Original Article

Postoperative complications in underweight patients undergoing total hip arthroplasty: A comparative analysis to normal weight patients

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ABSTRACT

Background: Underweight patients undergoing total hip arthroplasty have been largely overlooked. The purpose of this study was to evaluate their complications profiles compared to normal weight individuals.

Methods: Patients were selected from the NSQIP database, matched, and arranged into 2 groups based on BMI. Complications were recorded and analyzed to determine differences in outcomes.

Results: Multivariate analysis demonstrated increased length of hospital stay (LOS) ($p = 0.006$) for underweight patients but failed to demonstrate higher rates of medical or surgical complications.

Conclusion: There are no increased rates of infectious or medical complications in underweight patients undergoing THA. However, increased LOS was demonstrated.

1. Introduction

In 2012, over 700,100 total knee (TKA) and 468,000 total hip (THA) arthroplasties were performed in the US, making each intervention the first and fourth most frequent inpatient surgical procedures, respectively.¹ Estimates predict that by 2030, over 4 million total joint arthroplasties (TJA) will be performed annually.² Increasing hospital costs and an emphasis on improving patient safety have led to the investigation of pre-surgical risk factors and their preventative measures. While obesity has received significant attention from the arthroplasty community, due to the inherent associated medical comorbidities and risks of post-operative complications,^{3–5} research concerning TJA in underweight patients and their associated medical comorbidities have been largely understudied.

Malnutrition is a common manifestation in the underweight population and is a modifiable risk factor, affecting 15% of patients in the arthroplasty inpatient setting.⁶ Several studies have demonstrated that malnutrition may lead to poor post-operative outcomes, including increased rates of post-operative infection, transfusion, cardiovascular events and renal complications.^{7–10} Malnutrition has also been shown to potentially delay mobilization, increase lengths of stay and hospital expenditures.^{7,8,11}

Laboratory indicators of malnutrition have included low serum albumin, pre-albumin, retinol-binding protein, transferrin, total cholesterol, and inflammatory markers (i.e. CRP and WBC count).^{8,12} However, these indicators can be confounded by underlying physiological or

pathological processes,¹² and are inconsistently collected pre-operatively. BMI, on the other hand, remains to be one of the most well documented exam findings during standard clinic visits, and could prove to be a useful proxy for malnutrition in the underweight patient. The primary aim of this study is to therefore evaluate and compare the complication profile in underweight (BMI < 18.5 kg/m²) versus normal weight patients (BMI 18.5–24.9) undergoing total hip arthroplasty. We hypothesize that underweight patients will have higher rates of medical and infectious complications due to underlying medical comorbidities.

2. Methods

2.1. Data source

Patients participating in the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) were examined. The structure of the ACS NSQIP has been described previously.^{13,14} In short, the program prospectively collects detailed data regarding patient demographics, preoperative comorbidities, laboratory values, and specific operative variables. Patients are then followed for 30 days after the index operation, and postoperative complications are collected regardless of whether the patient is an inpatient, has been discharged to their home or other facility, or has been readmitted to another hospital or outpatient facilities. Data is abstracted at each site by surgical certified reviewers using clinical records, physician charts, and by contacting patients directly. Surgical certified reviewers are

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formally trained by the ACS NSQIP team with continuing education courses and annual certifications to ensure high quality, standardized data collection. Data definitions are strictly defined and standardized across all participating institutions. Data consistency and reliability are assessed at each hospital through an on-site interrater reliability audit program.¹⁵

2.2. Patient selection and exclusion

Patients who underwent primary total hip arthroplasty between January 1, 2008, to December 31, 2015 were identified using Current Procedural Terminology (CPT) code 27130 (primary total hip arthroplasty) and separated into two groups. Patients with body mass indexes (BMI) < 18.5 kg/m² were categorized as underweight, and those with BMIs between 18.5–24.9 kg/m² were categorized as normal weight. All cases involving a diagnosis of infection, hip fracture and/or malignancy according to ICD-9 coding were excluded from this study. Propensity match scoring was used to identify a cohort of normal weight patients that were statistically similar to the underweight cohort according to age, sex, and preoperative comorbidities by SPSS Statistics version 22 (IBM, Armonk, NY) at a ratio of approximately 1.6:1. Patients were not matched according to BMI or history of recent weight loss (10%, as defined by NSQIP criteria).

2.3. Preoperative variables

Patient demographics, medical comorbidities, and 30-day complications were compared between the two groups. Demographics included age, gender, height, weight, and BMI. Medical comorbidities included a previous history of severe chronic obstructive pulmonary disease, myocardial infarction, congestive heart failure, hypertension requiring antihypertensive medications, bleeding disorders, previous transfusions, diabetes mellitus, dialysis, acute renal failure, ascites, disseminated cancer, and weight loss greater than 10% in the past 6 months prior to surgery.

2.4. Outcomes

Postoperative variables included operative time, hospital length of stay, and 30-day reoperation and readmission rates. Postoperative complications encompassed death, deep venous thrombosis, pulmonary embolism, renal insufficiency and failure, urinary tract infections, cerebrovascular accidents, cardiac arrest, myocardial infarction, bleeding requiring transfusion, superficial and deep surgical site infections, and wound disruption. All variables were used as defined in the ACS NSQIP user guide.¹⁶

2.5. Statistical methods

SPSS Statistics version 22 (IBM, Armonk, NY) was used to perform all statistical analyses in this study. Kolmogorov-Smirnov tests of normality were performed and deemed adequate. Univariate analyses of categorical variables were performed using Fisher's exact test. Independent-samples T-test assuming equal variances was used to compare continuous variables between the 2 procedures. A p value less than 0.05 was deemed statistically significant. To demonstrate whether specific preoperative variables were independently associated with higher risk of 30-day postoperative complications, binary logistic regression analyses were performed. Only univariate candidates with an association $p \leq 0.20$ were included in the model.

3. Results

A total of 16,831 patients undergoing total hip arthroplasty with BMI's below 18.5 and those between 18.5 and 24.9 were identified. From the database, patients were matched using propensity scores

Table 1
Characteristics of 840 Normal and Underweight Patients Undergoing Total Hip Arthroplasty.

	Underweight BMI < 18.5 n (%)	Normal Weight BMI 18.5–24.9 n (%)	P-Value ^a
Number of Patients	301	539	na
Female	239 (79.4)	421 (78.1)	0.726
Non-Caucasian	26 (8.6)	70 (13.0)	0.295
Age (mean, yrs)	71.6	72.5	0.096
Preoperative Testing			
Albumin ^b	4.0	4.1	0.326
Hematocrit ^b	39.1	37.7	< 0.001
Current smoker	41 (13.6)	83 (15.4)	0.543
Diabetes mellitus	3 (1.0)	2 (0.4)	0.356
Hypertension requiring medications	138 (45.8)	250 (46.4)	0.886
History of $\geq 10\%$ weight loss	5 (1.7)	0 (0.0)	0.006
Recent congestive heart failure exacerbation	19 (6.3)	35 (6.5)	1.000
History of chronic obstructive pulmonary disease			
Ascites	0 (0.0)	0 (0.0)	1.000
History of active malignancy	0 (0.0)	0 (0.0)	1.000
Dialysis	0 (0.0)	2 (0.4)	0.540
Recent acute renal failure with creatinine ≥ 2 mg/dL	0 (0.0)	1 (0.2)	1.000
Chronic steroid use	17 (5.6)	29 (5.4)	0.875
Bleeding disorder	2 (0.7)	3 (0.6)	1.000
Preoperative Transfusion ≥ 1 unit pRBC	2 (0.7)	3 (0.6)	1.000
ASA Class ≥ 3	128 (42.5)	211 (39.1)	0.342

BMI, body mass index; ASA, American Society of Anesthesiologists; pRBC, packed red blood cells.

^a Calculated using Fisher's Exact Test for categorical variables and independent samples t-test for continuous variables.

^b Preoperative laboratory values completed for 47.7% of patients.

based on age, sex, and preoperative comorbidities at a ratio of 1.6 to 1 of normal weight to underweight patients, respectively. The propensity matched scores yielded, a total of 840 patients who underwent primary total hip arthroplasty. Of those, 539 were categorized as normal body weight (BMI 18.5–24.9), while 301 were underweight (BMI < 18.5). 78% were female and 11.4% were non-Caucasian.

There were 2 significant differences in the demographics between the 2 groups. The normal weight group had an average hematocrit that was 37.7 compared with an average of 39.1 in the underweight group ($P < 0.001$) and the underweight group had more patients with a history of $> 10\%$ weight loss ($p < 0.001$) compared to the control normal weight group. The difference in hematocrit is likely not clinically significant. There was no statistical difference between levels of preoperative albumin between the two groups. The most prevalent comorbidity was hypertension, which accounted for 48.8% of the underweight group and 46.4% of the normal weight group (Table 1).

A univariate analysis was completed to determine statistical differences in the postoperative complication profile of normal weight and underweight patients undergoing elective total hip arthroplasty. Differences between the 2 groups were observed as seen in Tables 2 and 3.

Based on the univariate analysis, underweight patients had statistically significant longer operative times ($p = 0.023$) and length of hospital stay ($p = 0.048$). Unplanned readmissions ($p = 0.096$) and renal insufficiency ($p = 0.128$) rates were higher in underweight patients and approached significance. There were no observed differences between medical complications including cardiac issues, pneumonia, pulmonary emboli, cerebrovascular accidents, and deep venous thromboembolism. There were also no differences in superficial or deep surgical infections or rates of wound dehiscence (Table 2).

Table 2

Postoperative Complication Rates by Body Mass Index Among 840 Normal and Underweight Patients Undergoing Total Hip Arthroplasty.

	Underweight BMI < 18.5 (n = 301)	Normal Weight BMI 18.5–24.9 (n = 539)	P-Value ^a
Perioperative Metrics			
Operation Time (min)	96.0	89.6	0.023
Length of Hospital Stay (days)	3.4	3.1	0.048
Unplanned Readmission (%)	11 (3.7)	9 (1.7)	0.096
Unplanned Reoperation (%)	4 (1.3)	5 (0.9)	0.729
Death (%)	0 (0.0)	0 (0.0)	1.000
Deep Venous Thrombosis (%)	1 (0.3)	0 (0.0)	0.358
Pulmonary Embolism (%)	1 (0.3)	1 (0.2)	1.000
Pneumonia (%)	1 (0.3)	3 (0.6)	1.000
Renal Insufficiency (%)	2 (0.7)	0 (0.0)	0.128
Urinary Tract Infection (%)	4 (1.3)	4 (0.7)	0.467
Cerebrovascular Accident (%)	0 (0.0)	2 (0.4)	0.540
Cardiac Arrest (%)	0 (0.0)	0 (0.0)	1.000
Myocardial Infarction (%)	1 (0.3)	1 (0.2)	1.000
Bleeding Requiring Transfusion (%)	53 (17.6)	104 (19.3)	0.580
Superficial Surgical Site Infection (%)	1 (0.3)	2 (0.4)	0.707
Deep Surgical Site Infection (%)	0 (0.0)	0 (0.0)	1.000
Wound Disruption (%)	0 (0.0)	0 (0.0)	1.000

^a Calculated using Fisher's Exact Test for categorical variables and independent samples t-test for continuous variables.**Table 3**

Risk Adjusted Odds Ratios of 30-day Adverse Events in Underweight Patients Vs. Normal Weight Patients Undergoing Total Hip Arthroplasty.

	Odds Ratio	P Value ^a	95% CI
Operative Time ≥ 120 min	1.08	0.696	0.640–1.347
Length of Stay ≥ 4 days	1.60	0.006	0.447–0.874
Renal Insufficiency	1.02	0.784	0.227–1.569
Unplanned Readmission	1.87	0.182	0.213–1.341

CI, confidence interval.

^a Calculated using binary logistic regression multivariate analysis; Controlled for pre-operative demographics and medical comorbidities.

A multivariate analysis was performed on the statistically significant variables which included operative times and length of hospital stay as well as the 2 variables approaching significance, renal insufficiency and unplanned readmission, and further illustrated that underweight patients have longer hospital stays ($p = 0.006$) but failed to show significance for longer operative time, rates of renal insufficiency, and unplanned readmissions.

4. Discussion

Underweight patients undergoing TJA are challenging surgical patients due to the potential for postoperative medical and surgical complications. Though the majority of literature focuses on postoperative outcomes in obese patient undergoing TJA, several authors have evaluated complications of underweight patients, however some of the reported data is controversial. Many authors contend that underweight patients have a higher complication rate than their normal weight or even obese counterparts.^{7–11}

Venzin et al. evaluated the nutritional status of 430 patients hospitalized for various causes and found that malnutrition was associated with a low BMI and anemia.¹⁷ This study proposed that anemia and malnutrition are likely independent risk factors for postoperative complications due to the delayed healing capacity.

Several authors subsequently evaluated underweight and malnourished patients undergoing TJA and found that these patients have a higher rate of postoperative anemia,^{8,11} infection,^{9,10} renal complications,⁹ cardiac complications,^{8,9} and transfusion requirement.^{7,10} Sayeed et al. demonstrated that underweight patients have higher rate of venous thromboemboli, length of hospital stay, and total cost accumulated.¹¹ Gholson et al. further evaluated the increased length of stay in underweight patients undergoing orthopedic surgery and found that

underweight patients stayed an entire day longer than normal weight patients.¹⁸

Our study supports some of the findings by previous authors but contests others. The univariate and multivariate analysis both reinforced the notion that underweight patients have statistically significant longer hospital stays. The reason for this has been discussed by other authors.^{11,19,20} Sayeed et al. demonstrated that underweight patients have higher rates of postoperative anemia that may require blood transfusion.¹¹ This variable may be a major determinant in the increased length of stay seen in this category of patients. This may potentially be due to an underlying difference in the baseline total blood volume (BV) of underweight patients. In a study by Feldschuh et al., BV was shown not to be a constant fraction determined by the height, weight or body surface area.¹⁹ As intraoperative blood losses are similar for underweight and normal weight patients, the relative percentage of total BV loss due to surgery is greater in underweight patients.²⁰ Our data, however did not show differences in post operative transfusions rates likely due to the propensity matched nature of the statistics which was absent in the aforementioned studies.

Manrique, Sayeed, and Anoushiravani showed that underweight patients have increased risks for infection, cardiac complications, and Venous thromboemboli.^{8,10,11} Our data, however demonstrates that underweight patients have no increased risk for these complications. The reason for the contention is not entirely clear, however in their studies it appears that the underweight group tends to have lower preoperative hematocrit and albumin which are markers of malnutrition and predispose patients to medical complications. In our study, the differences between preoperative albumin and hematocrit were statistically different but not clinically significant between the 2 groups (Table 1).

The major limitation in this study is that it is restricted to the ACS NSQIP database. This database represents hospitals with a presumed interest in quality improvement and the financial means to participate. Compared with other acute care hospitals in the United States, ACS NSQIP hospitals are larger, more often teaching oriented, and tend to be located in urban areas. Although over 500 hospitals were included, the data might be skewed due to coding errors or incomplete charting of postoperative complications.

5. Conclusion

Underweight patients are a challenging group to indicate for elective total hip arthroplasty due to the controversial postoperative complications profile. Though our study did not demonstrate higher rates of

medical or surgical complications in this category of patients, the data did demonstrate that they have longer hospital stays. Underweight patients undergoing THA spend on average \$10,000 dollars more than normal weight counterparts and in today's fastidious medical climate, the increased cost becomes an important factor to consider.¹¹ Therefore, we propose that underweight patients are at no increased risk from a medical or surgical standpoint to undergo elective total hip arthroplasty, but due to increased length of stays and associated cost, these patients should work closely with our medical colleagues to address their BMI prior to being offered elective surgery.

Conflict of interest

Dr. Schwarzkop is a paid consult for Smith and Nephew.

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