfusion, infection, pulmonary embolism, and readmission. Patients in higher BMI groups or with comorbidities were more likely to experience peri/postoperative complications following TKA, though the level of risk depends on the severity of obesity. These findings may be used by health care providers to educate patients in higher BMI groups about the risks of TKA and optimize comorbidities prior to the surgery.

Keywords

Obesity impacts over 600 million adults around the world.[1] It is associated with an elevated risk of adverse health outcomes, including cardiovascular disease, diabetes, cancer, and osteoarthritis (OA).[2] The rising prevalence of obesity and its associated health risks make it a major public health issue worldwide.[2,3] Obesity, a common risk factor for the onset and progression of OA,[4] accelerates joint deterioration in patients with knee OA resulting in the need for early total knee arthroplasty (TKA). Thus, the management of OA requires an understanding of the role that obesity plays in the development and progression of end-stage knee OA.[5] With the rise in demand for TKA, orthopaedic surgeons are concerned about whether patients with higher body mass index (BMI), notably BMI class III, are at an increased risk for perioperative or postoperative complications compared with other BMI groups.[4]

There has been an abundance of literature over the past decade that has raised concerns regarding the outcomes of TKA, including complications, in patients with obesity.[6–10] These studies have consistently demonstrated increased rates of wound healing complications, superficial and deep infections, early revisions, and poor functional outcomes following TKA in patients with obesity.[11–13] However, the role and importance that obesity plays in the decision to perform TKA remains under debate.[4,14] This reflects a lack of general consensus about performing TKA surgery on patients with obesity.[4]

A literature review conducted by a workgroup of the American Association of Hip and Knee Surgeons on obesity and total joint arthroplasty concluded that most studies examining TKA in patients with obesity used different surgical procedures and postoperative care protocols, small sample sizes, and different definitions of obesity.[4] The majority of previous studies did not use the World Health Organization (WHO) classification of obesity to stratify patients into subclasses of obesity; instead, they classified patients as either with obesity (BMI $\geq$ 30 kg/m^2) or without obesity (BMI $<$ 30 kg/m^2).[4] Moreover, patients with OA and obesity often have multiple medical comorbidities, such as diabetes and cardiopulmonary diseases.[1] Many of these comorbidities have been shown to be independent risk factors for the development of joint infection and also perioperative complications.[4] If the risks associated with these comorbidities have not been taken into account in the statistical analysis, they may act as confounders and affect the results of the study. Methodological approaches to adjust for comorbidities in the statistical analysis have been suggested, but they have not been consistently taken into consideration in previous studies of the association between obesity with complication.[4,15] Therefore, the primary purpose of our study was to examine whether obesity using the WHO classification of BMI is associated with other comorbidities, as well as with perioperative/postoperative complications in patients who underwent TKA adjusting for putative confounders. We also examined the association between major comorbidities and complications in people who underwent primary unilateral TKA over a 5-year period (2012–2016) in Alberta, Canada.

Method

Data Acquisition

We extracted data for a retrospective cohort of patients who underwent primary unilateral TKA between January 2012 and March 2016, from a provincial database managed by the Alberta Bone and Joint Health Institute (ABJHI). Standardized care processes and consistent data collection commenced in 2009 and remain ongoing for the province. Data have been collected under the authority of the provincial Privacy Impact Analysis (PIA) agreement in place (Office of the Information and Privacy Commissioner, OIPC file no.: H2801) for all private clinics and public hospitals where TKAs are performed. Knee surgeries are performed at 12 hospitals across Alberta, Canada, and all data are sent to ABJHI for quality assurance purposes. The Discharge Abstract Database (DAD) is a national database that contains data captured in acute care hospitals and includes administrative, clinical, and demographic information for hospital discharges. Data from DAD were linked to the database managed by ABJHI to identify comorbidities and complications in patients. Diagnosis for morbidity and mortality and procedure coding were based on the 10th version of the International Classification of Diseases combined with the Canadian Classification of Health Intervention (ICD-10-CA/CCI).

Study Sample

We were able to identify 26,962 patients who underwent primary unilateral TKA between 2012 and 2016. Weight and height records were available for 15,151 (56.2%) patients to calculate BMI as weight in kilograms (kg) divided by height in meter squared (m^2). Only those patients with BMI records who underwent primary unilateral TKA were included in the analysis. There were no differences in participant characteristics (i.e., mean age and sex), the rate of major comorbidities, or complications (►**Supplementary Table S1**; available in the online version) between the included and excluded cohorts. Patients in the included cohort were classified into one of five groups according to the WHO classification of normal weight (BMI $\leq$ 24.99 kg/m^2), overweight (25 $\leq$ BMI $\leq$ 29.99 kg/m^2), obese class I (30 $\leq$ BMI $\leq$ 34.99 kg/m^2), obese class II (35 $\leq$ BMI $\leq$ 39.99 kg/m^2), and obese class III (BMI $\geq$ 40 kg/m^2).[1] A total of 17 patients with a BMI lower than 18.5 (underweight) were included in the normal BMI group. Patients' demographic information including age, discharge date, and sex were available. Age was categorized into five groups of $<$50, 50 to 59, 60 to 69, 70 to 79, and $>$80 years. The discharge date was categorized by year into six groups: 2012, 2013, 2014, 2015, and 2016. Comorbidities included diabetes, moderate or severe mental health issues, cardiac disease, pulmonary disease, circulatory/clotting disorder, dementia, renal failure, cerebrovascular disease, and moderate or severe liver disease as recorded in the database.

Outcomes

Perioperative and postoperative complications were blood transfusion, pulmonary embolism, deep wound infection, myocardial infarction, ileus, pneumonia, deep vein

thrombosis, gastrointestinal bleeding, readmission within 30 days, and cerebrovascular accident.

Statistical Analysis

The prevalence of obesity among patients who underwent primary unilateral TKA and the incidence rate of comorbidities and complications within each of the BMI groups were determined and compared using Chi-squared testing. The association between each of the main dependent variables (a complication or comorbidity) with each of the nominal/categorical independent variables (year of surgery, age, sex, length of surgery, and BMI groups) was examined in a univariate fashion using Chi-squared test of independence. Independent variables with $p < 0.15$ were included in the full model. Model selection was performed using backward and forward stepwise regression analysis, and competing models were compared using the Akaike Information Criterion. Both stepwise forward and backward methods confirmed that the full logistic regression model was the best model (the model with all variables). Binomial logistic regression was used to determine whether the dependent variable (presence or absence of a complication or comorbidity) was associated with the independent variables (year of surgery, age, sex, length of surgery, and BMI groups). When complication was considered as a dependent variable, comorbidities were included as independent variables. Results for each dependent variable are reported as odds ratios (OR) with 95% confidence intervals (CIs) calculated to compare the likelihood between each of the BMI groups and the normal BMI group, adjusting for all covariates of interest in the model.[16] An OR of 1 (i.e., OR = 1) means the likelihood of the event is the same for the group of interest (high BMI) when compared with the reference group (normal BMI group). An OR > 1 or OR < 1 suggests an increased or reduced likelihood of the event in each group of interest occurring compared with the reference group. If a 95% CI for the OR includes the value of 1, then there is insufficient evidence to conclude that there is a statistically significant difference in likelihoods for the groups. All statistical analyses were performed using R software package version 0.99.902.

Results

Patients' characteristics are presented in (►**Supplementary Table S1**; available in the online version). Between January 2012 and March 2016, a total of 15,151 patients who underwent TKA and had BMI records were identified, including 1,240 (8.2%) individuals with normal BMI, 4,189 (27.6%) overweight, 4,541 (30.0%) obese class I, 2,839 (18.7%) class II, and 2,342 (15.5%) in the class III BMI groups. Overall, the mean age ± standard deviation of the cohort was 66 ± 9.2 years. Unadjusted analysis showed as BMI increased, patients were more frequently younger in age and female. In total, 23.7% ($n = 3,590$) of patients who underwent TKA with BMI records had comorbidities. The most frequent comorbidities among patients were diabetes (58.1%, $n = 2,086$), moderate or severe mental health issues (37%, $n = 1,329$), and cardiac disease (3.3%, $n = 118$). The remaining comorbidities were pulmonary

disease (0.8%, $n = 29$), and circulatory/clotting disorder (0.6%, $n = 21$). As BMI increased, the proportion of people with diabetes increased, with obese class-III group having the highest proportion, and differences in proportions among the groups were significant ($p < 0.001$). There were also significant differences in the proportion of people with mental health issues ($p < 0.001$), circulatory/clotting disorders ($p < 0.03$), smoking ($p < 0.002$), and alcohol abuse ($p < 0.001$) between the different BMI groups.

Results from unadjusted analysis also showed that the most frequent complications among patients were readmission (52.8%, $n = 569$), pulmonary embolism (21.7%, $n = 233$), and deep wound infection (10.7%, $n = 115$). The remaining complications were myocardial infarction (4.2%, $n = 45$), ileus (4.0%, $n = 43$), pneumonia (3.3%, $n = 35$), deep vein thrombosis (1.6%, $n = 17$), gastrointestinal bleeding (1.7%, $n = 18$), and cerebrovascular accident (0.1%, $n = 1$). Patients with very low or very high BMI had a higher proportion of readmission ($p < 0.001$). As BMI increased, the proportion of people with pulmonary embolism and deep wound infection increased, with obese class-III group having the highest proportion, and differences in proportions among the groups were significant ($p < 0.001$).

Results of adjusted multiple regression analysis (►**Table 2**; ORs and their 95% CIs) showed that obese classs I, II, and III were more likely ($p < 0.001$) to have diabetes compared with the normal BMI group. There was a nonsignificant ($p = 0.14$) trend toward a higher incidence of cardiac disease in patients with obese class III compared with the normal BMI group. Obese classes I, II, and III groups, irrespective of other covariates, compared with normal BMI group, were more likely to experience pulmonary embolism (obese class I: $p = 0.004$; class II: $p = 0.006$; and class III: $p < 0.001$). Patients with obese class III compared with the patients in normal BMI group were more likely to have deep wound infection ($p = 0.04$) and a trend ($p = 0.10$) of the increased likelihood of readmission (►**Table 2**).

Results of the association between comorbidities and complications (►**Table 3**; ORs and their 95% CIs) showed that patients with a history of diabetes ($p < 0.001$), cardiac disease ($p < 0.001$), circulatory/clotting disorder ($p < 0.001$), mental health ($p < 0.001$), alcohol abuse ($p = 0.04$), and smoking ($p = 0.002$) were more likely to also receive a blood transfusion compared with the patients without those comorbidities. Patients with a history of diabetes ($p < 0.001$), mental health ($p < 0.001$), alcohol abuse ($p < 0.001$), and smoking ($p < 0.001$) were more likely to be readmitted to the hospital. Patients with cardiac ($p < 0.001$) and pulmonary ($p < 0.001$) diseases were more likely to have pulmonary embolism compared with patients without a history of cardiac and pulmonary disease. There was no association between deep wound infections and any of the comorbidities listed. The model did not generate odd ratios for some of the comorbidities due to the lower frequency of occurrence.

Discussion

The results of this study indicate that the obese class-III group had a higher proportion of younger patients (<50

Table 1 Patients characteristics by body mass index (BMI) group; $n = 15{,}151$

	BMI groups (kg/m²)[a]					
	Normal (%)	Overweight (%)	Obese class I (%)	Obese class II (%)	Obese class III (%)	*p*-Value
Total number (*n*)	1,240	4,189	4,541	2,839	2,342	
Age group (y)						
< 50	2.0	1.3	2.0	2.6	4.1	<0.001
50–59	16.4	15.8	19.7	23.0	32.2	<0.001
60–69	29.4	36.0	38.5	44.4	45.4	<0.001
70–79	31.3	33.4	30.5	25.4	16.2	<0.001
≥80	21.0	13.6	9.4	4.6	2.1	<0.001
Sex						
Male	30.5	44.6	43.7	35.4	28.6	<0.001
Female	69.5	55.4	56.3	64.6	71.4	<0.001
Comorbidities						
Diabetes	10.1	10.0	13.4	15.7	20.9	<0.001
Mental health	11.1	8.3	8.4	8.0	10.1	<0.001
Cardiac disease	0.7	0.8	0.8	0.7	0.8	0.871
Pulmonary disease	0.2	0.1	0.2	0.2	0.3	0.242
Blood circulatory/clotting	0.2	0.2	0.2	0.1	0.1	0.030
Smoker	7.2	7.4	8.6	7.8	8.2	0.002
Alcohol abuse	2.8	2.5	2.2	1.9	2.2	<0.001
Complications						
Readmission/30 days	4.5	3.7	3.6	3.3	4.3	<0.001
Pulmonary embolism	0.7	1.3	1.7	1.7	1.9	<0.001
Deep wound infection	0.7	0.5	0.6	0.8	1.5	<0.001
Myocardial infarction	0.3	0.4	0.3	0.3	0.1	<0.001
Ileus	0.2	0.2	0.3	0.4	0.3	0.070
Pneumonia	0.2	0.2	0.3	0.3	0.1	0.020
Deep vein thrombosis	0.1	0.2	0.1	0.1	0.0	0.060
Gastrointestinal bleed	0.1	0.0	0.2	0.2	0.1	0.030
Cerebrovascular accident	0.1	0.0	0.0	0.0	0.0	0.040

Note: *p*-Values are comparing the percentage of each row among different BMI groups.
[a]Normal weight (BMI ≤ 24.99 kg/m²), overweight (BMI = 25–29.99 kg/m²), obese class I (BMI = 30–34.99 kg/m²), obese class II (BMI = 35–39.99 kg/m²), and obese class III (BMI ≥ 40 kg/m²).

years) and a lower proportion of older patients (≥80 years) compared with the normal BMI group. This suggests that patients with obesity generally receive TKA at a younger age. Patients with obesity class III were on average 7.5 years younger than the group with normal BMI. Other studies have similarly reported that patients with obesity and severe OA were younger.[12,16,17] For example, Dowsey and colleagues[16] found that patients with severe obesity who had undergone TKA were 6 years younger than patients without obesity. Taken together, these results may suggest that obesity accelerates the progression of OA,[9] resulting in patients with obesity reaching end-stage knee OA earlier. Consequently, patients with obesity seek surgical solutions at a younger age compared with patients with normal BMIs. It is

well known that females require TKA more frequently than males.[12] In our cohort of patients who underwent TKA, there was also a higher proportion of females than males across all BMI groups, with obese class-III group having the highest proportion. It is noteworthy that females tend to delay joint replacement and only consider TKA when they are in extreme need because they are more concerned about the surgical risk and being a burden on the family.[18] Delaying surgery may result in decreased physical activity (because of pain) and resultant weight gain which may explain why there is an even higher proportion of females in the obese class-III group.[18]

Previous studies have shown that obesity increases the risk of adverse events after TKA.[11–13] However, defining

Table 2 Odds ratio for different BMI groups versus normal BMI group for comorbidities and complications

	Overweight versus normal BMI		Obese class I versus normal BMI		Obese class II versus normal BMI		Obese class III versus normal BMI	
	OR (95% CI)	p-Value	OR (95%CI)	p-Value	OR (95%CI)	p-Value	OR (95%CI)	p-Value
Comorbidities[a]								
Diabetes	0.96 (0.77–1.19)	0.68	1.44 (1.17–1.78)	<0.001	1.99 (1.60–2.48)	<0.001	3.38 (2.70–4.10)	<0.001
Mental health	0.83 (0.67–1.02)	0.08	0.85 (0.69–1.05)	0.13	0.81 (0.64–1.02)	0.07	0.94 (0.74–1.19)	0.72
Cardiac disease	1.18 (0.58–2.48)	0.66	1.22 (0.58–2.57)	0.60	1.33 (0.59–2.99)	0.48	1.95 (0.84–4.29)	0.14
Complications[b]								
Blood transfusion	0.77 (0.64–0.93)	<0.001	0.61 (0.50–0.74)	0.006	0.53 (0.42–0.66)	<0.001	0.38 (0.29–0.49)	<0.001
Pulmonary embolism	1.95 (0.96–3.97)	0.07	2.73 (1.37–5.51)	<0.001	2.77 (1.34–5.71)	<0.001	3.62 (1. 37–7.56)	<0.001
Deep wound infection	0.58 (0.26–1.29)	0.18	0.74 (0.34–1.59)	0.44	1.15 (0.53–2.52)	0.73	2.25 (1.07–4.85)	0.04
Readmission/30 days	0.89 (0.65–1.23)	0.51	0.90 (0.66–1.24)	0.53	0.93 (0.65–1.31)	0.67	1.27 (0.89–1.99)	0.12

Abbreviations: BMI, body mass index; CI, confidence intervals; OR, odd ratios.
Note: Normal weight (BMI ≤ 24.99 kg/m^2), overweight (BMI = 25–29.99 kg/m^2), obese class I (BMI = 30–34.99 kg/m^2), obese class II (BMI = 35–39.99 kg/m^2), and obese class III (BMI ≥ 40 kg/m^2).
ORs are generated from multiple logistic regression and are adjusted for other comorbidities/complications and demographic info.
[a]ORs for blood clots, pulmonary disease, and dementia were not generated due to lower or zero frequency for some BMI groups.
[b]ORs for myocardial infarction, Ileus, pneumonia, deep vein thrombosis, gastrointestinal bleed, and cerebrovascular accident were not generated due to lower or zero frequency for some BMI groups.

Table 3 Odds ratio of having peri/postoperative complications given a certain comorbidity

	Complications							
	Blood transfusion		Readmission/30 days		Pulmonary embolism		Deep wound infection	
Comorbidities	OR (95% CI)	p[b]	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Diabetes	1.76 (1.52–2.05)	<0.001	1.60 (1.30–1.98)	<0.001	0.78 (0.53–1.16)	0.23	0.72 (0.41–1.26)	0.25
Cardiac disease	3.07 (1.98–4.76)	<0.001	1.78 (0.92–3.47)	0.09	4.89 (2.47–9.70)	<0.001	NC[a]	NC
Pulmonary disease	2.20 (0.89–5.44)	0.08	0.43 (0.06–3.30)	0.42	7.51 (2.46–2.29)	<0.001	NC	NC
Circulatory/ clotting disorder	7.02 (2.88–17.08)	<0.001	2.85 (0.81–9.99)	0.10	NC	NC	NC	NC
Mental health	1.62 (1.36–1.93)	<0.001	2.12 (1.69–2.67)	<0.001	1.15 (0.74–1.78)	0.52	1.34 (0.74–2.44)	0.33
Alcohol abuse	1.47 (1.02–2.11)	0.04	2.07 (1.39–3.09)	<0.001	0.41 (0.10–1.70)	0.22	1.66 (0.70–3.94)	0.25
Smoker	1.37 (1.12–1.67)	0.002	1.65 (1.28–2.14)	<0.001	1.31 (0.84–2.04)	0.23	1.54 (0.88–2.69)	0.13

Abbreviations: CI, confidence intervals; NC, not converged; OR, odd ratio.
Note: Results are from multivariate logistic regression to find the association between each of the complications and comorbidities adjusting for demographic information.
[a]Logistic regression to find out the association between dementia, myocardial infarction, Ileus, pneumonia, deep vein thrombosis did not converge due to lower or zero frequency.
[b]p = significance level.

obesity simply based on BMI below or above 30 kg/m^2 leaves out critical information because the degree of obesity also plays an important role in determining the risk of perioperative/postoperative complications. There is limited information about the association between different grades of obesity, categorized according to WHO classification, and TKA complications in the literature. In our study, we categorized patients based on BMI using WHO classification to evaluate the effect of different BMI levels on complications following TKA. Results of the current study show that patients with higher BMI, independent of other factors, were more likely to have a pulmonary embolism, deep wound infection, and be readmitted to the hospital within 30 days of discharge. Besides obesity, other comorbidities

were also associated with TKA complications. Patients with comorbidities were more likely to have a blood transfusion, infection, pulmonary embolism, and readmission.

Previous studies have similarly reported increased probability of pulmonary embolism in patients with higher BMI (obese classes I, II, and III)[19–21]; while others did not find obesity to be an independent risk factor for pulmonary embolism.[22,23] The variability of research findings in this area may be due to different cut-offs used to define obesity, as well as inadequate adjustments for the possible confounding factors. Other studies similarly reported that the obese class-III group compared with BMI normal group was more likely to have wound-related complications.[20,21,24] The higher amount of fat deposition around the knee may be

related to delay in wound closure and healing, longer operative times, poor vascularization of fatty tissues, and a weakened immune response.[20] Other studies report that the higher risk of wound-related complications in the obese class-III group may be related to the presence of diabetes.[21] However, we did not find any association between diabetes and wound-related complications.

Of note, further detailed analysis revealed that the normal BMI and obese class-III groups were significantly more likely ($p < 0.001$) to be readmitted to the hospital within 30 days of discharge compared with the other BMI groups (classes I, II, and overweight). Previous studies have also suggested that readmission has a **U**-shaped relationship with BMI, and those with very low or very high BMI had a higher risk of readmission.[20,25] The higher risk of readmission in BMI class III could be due to higher rates of comorbidities and wound-related infections associated with obesity.[20,26,27] Whereas the higher risk of readmission in the normal BMI group could be related to higher rates of blood transfusion, mental health issues, and lower length of hospital stays.[20,26,27] We also found that the likelihood of blood transfusion was lower in patients with higher BMI which is in line with other studies.[20,28] In patients with higher BMIs, the actual percentage of blood volume lost following TKA might be lower due to the higher blood volume in these patients[29] which eventually leads to lower rates of blood transfusion compared with patients with normal BMI quality of life following TKA.

Besides obesity, other comorbidities are also independent predictors for postoperative complications. We found a higher likelihood of pulmonary embolism in patients with cardiac and pulmonary disease. A higher likelihood of readmission was detected in patients with diabetes, mental health problems, alcohol abuse, or current smokers. The higher likelihood of blood transfusion was observed in all of the comorbidities except pulmonary disease. These results are similar to previous research.[26,30–34] However, some studies did not find an association between complications and comorbidities including diabetes,[35,36] cardiac disease, mental health,[37] and smoking.[38,39] The discrepancy in results could be due to sample size, severity of the disease, and lack of analysis of other potential confounding variables including age, sex, and number of medical comorbidities. Altogether, our results support the finding that obesity along with other comorbidities is an independent risk factor for adverse events following TKA; however, the level of the risk depends on the type of complication. As Bone and Joint Health Strategic Clinical Network (BJHSCN) recommended no specific BMI value is being proposed as a threshold to consider patients for TKA.[40] Since risks associated with the surgery may outweigh benefits and health outcomes in patients with obesity, an individualized preoperative optimization program is being recommended for patients with obesity undergoing TKA.[41]

Strength and Limitations

Our study included a large dataset routinely checked by ABJHI for quality assurance. These data were collected from the whole province which makes our results more generalizable. We categorized patients into five groups based on BMI according to WHO classification which allowed us to demonstrate a clear relationship between BMI group with complications and comorbidities. Certain aspects of our study methodology should be emphasized. We only examined perioperative and postoperative events within 30 days of TKA. Some of the potential postoperative complications may occur after this time period, and our study did not capture those events. We were not able to report odd ratios for some of the parameters due to very low or zero event rates. There was a lack of information on the number of deaths in the dataset. Incomplete data collection for some variables such as weight and height records, length of stay in hospital, and lack of detailed clinical information including presurgical OA severity diagnosis, and the number of deaths that occurred in the cohort are all valid concerns. Moreover, we used BMI as a measure of obesity; however, BMI does not provide information about body composition and fat distribution.[42] Further studies are needed to elucidate the association between body composition and fat distribution using sophisticated methods such as dual-energy X-ray absorptiometry (DEXA) with complications in patients with TKA. It is also noteworthy that obesity definition has been changed in the newly released obesity guideline to "a chronic disease characterized by excessive or abnormal body fat that impairs health."[41,43] The new guideline recommended use of the Edmonton Obesity Staging System[41] as a complementary measure for BMI. Future studies can explore the association between obesity staging and surgery outcomes. These recognized limitations are inherent to retrospective studies of administrative databases and could potentially be improved through prospective data collection.

Conclusion

This study added to the literature on the association between obesity and other major comorbidities on short-term complications in patients who underwent TKA. Overall, we demonstrated that the patients in the obese cohort were younger, included more females, and had a higher incidence of major comorbidities. With increase in BMI, the likelihood of having pulmonary embolism and deep wound infection were increased. The normal BMI group had the highest likelihood of blood transfusion. There was also a high association between major comorbidities with peri/postoperative complications. Obesity, independent of other comorbidities, places patients at increased risk of adverse events after TKA, though the level of risk depends on the severity of obesity and the type of complication. These findings may be used by patients and care providers to educate patients in higher BMI groups about the risks and benefits of an elective procedure.

Ethical Approval and Consent to Participate
The study was approved by the University of Alberta Health Research Ethics Board (ID: Pro00053754), and permission was obtained to extract data from the Alberta

Bone and Joint Health Institute (ABJHI) registry. Because of the anonymous nature of the data, the requirement for individual patient written informed consent was waived.

Conflict of Interest
None declared.

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