Clin Orthop Relat Res (2018) 476:964-973
DOI 10.1007/s11999.0000000000000218

Clinical Orthopaedics and Related Research®
A Publication of The Association of Bone and Joint Surgeons®

Clinical Research

Can Patient Selection Explain the Obesity Paradox in Orthopaedic Hip Surgery? An Analysis of the ACS-NSQIP Registry

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Received: 19 August 2017 / Accepted: 22 January 2018 / Published online: 16 February 2018

Abstract

Background The "obesity paradox" is a phenomenon described in prior research in which patients who are obese have been shown to have lower postoperative mortality and morbidity compared with normal-weight individuals. The paradox is that clinical experience suggests that obesity is a risk factor for difficult wound healing and adverse cardiovascular outcomes. We suspect that the obesity paradox may reflect selection bias in which only the healthiest patients who are obese are offered surgery, whereas nonobese surgical patients are comprised of both healthy and unhealthy individuals. We questioned whether the obesity paradox (decreased mortality for patients who are obese) would be present in nonurgent hip surgery in which patients can be carefully selected for surgery but absent in urgent hip surgery where patient selection is minimized.

Questions/purposes (1) What is the association between obesity and postoperative mortality in urgent and nonurgent hip surgery? (2) How is obesity associated with individual postoperative complications in urgent and nonurgent hip surgery? (3) How is underweight status associated with postoperative mortality and complications in urgent and nonurgent hip surgery?

One of the authors (PC) received funding from the National Institute of Arthritis and Musculoskeletal and Skin Diseases (AR062133).
Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.
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All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research*® editors and board members are on file with the publication and can be viewed on request.

Methods We used 2011 to 2014 data from the American College of Surgeons National Surgical Quality Improvement Project (ACS-NSQIP) to identify all adults who underwent nonurgent hip surgery (n = 63,148) and urgent hip surgery (n = 29,047). We used logistic regression models, controlling for covariants including age, sex, anesthesia risk, and comorbidities, to examine the relationship between body mass _index (BMI) category (classified as underweight < 18.5 kg/m^2, normal 18.5–24.9 kg/m^2, overweight 25–29.9 kg/m^2, obese 30–39.9 kg/m^2, and morbidly obese > 40 kg/m^2) and adverse outcomes including 30-day mortality and surgical complications including wound complications and cardiovascular events.
Results For patients undergoing nonurgent hip surgery, regression models demonstrate that patients who are morbidly obese were less likely to die within 30 days after surgery (odds ratio [OR], 0.12; 95% confidence interval [CI], 0.01-0.57; p = 0.038) compared with patients with normal BMI, consistent with the obesity paradox. For patients undergoing urgent hip surgery, patients who are morbidly obese had similar odds of death within 30 days compared with patients with normal BMI (OR, 1.18; 95% CI, 0.76-1.76; p = 0.54). Patients who are morbidly obese had higher odds of wound complications in both nonurgent (OR, 4.93; 95% CI, 3.68-6.65; p < 0.001) and urgent cohorts (OR, 4.85; 95% CI, 3.27-7.01; p < 0.001) compared with normal-weight patients. Underweight patients were more likely to die within 30 days in both nonurgent (OR, 3.79; 95% CI, 1.10-9.97; p = 0.015) and urgent cohorts (OR, 1.47; 95% CI, 1.23-1.75; p < 0.001) compared with normal-weight patients.
Conclusions Patients who are morbidly obese appear to have a reduced risk of death in 30 days after nonurgent hip surgery, but not for urgent hip surgery. Our results suggest that the obesity paradox may be an artifact of selection bias introduced by careful selection of the healthiest patients who are obese for elective hip surgery. Surgeons should continue to consider obesity a risk factor for postoperative mortality and complications such as wound infections for both urgent and nonurgent surgery.
Level of Evidence Level III, therapeutic study.

Introduction

The obesity paradox describes the phenomenon whereby patients with higher body weight or body mass index (BMI) have been observed to have reduced mortality in many research studies despite a general consensus among physicians that patients who are obese are at higher risk for surgical complications than their nonobese counterparts [5, 9, 15, 18, 20, 34, 37, 39, 42]. This phenomenon is counterintuitive. Obesity is associated with increased risk of cardiovascular disease, hypertension, and diabetes; therefore, obesity should be a risk factor for death after surgery and surgical complications.

One potential explanation for the obesity paradox may be selection bias. Internists, anesthesiologists, and surgeons, when assessing suitability for surgery, may more carefully screen patients who are obese; the healthiest patients who are obese are referred for surgery, whereas nonobese patients are a mixture of both healthy and unhealthy individuals. Studies of coronary artery bypass graft surgery provide indirect evidence that obese and nonobese patients are different; patients who are obese tend to be younger [3, 17, 18, 21, 24, 25, 30, 33, 35, 36, 38, 44] and have better renal function [24, 30] at baseline compared with their nonobese counterparts. Most studies attempt to account for differences between patients who are and who are not obese by adjusting for measured covariates including age and presence of certain comorbidities in regression models [4, 5, 9, 15, 18, 20, 22, 34, 37, 39, 42], but such risk adjustment may be incomplete as a result of residual confounders.

We sought to investigate the obesity paradox more rigorously using a novel study design comparing 30-day mortality and postoperative complications in patients who are or who are not obese undergoing urgent and nonurgent hip surgery. We suspected that for urgent hip surgery (primarily hip fracture), the opportunity for patient selection would be minimal because clinical need for surgery would preempt excluding unwell patients who are obese from recommended surgical treatments. We suspected that for nonurgent surgery (primarily elective THA), patient selection would have an important influence on the results and we would observe the obesity paradox described previously. Although previous studies have explored the relationship between BMI and hip arthroplasty complications [42], these studies typically focused on elective procedures and are thus subject to the selection bias issues mentioned previously. In an effort to overcome the issues of selection bias present in many other studies [4, 5, 9, 15, 18, 20, 22, 34, 37, 39, 42], we used this study design with data obtained from the National Surgical Quality Improvement Project (NSQIP) [1, 6].

Specifically, we asked: (1) What is the association between obesity and postoperative mortality in urgent and nonurgent hip surgery? (2) How is obesity associated with individual postoperative complications in urgent and nonurgent hip surgery? (3) How is underweight status associated with postoperative mortality and complications in urgent and nonurgent hip surgery?

Patients and Methods

We used 2011 to 2014 participant use data files (PUF) from the ACS-NSQIP, a large voluntary registry of > 450 participating hospitals, mostly in the United States [1, 6]. We selected ACS-NSQIP for our study because of the database size, extensive validation and quality control processes, and because the database contains key variables we required including surgical urgency, BMI, and surgical outcomes. Trained clinical reviewers enter > 300 demographic, clinical, surgery-related, and outcome-related variables collected from various sources, including patient charts, hospital medical records, and computer systems, into an online data repository [19]. Demographic variables include age, sex, and race. Clinical variables include comorbidities (congestive heart failure, hypertension treated with medications, chronic obstructive pulmonary disease, diabetes, ascites, disseminated cancer, renal failure), smoking status, dyspnea, ventilator dependence, dialysis dependence, preoperative sepsis, steroid use, weight and height, which allow for calculation of BMI, functional status (total dependence, partial dependence, and independent), and American Society of Anesthesiologists (ASA) score (scores range from 1 [least severe] to 6 [most severe]).

We developed a list of potential surgical procedures that would allow us to investigate the role of selection bias in the obesity paradox. Specifically, we were searching for a single organ system (ie, hip, colon, biliary tree) that was both common (for sample size purposes) and had urgent and nonurgent counterparts. In conjunction with practicing academic surgeons (RG, DU, TJ), we compiled a list of candidate procedures that included hip surgery, colon surgery, and gallbladder surgery; we chose hip surgery through discussion and our extensive prior research experience in this area.

We used Current Procedure Terminology (CPT) codes to identify all patients undergoing THA (CPT 27130); hemiarthroplasty (CPT 27125); percutaneous skeletal fixation of femoral neck fractures (CPT 27235); open reduction with internal fixation (ORIF) of femoral neck fractures (CPT 27236); ORIF of intertrochanteric, peritrochanteric, or subtrochanteric femoral fractures (CPT 27244); and intramedullary fixation of intertrochanteric, peritrochanteric, or subtrochanteric femoral fractures (CPT 27245) in the NSQIP PUF. We excluded patients with missing baseline demographic (age, sex, height, weight) and clinical (functional status, ASA class) information. We also excluded patients with extremes of BMI (< 10 and > 80 kg/m^2) because such values are rare and likely represent either erroneous values or patients with extreme alterations in weight with little generalizability [11].

We began by stratifying patients undergoing hip surgery into urgent and nonurgent cohorts. Elective surgery is defined by the NSQIP as occurring if the patient is brought to the hospital or facility for a scheduled surgery from their home or normal living situation on the day that the procedure is performed. Patients were considered nonelective in the NSQIP if they were inpatients at an acute care hospital, transferred from an emergency department or clinic, or were admitted to the hospital on the day(s) before a scheduled procedure for any reason. The urgent cohort included patients with hip fractures identified on the basis of CPT codes 27235, 27236, 27244, or 27245 or International Classification of Diseases, 9th Revision codes 820 to 829; the urgent cohort also included patients who received nonelective total or hemiarthroplasty (CPT 27130, 27125) in accordance with coding schemes used in prior research [10]. The nonurgent hip surgery group includes patients undergoing elective total or partial hip arthroplasty as defined by the NSQIP, typically for osteoarthritis.

To answer our first question, we compared 30-day mortality after surgery across the various BMI categories in urgent and nonurgent groups. Next, we evaluated our second question by investigating the incidence of individual complications within 30 days of surgery using NSQIP definitions of various surgical complication types [2]: wound complications (superficial, deep incisional, organ space infections, or wound disruption); infection (pneumonia, urinary tract infection, sepsis, or septic shock); thromboembolism (pulmonary embolism or deep vein thrombosis); cardiac complications (myocardial infarction or cardiac arrest); blood loss resulting in transfusion; respiratory failure (unplanned intubation or failure to wean > 48 hours); renal failure (progressive renal insufficiency of acute renal failure resulting in dialysis); nervous system complication (stroke, coma, or peripheral nerve injury); and we created a composite measure representing occurrence of any one or more of the individual complications. Lastly, we evaluated our third question by investigating the incidence of the same NSQIP complications and the composite measure for underweight patients.

Statistical Analysis

We identified 103,188 hip procedures between 2011 and 2014 with a final cohort consisting of 29,047 urgent and 63,148 nonurgent hip surgeries (Fig. 1). We used chi square statistic and t-test to examine differences between the urgent and nonurgent cohorts with respect to demographics (age, sex), comorbid illnesses, and other clinical factors (such as ASA class, functional status, type of procedure; Table 1). We evaluated World Health Organization (WHO) BMI categories for the urgent and nonurgent cohorts categorized as: underweight (< 18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2), obese (30–39.9 kg/m^2), and morbidly obese (> 40 kg/m^2). We also examined differences in baseline information stratified by both surgical urgency and BMI categories (see Table, Supplemental Digital Content 1).

Second, we used multiple logistic regression modeling to calculate adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for each group, the reference category being

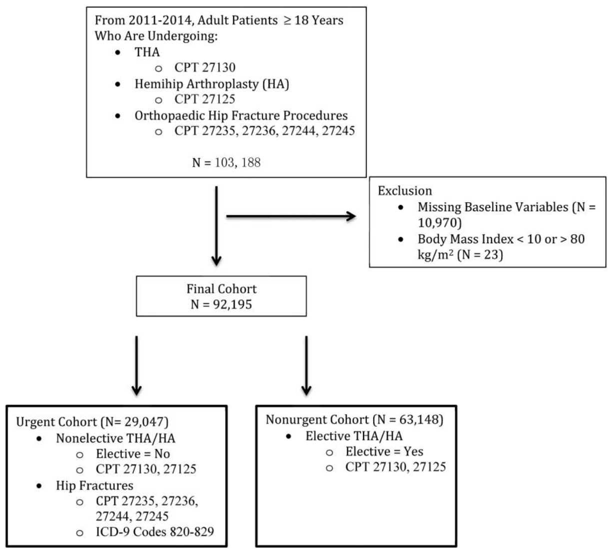

Fig. 1 Patients in the study are selected using the American College of Surgeons American College of Surgeons National Surgical Quality Improvement Project Participant Use Data Files. ICD-9 = International Classification of Diseases, 9^{th} Revision.

normal BMI (18.5–24.9 kg/m^2). For purposes of these models, our dependent variable was a patient-level variable representing whether a patient did or did not experience a complication (or death); our independent variable of interest was WHO BMI category with normal BMI being the reference group. Covariates were chosen a priori and included an array of demographic and clinical factors based on variables included in the NSQIP surgical risk calculator. These include age, sex, functional status, emergency case status, ASA class, steroid use, ascites within 30 days before surgery, systemic sepsis within 48 hours before surgery, ventilator dependency, disseminated cancer, diabetes, hypertension requiring medication, congestive heart failure in 30 days before surgery, dyspnea, current smoker, history of severe chronic obstructive pulmonary disease, dialysis, acute renal failure, height, and weight [29]. We also reported unadjusted complication event rates by surgical urgency and BMI categories (see Table, Supplemental Digital Content 2).

All analyses were conducted using R Version 3.0.2 (The R project, Vienna, Austria) with $p < 0.05$ considered statistically significant. This project was approved by the University Health Network Research Ethics Board.

Results

After controlling confounding variables such as age, sex, and comorbidities, we found that compared with normal-weight patients, patients who are morbidly obese had reduced odds of 30-day mortality after nonurgent surgery (OR, 0.12; 95% CI, 0.01-0.57; p = 0.038). However, for urgent hip surgery, patients who are morbidly obese had similar 30-day mortality (OR, 1.18; 95% CI, 0.76-1.76; p = 0.534) compared with normal-weight patients.

We found that for nonurgent hip surgery, patients who are morbidly obese appeared to have lower odds of most complications, but for urgent hip surgery, patients who are morbidly obese had similar odds of most complications. Specifically, in the nonurgent setting, patients who are morbidly obese had reduced odds of cardiac (OR, 0.38; 95% CI, 0.16-0.81; p = 0.02) and respiratory complications (OR, 0.26; 95% CI, 0.08-0.68; p = 0.013) compared with normal-weight patients; in the urgent setting, however, patients who are morbidly obese had odds of cardiac (OR, 1.14; 95% CI, 0.61-1.95; p = 0.12) and respiratory (OR, 1.16; 95% CI, 0.62-2.01, p = 0.16) complications that were similar to normal-weight patients. Comparing patients with wound complications with normal-weight patients, patients who are morbidly obese had increased odds of wound complications in both nonurgent (OR, 4.93; 95% CI, 3.68-6.65; p < 0.001) and urgent cohorts (OR, 4.85; 95% CI, 3.27-7.0; p < 0.001) (Table 2).

Underweight patients who underwent both nonurgent and urgent hip surgery had an increased risk of complications compared with normal-weight patients. Underweight patients had increased odds of having any complication (composite measure) and 30-day mortality in both nonurgent (composite OR, 1.35, 95% CI, 1.10-1.65, p = 0.003; mortality OR, 3.79, 95% CI, 1.10-9.97, p = 0.015) and urgent (composite OR, 1.16, 95% CI, 1.06-1.27, p = 0.021; mortality OR, 1.47, 95% CI, 1.23-1.75, p < 0.001) settings compared with normal-weight patients (Table 2).

Discussion

The obesity paradox describes a counterintuitive phenomenon reported in the medical literature whereby patients who are obese have fewer postoperative complications compared with normal-weight patients [5, 9, 15, 18, 20, 34, 37, 39, 42]. One potential explanation of the obesity paradox is a methodological flaw in many prior studies whereby careful selection of healthier patients who are obese to undergo preplanned surgery (ie, selection bias) creates the appearance of a paradox where none exists. Although studies in cardiovascular surgery have demonstrated that patients who are obese may be less likely to undergo cardiac bypass surgery [30] or percutaneous coronary intervention [31], the role of selection bias in orthopaedic surgery is less clear [31]. We examined whether the previously described obesity paradox existed in

Table 1. Baseline demographic and clinical variables of patients undergoing urgent and nonurgent hip surgeries from 2011 to 2014

Variables	Nonurgent (N = 63,148)	Urgent (N = 29,047)	p value
Demographics			
Age (years), mean (SD)	64.6 (11.7)	77.2 (11.6)	< 0.001
Female, number (%)	34,751 (55.0)	20,005 (68.9)	< 0.001
Race, number (%)			< 0.001
White	49,001 (77.6)	22,159 (76.3)	
Black	4284 (6.8)	1047 (3.6)	
Hispanic	1662 (2.6)	1296 (4.5)	
Asian	887 (1.4)	759 (2.6)	
Other*	349 (0.6)	181 (0.6)	
Body mass index category (kg/m^2), number (%)			< 0.001
< 18.5	517 (0.8)	2582 (8.9)	
18.5-24.9	12,572 (19.9)	13,522 (46.6)	
25-29.9	21,629 (34.3)	8185 (28.2)	
30-39.9	23,739 (37.6)	4143 (14.3)	
> 40	4691 (7.4)	615 (2.1)	
Functional status, number (%)			< 0.001
Independent	61,760 (97.8)	23,422 (80.6)	
Partially dependent	1330 (2.1)	4755 (16.4)	
Totally dependent	58 (0.1)	870 (3.0)	
ASA class,[†] number (%)			< 0.001
1	2764 (4.4)	409 (1.4)	
2	35,199 (55.7)	6065 (20.9)	
3	24,069 (38.1)	17,763 (61.2)	
4	1114 (1.8)	4776 (16.4)	
5	2 (0)	34 (0.1)	
Comorbidities, number (%)			
Diabetes	7157 (11.3)	5429 (18.7)	< 0.001
Smoking	8369 (13.3)	4032 (13.9)	0.01
Dyspnea[‡]	3029 (4.8)	2204 (7.6)	< 0.001
Ventilator use	3 (0)	67 (0.2)	< 0.001
Chronic obstructive pulmonary disease	2513 (4.0)	3458 (11.9)	< 0.001
Ascites	13 (0.0)	96 (0.3)	< 0.001
Chronic steroid use	2298 (3.6)	1793 (6.2)	< 0.001
Congestive heart failure	196 (0.3)	921 (3.2)	< 0.001
Hypertension	35,498 (56.2)	19,255 (66.3)	< 0.001
Renal failure	25 (0.0)	197 (0.7)	< 0.001
Dialysis	129 (0.2)	673 (2.3)	< 0.001
Disseminated cancer	225 (0.4)	955 (3.3)	< 0.001
Systemic sepsis 48 hours before surgery	98 (0.2)	3097 (10.7)	< 0.001
Type of procedure, number (%)			
THA	62,746 (99.4)	2578 (8.9)	< 0.001
Hemihip arthroplasty	402 (0.6)	4898 (16.9)	
Percutaneous skeletal fixation of femoral neck fractures	0	281 (1.0)	

Table 1. continued

Variables	Nonurgent (N = 63,148)	Urgent (N = 29,047)	p value
Open reduction internal fixation (ORIF) of femoral neck fractures	0	8269 (28.5)	
ORIF of intertrochanteric, peritrochanteric, or subtrochanteric femoral fractures	0	4112 (14.2)	
Intramedullary fixation of intertrochanteric, peritrochanteric, or subtrochanteric femoral fractures	0	8909 (30.7)	

*Other races include Native American or Alaska native, native Hawaiian or Pacific islander, unknown.
†American Society of Anesthesiologists physical status classification score.
‡dyspnea includes at rest or with moderate exertion.

patients undergoing nonurgent orthopaedic hip surgery and whether the paradox might be absent in urgent hip procedures where opportunities for patient selection were minimized. We used data from the ACS-NSQIP surgical registry to answer this question. Indeed, we found that patients who are morbidly obese undergoing preplanned (nonurgent) surgery had a reduced risk of death in 30 days after surgery compared with normal-weight individuals, but this advantage vanished in the urgent population, supporting our contention that the obesity paradox may be an artifact of patient selection.

Our study has limitations that warrant mention. First, our cohorts of nonurgent and urgent hip surgery patients consisted of heterogeneous groups of surgical procedures, meaning that the two groups were not directly comparable; this was intentional and consistent with our objective of evaluating the relationship between obesity and surgical complications in the nonurgent and urgent hip surgery populations. Comparing the urgent and nonurgent hip surgery cohorts was not the focus of our analysis. Second, although we adjusted for a wealth of elements, we cannot rule out residual confounding in our exploration of the association between BMI and surgical complications. For instance, we did not have waist circumference or cholesterol levels to take into account waist-to-hip ratio or metabolic syndrome as markers for obesity or markers of malnutrition [14, 27]. Third, we are also limited by the data elements available. For instance, complication occurrences are documented for 30 days after surgery and we are unable to comment on complications beyond this timeframe. Fourth, although the NSQIP is a rigorously evaluated registry with data obtained from chart abstraction, coding errors can potentially occur. We are also limited to the hospitals that voluntarily participate in the registry. However, protocols are in place to ensure complete or randomized patients. Lastly, given the retrospective observational nature of the study, we are limited to drawing associations for the observed findings. It would be important to verify these results in a prospective future study.

First, we found that for patients undergoing nonurgent hip surgery, which mostly consisted of preplanned hip arthroplasty for osteoarthritis, patients who are morbidly obese (BMI > 40 kg/m^2) had lower 30-day mortality after surgery than normal-weight patients, consistent with previous reports of an "obesity paradox" [4, 42]. However, the paradox was not observed for urgent hip surgery. In fact, we found that patients who are morbidly obese have similar mortality compared with normal-weight patients undergoing urgent hip surgery. The disappearance of the survival advantage in patients who are morbidly obese in urgent surgery suggests that selection bias in nonurgent hip surgery (ie, selecting only the healthiest patients who are morbidly obese for nonurgent surgery) may be partially responsible for the obesity paradox reported in the literature. Patients who are overweight (BMI 25–29.9 kg/m^2) or obese (30–39.9 kg/m^2) have reduced mortality in both urgent and preplanned settings compared with normal-weight patients. This may be secondary to BMI being an imperfect marker for obesity; patients with above average BMIs may not reflect true clinical obesity [7, 27, 31].

We also found that the relationship between BMI and surgical complications differed across different types of surgical complications. For example, patients who are obese were more likely to experience wound-related complications in both urgent and nonurgent patient cohorts. Alternatively, cardiac, respiratory, and thrombosis complications for patients who are morbidly obese were low in the nonurgent surgery setting but higher in the urgent setting. The higher incidence of wound complications for patients who are morbidly obese may be the result of the effect of obesity on impaired wound healing, which may be independent of other comorbid conditions [8, 40]. More vigilant postoperative wound care and monitoring may be warranted for patients who are obese to prevent wound complications. The likelihood of developing

Table 2. Adjusted odds ratios of postoperative complications in nonurgent and urgent hip surgeries from 2011 to 2014

Variable	BMI category (kg/m²)	Nonurgent Adjusted OR (95% CI)	Nonurgent p value	Adjusted OR (95% CI)	Urgent p value
30-day mortality after surgery	< 18.5	3.79 (1.10-9.97)	0.015	1.47 (1.23-1.75)	< 0.001
	18.5-24.9	Reference		Reference	
	25-29.9	0.59 (0.33-1.04)	0.069	0.68 (0.59-0.79)	< 0.001
	30-39.9	0.74 (0.44-1.29)	0.285	0.60 (0.48-0.73)	< 0.001
	> 40	0.12 (0.01-0.57)	0.038	1.18 (0.76-1.76)	0.534
Wound complications*	< 18.5	0.91 (0.22-2.45)	0.87	0.62 (0.38-0.96)	0.052
	18.5-24.9	Reference		Reference	
	25-29.9	1.49 (1.14-1.98)	0.005	1.21 (0.94-1.54)	0.091
	30-39.9	2.69 (2.09-3.51)	< 0.001	2.11 (1.63-2.73)	< 0.001
	> 40	4.93 (3.68-6.65)	< 0.001	4.85 (3.27-7.01)	< 0.001
Respiratory complications†	< 18.5	0.77 (0.04-3.61)	0.793	1.23 (0.90-1.66)	0.167
	18.5-24.9	Reference		Reference	
	25-29.9	0.61 (0.36-1.02)	0.057	1.00 (0.80-1.24)	0.357
	30-39.9	0.99 (0.64-1.58)	0.971	0.94 (0.70-1.24)	0.272
	> 40	0.26 (0.08-0.68)	0.013	1.16 (0.62-2.01)	0.16
Renal complications‡	< 18.5	0	0.966	0.91 (0.48-1.60)	0.713
	18.5-24.9	Reference		Reference	
	25-29.9	0.89 (0.44-1.92)	0.754	1.33 (0.96-1.85)	0.176
	30-39.9	1.32 (0.70-2.73)	0.416	1.70 (1.16-2.47)	0.174
	> 40	2.17 (1.00-4.89)	0.054	2.59 (1.22-4.92)	0.171
Infection§	< 18.5	1.52 (0.84-2.55)	0.137	1.13 (0.98-1.29)	0.135
	18.5-24.9	Reference		Reference	
	25-29.9	0.84 (0.70-1.01)	0.063	0.93 (0.85-1.03)	0.681
	30-39.9	1.05 (0.89-1.26)	0.547	0.95 (0.83-1.08)	0.663
	> 40	1.24 (0.96-1.58)	0.098	1.04 (0.77-1.38)	0.542
Central nervous system complications‖	< 18.5	2.87 (0.45-10.16)	0.162	1.03 (0.61-1.66)	0.36
	18.5-24.9	Reference		Reference	
	25-29.9	0.74 (0.38-1.47)	0.385	1.04 (0.73-1.47)	0.981
	30-39.9	1.02 (0.55-1.96)	0.944	0.93 (0.56-1.47)	0.606
	> 40	0.93 (0.30-2.45)	0.885	0.32 (0.02-1.45)	0.985
Cardiac complications¶	< 18.5	1.02 (0.17-3.31)	0.983	1.22 (0.91-1.60)	0.123
	18.5-24.9	Reference		Reference	
	25-29.9	0.78 (0.54-1.14)	0.189	0.88 (0.72-1.08)	0.77
	30-39.9	0.70 (0.48-1.03)	0.065	0.76 (0.57-1.01)	0.423
	> 40	0.38 (0.16-0.81)	0.02	1.14 (0.61-1.95)	0.123
Transfusion	< 18.5	1.37 (1.11-1.67)	0.003	1.13 (1.03-1.23)	0.062
	18.5-24.9	Reference		Reference	
	25-29.9	0.67 (0.63-0.71)	< 0.001	0.89 (0.83-0.94)	0.044
	30-39.9	0.50 (0.47-0.53)	< 0.001	0.84 (0.78-0.91)	0.023
	> 40	0.45 (0.40-0.49)	< 0.001	0.92 (0.77-1.10)	0.594
Thrombosis**	< 18.5	1.95 (0.75-4.16)	0.119	0.64 (0.43-0.93)	0.01
	18.5-24.9	Reference		Reference	
	25-29.9	0.99 (0.73-1.34)	0.935	1.27 (1.03-1.56)	0.004
	30-39.9	1.26 (0.95-1.69)	0.117	1.30 (1.00-1.67)	0.042
	> 40	0.98 (0.61-1.55)	0.941	1.64 (0.92-2.70)	0.187

Table 2. continued

Variable	BMI category (kg/m^2)	Nonurgent Adjusted OR (95% CI)	Nonurgent p value	Adjusted OR (95% CI)	Urgent p value
Composite††	< 18.5	1.35 (1.10-1.65)	0.003	1.16 (1.06-1.27)	0.021
	18.5-24.9	Reference		Reference	
	25-29.9	0.71 (0.67-0.75)	< 0.001	0.90 (0.85-0.96)	0.073
	30-39.9	0.60 (0.57-0.64)	< 0.001	0.87 (0.81-0.94)	0.057
	> 40	0.61 (0.56-0.67)	< 0.001	1.07 (0.91-1.27)	0.386

Multivariable logistic regression models adjusted for all patient-based variables in the National Surgical Quality Improvement Project surgical risk calculator [29].
*superficial, deep incisional, organ space infections, or wound disruption.
†unplanned intubation or failure to wean > 48 hours.
‡progressive renal insufficiency of acute renal failure requiring dialysis.
§pneumonia, urinary tract infection, sepsis, or septic shock.
||stroke, coma, or peripheral nerve injury.
¶myocardial infarction or cardiac arrest.
**pulmonary embolism or deep vein thrombosis.
††composite outcome of one or more of the previously mentioned complications; BMI = body mass index; OR = odds ratio; CI = confidence interval.

systemic infections such as urinary tract infection, pneumonia, and sepsis did not differ across BMI categories in preplanned and urgent settings. Other studies using the NSQIP data demonstrating reduced morbidity in overweight and obese I individuals [34, 37] have not examined the relationship accounting for surgical urgency.

Third, we found that underweight patients had an increased risk of mortality relative to normal-weight individuals in both the urgent and nonurgent cohorts. Underweight patients also have increased risk of needing transfusions. These findings are consistent with previous reports supporting an association between low weight and increased morbidity and mortality [13, 41], because researchers have suggested that underweight may be a marker of poor health above and beyond the standard comorbidities captured in clinical registries. The increased risk of complications and deaths among underweight individuals may represent an opportunity for preoperative optimization wherever possible such as smoking cessation, improving exercise tolerance [16, 43], and increased postoperative monitoring for underweight patients to reduce complications and mortality. We also observed that there were more overweight and patients with obesity in the nonurgent group, which mostly consisted of hip arthroplasty for osteoarthritic disease, as opposed to hip fractures seen in the urgent group. This was likely the result of a different mechanism of disease pathogenesis in which obesity increased the risk of osteoarthritis, whereas being normal and underweight predisposed patients to osteoporosis [12, 26].

We believe that our finding that the obesity paradox was present in nonurgent hip surgery but vanishes in the urgent population may be consistent with selection bias. Selection bias could take place either when clinicians choose not to offer surgery to patients who are obese or when patients who are obese choose not to pursue surgery. Data from cardiac surgery suggest that patients who are obese were not unduly reluctant to undergo surgery [28], implying that reduced rates of cardiac surgery in the obese patient may not be attributable to patient preference but rather provider attitudes and referral patterns [23]. Analogous research is needed to better characterize whether patients who are obese might be underrepresented in hip arthroplasty and, if so, why. One possible explanation is the increased risk of prosthetic joint infections associated with obesity [32], and our observed finding of increased wound infections is consistent with this possibility.

In summary, the finding that patients who are morbidly obese appear to have reduced 30-day mortality after nonurgent hip surgery, but not for urgent hip surgery, suggests that the obesity paradox may be an artifact of selection bias for healthier patients in the preplanned surgical setting. Surgeons and patients should not consider increased BMI to be associated with reduced risk of surgical complications when considering preplanned surgery.

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