Correlation of Body Mass Index and Blood Loss During Total Knee and Total Hip Arthroplasty

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Abstract

Almost one-third of Americans older than 20 years are considered obese. Excessive weight has been linked to faster destruction of weight-bearing joints, which may then need to be replaced. Joint replacement surgeons disagree about an association between obesity and increased blood loss during hip or knee joint replacement.

In this retrospective study, we examined the effect of body mass index (BMI), operative time (length of procedure), and anesthesia time on total blood loss during primary total knee arthroplasty (TKA) and primary total hip arthroplasty (THA). Intraoperative data from 94 primary TKAs and 78 primary THAs were reviewed, and divided into obese and nonobese groups on the basis of calculated BMI. Regression analysis was used to compare intraoperative blood loss amounts to patient characteristics. TKA and THA groups were analyzed separately.

Obesity did not correlate with increased intraoperative blood loss in the TKA or THA group. However, operative time correlated with increased intraoperative blood loss. A 1-minute increase in anesthesia time resulted in total blood loss increases of 3.167 mL during TKA and 1.552 mL during THA.

The obesity epidemic in the United States is growing.[1] Data from the 2003-2004 National Health and Nutrition Examination Survey show that, in the United States, 32% of people who are 20 years or older are obese, and almost 5% are morbidly obese.[2] Obesity has been identified as a significant risk factor for many personal health risks. Degenerative joint disease has been associated with obesity.[3-6] The mechanism most often suggested for increased arthritic changes is the increased load placed across a joint.[3,6]

In total knee arthroplasty (TKA) and total hip arthroplasty (THA), intraoperative blood loss can be significant.[7] In TKA, blood loss amounts have varied because of tourniquet and cement use.[8-13] When a large amount of blood is lost, autogenic and/or allogenic blood transfusions may be required. Transfusion risks include human immunodeficiency virus, hepatitis C infection, and immunologic transfusion reactions.[14-16]

To our knowledge, very little has been published on blood loss during total joint replacement in an obese population in the English literature. Some authors have found significantly increased blood loss in obese patients compared with nonobese patients during primary THA.[17-20] In 2007, Prasad and colleagues[21] reported no significant correlation between body mass index (BMI) and blood loss during TKA.

We conducted a retrospective study to examine the effects of BMI, operative time, and anesthesia time on blood loss during primary TKA and primary THA. For the TKA analysis, we also considered tourniquet time and cement use.

Materials and Methods

After obtaining institutional review board approval, the Adult Reconstruction Division knee and hip joint replacement database at Texas Tech University Health Sciences Center was used to access data for patients who had primary TKA or primary THA performed by the senior author (AOR) between August 2004 and March 2007. Cases involving patients with bleeding disorders, patients taking medications that cause increased bleeding, patients who underwent bilateral procedures, prisoners, minors, and pregnant patients were excluded from the study.

Ninety-four TKA cases and 78 THA cases were eligible for study inclusion. Standard protocols were followed. For TKAs, standard midline incisions and medial parapatellar approaches were used; for THAs, hip incisions and modified anterolateral approaches. Tourniquet times for TKAs were obtained from nurse records. During surgery for cemented TKA components, the tourniquet was inflated before they were cemented and was released after the cement cured.

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Table I. Patient and Operative Characteristics for Total Knee Arthroplasty (n = 92)

Characteristic	Mean or %	SD	*P* Value[a]
Estimated blood loss, mL	325.5	173.9	—
Tourniquet time, min	24.9	11.8	.28
Operative time, min	133.3	26.5	<.01
Anesthesia time, min	194.2	32.5	<.01
Age, years	65.7	8.9	.03
Sex	—	—	.81
Women	59.6%	—	—
Men	40.4%	—	—
Obesity status	—	—	.18
Nonobese	41.5%	—	—
Obese	58.5%	—	—
Anesthesia type	—	—	.461
General	73%	—	—
Spinal	27%	—	—

[a]From bivariate analyses between estimated blood loss and all other variables.

Similar implants were used for all knees and hips. The standard estimate of total blood loss was based on suction collection and amount absorbed on lap sponges. Additional operative data collected included operative time (length of procedure) and anesthesia time and type.

Patient age, sex, weight, and height data were collected, and BMI was calculated. Obesity was defined as BMI of 30 kg/m^2 or higher (Centers for Disease Control and Prevention standard definition). That threshold was used to categorize patients as either nonobese or obese.

Cementless acetabular and femoral components were used in all THA cases. TKA cases were divided into 3 groups: cemented (cemented femoral and tibial components), cementless (noncemented components), and hybrid (noncemented femoral component, cemented tibial component).

To determine which factors predicted total intraoperative blood loss, we performed bivariate analyses, first for blood loss and patient and procedure characteristics. For continuous characteristic variables, such as operative time, correlational analyses were performed; for discrete variables, such as sex, a *t* test or analysis of variance (ANOVA) was performed. Variables with $P>.25$ were not included in further multivariate analysis. To establish a parsimonious multivariate model for intraoperative blood loss, we made a stepwise ordinary least squares (OLS) estimation. In the first step, all variables with $P<.25$ in the bivariate analyses were entered into the estimation. In the next step, only variables with $P<.25$ were used.

TKA and THA cases were analyzed separately. Further correlation analyses, involving total intraoperative blood loss, cement use, and tourniquet time, were performed on TKA patient data. Regression analysis and ANOVA, similar to those already mentioned, were used to calculate *P* values.

Each group (TKA, THA) was divided into 4 BMI subgroups. Normal was defined as BMI of less than 20 kg/m^2, overweight as 20 to 29 kg/m^2, obese as 30 to 39 kg/m^2, and morbidly obese as 40 kg/m^2 or higher. *P* values between subgroups and operative characteristics were calculated with *t* tests.

Results

Ninety-two TKA and 78 THA cases were eligible for this study.

Patient and operative characteristics for the TKA

Table II. Total Knee Arthroplasty by Implantation Technique

	Age, years		EBL, mL		TT, min		OT, min		AT, min	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cemented										
Nonobese	69.4	7.5	298.64	117.2	24.8	8.5	129.2	23.0	191.9	32.2
Obese	67.4	7.3	299.1	151.9	27.4	11.8	132.3	22.7	190.0	27.1
Hybrid										
Nonobese	68.2	10.9	338.9	145.3	29.7	8.6	140.2	47.3	202.3	58.1
Obese	65.8	6.8	366.7	139.7	26.8	12.6	131.7	21.9	196.0	28.0
Noncemented										
Nonobese	54.7	6.4	271.4	141.0	12.3	13.5	134.6	17.2	197.6	19.0
Obese	60.6	9.9	359.1	191.7	20.6	12.8	138.0	25.2	198.1	27.7
Obese, *P* value										
Cemented vs noncemented	.02		.32		.13		.51		.37	
Hybrid vs noncemented	.12		.91		.24		.52		.80	

Abbreviations: AT, anesthesia time; EBL, estimated blood loss; OT, operative time; TT, tourniquet time; SD, standard deviation.

group are listed in Table I. Mean (SD) BMI for these patients was 31.0 (6.3) kg/m^2, and BMI ranged from 19 kg/m^2 to 47 kg/m^2. Table I also lists the *P* values for the bivariate tests between estimated blood loss and the other operative variables. Correlation coefficients between total intraoperative blood loss and operative time (0.497), anesthesia time (0.439), and age (-0.220) were all statistically significant ($P<.05$). Although obese status was not statistically significant, it was entered into the first-step OLS described earlier. TKA patients were further divided according to implantation technique (Table II). Cemented, cementless, and hybrid TKAs did not differ in amount of blood lost. Furthermore, tourniquet use did not show any statistical differences. Therefore, these characteristics were not entered into the regression analysis. Only in younger, obese patients did there seem to be significantly ($P<.02$) fewer cemented TKAs than cementless TKAs. There was no statistical difference in any operative characteristic in comparisons of any of the 4 BMI subgroups.

TKA data from the bivariate analysis were entered into the first step of the OLS regression. As $P>.25$ was found for both anesthesia time and sex, these were eliminated from the next step. Results from the final multivariate regression are listed in Table III. Operative time was statistically significant ($P<.01$). In particular, the estimated coefficient indicated that, for each 1-minute procedure increment, total blood loss was 3.167 mL higher, controlling for age and obesity status. Another statistically significant predictor of blood loss was age. On average, for each 1-year age increment, total blood loss was 4.554 mL lower. Obesity status was not statistically significant ($P = .242$).

Patient and operative characteristics for the THA group are listed in Table IV. Mean blood loss was significantly ($P<.01$) higher and mean operative time significantly ($P<.01$) longer for THA cases than for TKA cases. In addition, general anesthesia was used significantly ($P<.01$) more often in THA cases than in TKA cases. For THA cases, mean (SD) BMI was 30.4 (5.8) kg/m^2, and BMI ranged from 17 kg/m^2 to 47 kg/m^2. In the bivariate analyses, only operative time correlated (0.225) significantly ($P = .048$) with blood loss; there were no significant differences in operative time, age, sex, or distribution of obese status between TKA and THA cases.

For the THA group, operative time, age, and sex were entered into the first step of the multivariate regression. Results indicated the age variable was eliminated. Table V lists the final results of the multivariate regression. The estimated coefficient indicated that, for each 1-minute procedure increment, total blood loss increased by 1.552 mL ($P = .067$), a magnitude about half that of TKA cases. On average, during surgery, male patients lost 89.158 mL more blood ($P = .085$) than female patients did, controlling for operative time. As with the TKA group, the THA group showed no statistical difference in any operative characteristic in comparisons of any of its 4 BMI subgroups. Comparisons of estimated blood loss for the 4 BMI subgroups in TKA and THA cases are reported in Tables VI and VII.

Table III. Factors Predicting Blood Loss in Total Knee Arthroplasty ($R^2 = 0.297$)

	β	SE	*P* Value	95% CI
Operative time, min	3.167	0.581	<.01	2.012, 4.321
Age, years	-4.554	1.738	.01	-8.006, -1.102
Obese (vs nonobese)	36.668	32.116	.24	-25.149, 98.485

Abbreviations: CI, confidence interval; SE, standard error.

Table IV. Patient and Operative Characteristics for Total Hip Arthroplasty (n = 78)

Characteristic	Mean or %	SD	*P* Value[a]
Estimated blood loss, mL	500.64	220.61	—
Operative time, min	134.06	29.31	.05
Anesthesia time, min	174.63	43.59	.52
Age, years	63.76	14.17	.22
Sex	—	—	.06
Female	65%	—	—
Male	35%	—	—
Obesity status	—	—	.34
Nonobese	44%	—	—
Obese	56%	—	—
Anesthesia type	—	—	.79
Spinal	10%	—	—
General	90%	—	—

[a]From bivariate analyses between estimated blood loss and all other variables.

Table V. Factors Predicting Blood Loss in Total Hip Arthroplasty ($R^2 = 0.088$)

	β	SE	*P* Value	95% CI
Operative time, min	1.552	0.834	.07	-0.110, 3.213
Men (vs women)	89.158	51.049	.09	-12.537, 190.854

Abbreviations: CI, confidence interval; SE, standard error.

Table VI. Comparison of Body Mass Index (BMI) Subgroups' Estimated Blood Loss (EBL) for Total Knee Arthroplasty

	EBL, mL		*P* Value			
BMI Subgroup	Mean	SD	Normal	Overweight	Obese	Morbidly Obese
Normal (n = 16)	298	124	N/A	.9	.2	.3
Overweight (n = 24)	360	138	.9	N/A	.1	.1
Obese (n = 43)	374	205	.2	.1	N/A	.05
Morbidly obese (n = 11)	275	121	.3	.1	.05	N/A

Table VII. Comparison of Body Mass Index (BMI) Subgroups' Estimated Blood Loss (EBL) for Total Hip Arthroplasty

	EBL, mL		*P* Value			
BMI Subgroup	Mean	SD	Normal	Overweight	Obese	Morbidly Obese
Normal (n = 11)	530	221	N/A	.2	.5	.4
Overweight (n = 22)	418	206	.2	N/A	.1	.06
Obese (n = 41)	491	166	.5	.1	N/A	.09
Morbidly obese (n = 4)	650	280	.4	.06	.09	N/A

Discussion

With the epidemic of obesity in the United States growing, and obesity leading to increased stresses across joints, studies that address obesity and joint replacement are becoming more relevant.[2-6] Our data, spanning a 3-year period at a tertiary referral center, identified 58% of study patients as obese (BMI, >30 kg/m^2), which correlates with results from other reports.[22]

There was no statistically significant difference between nonobese and obese patient groups in amount of blood lost during TKA and THA. In addition, cement or tourniquet use in TKA in the obese population had no influence on intraoperative blood loss.

These data conflict with those from several other studies, which found more blood lost during hip replacements in obese patients.[17-20] (Our data do support the conclusion reached by Prasad and colleagues[21]—that higher BMI does not correlate significantly with blood loss.) However, the authors of 4 of these studies[17-19,23] asserted that, despite the increase in intraoperative blood loss, there is no statistical significance in transfusion requirements between nonobese and obese patients.

Our data indicate that, regardless of BMI, operative time significantly increases amount of blood lost, especially during TKA. Whereas some investigators have found longer operative times for obese patients,[18,19,23] Søballe and colleagues[20] found no difference between nonobese and obese patients in TKA operative time. Given the conflicting data, investigation is needed to correlate operative time and blood loss in the obese population.

The limitations of our study are its retrospective design, failure to study perioperative blood loss, possible imprecision in actual volumetric blood loss estimations, and not accounting for blood volume differences in blood loss calculations (blood volume increases nonlinearly with increasing weight, so the standard mean adult blood volume of 70 mL/kg cannot be used for obese and morbidly obese patients[24]).

Obesity has been associated with many joint arthroplasty complications, including infection, increased wound breakdown, and inferior survivorship of components.[22,25-28] In the study reported here, we did not find any statistically significant differences between nonobese and obese patients in blood lost during TKA and THA, so we recommend excluding obesity as a risk factor for increased blood loss during these procedures. We conclude from our data that minimizing operative time in obese patients decreases intraoperative blood loss. Prospective randomized trials addressing these issues may be indicated.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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