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Morbidity and Mortality in the Thirty-Day Period Following Total Hip Arthroplasty: Risk Factors and Incidence

Philip J. Belmont Jr., MD [a], Gens P. Goodman, DO [a], William Hamilton, MD [b], Brian R. Waterman, MD [a], Julia O. Bader, PhD [c], Andrew J. Schoenfeld, MD, MSc [d]

[a] Department of Orthopaedic Surgery, William Beaumont Army Medical Center, Texas Tech University Health Sciences Center, El Paso, Texas
[b] Anderson Clinic, Alexandria, Virginia
[c] Statistical Consulting Laboratory, University of Texas at El Paso, El Paso, Texas
[d] Department of Orthopaedic Surgery, University of Michigan, Ann Arbor Veterans Administration Hospital, Ann Arbor, Michigan

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ABSTRACT

The study sought to ascertain the incidence rates and risk factors for 30-day post-operative complications after primary total hip arthroplasty (THA). Complications were categorized as systemic or local and subcategorized as major or minor. There were 17,640 individuals who received primary THA identified from the 2006-2011 ACS NSQIP. The mortality rate was 0.35% and complications occurred in 4.9%. Age groups ≥ 80 years ($P < 0.001$) and 70-79 years old ($P = 0.003$), and renal insufficiency ($P = 0.02$) best predicted mortality. Age ≥80 years ($P < 0.001$) and cardiac disease ($P = 0.01$) were the strongest predictors of developing any postoperative complication. Morbid obesity ($P < 0.001$) and operative time > 141 minutes ($P < 0.001$) were strongly associated with the development of major local complications.

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Total hip arthroplasty (THA) is one of the most frequent orthopedic surgical procedures performed in the United States, and the demand for THA has risen dramatically over the last two decades [1,2]. THA has been shown to markedly improve patient health-related quality of life and function and can greatly reduce direct costs attributed to arthritis compared to conservative management [3,4]. However, THA has also been associated with notable risks of mortality and multiple, short-term, perioperative complications. Modern medical care has increased life expectancy, particularly in patients with chronic, systemic disease, and this has contributed to a concordant rise in THA among patients with more extensive medical comorbidities [5,6]. While improvements in anesthesia and the surgical treatment of patients undergoing primary THA have been forged, these advances have been offset by diminishing health status among its patients.

At present, the orthopedic community's understanding of the influence of changing patient-based characteristics on outcomes following THA can be improved to better stratify those patient-based risk factors that increase mortality and complications. The majority of studies detailing post-operative mortality and morbidity after THA are either single institutional or regional reports [7–10] that have a limited capacity for generalization to individual surgeons and hospitals. Other studies conducted using registries are unable to examine patient-based and surgical characteristics that may have a robust impact on outcomes [6,11–15]. The present investigation details the influence of prospectively collected patient-based and surgical risk factors on the perioperative morbidity and mortality of over 17,000 primary unilateral THAs from a diverse national patient sample from across the United States. This study's purpose was to calculate incidence rates and quantify risk factors for 30-day post-operative mortality, complications and length of hospital stay in a cohort of patients derived from the National Surgical Quality Improvement Program (NSQIP).

Materials and Methods

This study received approvals from both our institutional review board and the American College of Surgeons NSQIP. Application was made to the NSQIP and the 2006–2011 national dataset was obtained. Previously utilized to evaluate common orthopedic surgical procedures [16,17], the NSQIP has been validated as a reliable and accurate prognostic tool, and its methodology has been carefully vetted with specific focus on case collection, dataset handling, and inter-rater reliability [16–19]. The NSQIP inter-rater reliability audits have reported agreement rates on variables approaching 98.6% [19]. Patients are prospectively entered in the NSQIP from over 480 academic and community United States hospitals and clinical outcomes are monitored for 30 days post-operatively, with all perioperative complications and

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Reprint requests: Andrew J. Schoenfeld, MD, MSc, Department of Orthopaedic Surgery, University of Michigan, Ann Arbor Veterans Administration Hospital, 2800 Plymouth Road, Building 10, RM G016, Ann Arbor, MI 48109.

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mortality recorded [20]. Those institutions involved in the NSQIP multispecialty model that entails reporting for joint arthroplasty must collect and submit 20% of their total orthopedic surgical caseload. Secondary surgeries performed within the 30-days post-operative window are carefully documented and screened but are not separately considered under new primary headings.

A search of the NSQIP was performed to identify all patients undergoing primary unilateral THA, as designated by Current Procedural Terminology (CPT) Code 27130. Patients with concomitant CPT codes at time of index surgery including bilateral THAs, staged THAs within 30 days, and/or hip resurfacing arthroplasty were excluded. Demographic variables and previous or current medical comorbidities were ascertained, and surgical data such as mode of anesthesia and total operative time were documented (Table 1). Presence and type of post-operative complications, mortality, and duration of hospital stay were also determined. As previously established in the literature [8–10], systemic and local complications were each classified as either major or minor within two discrete categories (Tables 2 and 3). Major systemic complications were deemed to require complex medical intervention while major local complications included deep wound infection, peripheral nerve injury, periprosthetic fracture and implant failure.

Table 1
Patient Demographic and Preoperative Characteristics.

Characteristic	Value	Patients for Whom Characteristic Was Determined, (N)
Age, y, mean ± SD	65.0 ± 12.4	17,640
59 or less, N (%)	5672 (32.2)	-
60–69, N (%)	5483 (31.1)	-
70–79, N (%)	4174 (23.7)	-
80 or greater, N (%)	2311 (13.1)	-
Sex, N (%)	-	17,561
Male, N (%)	7777 (44.3)	-
Female, N (%)	9784 (55.7)	-
Body mass index, kg/m^2 mean ± SD	29.8 ± 6.5	17,514
BMI ≤29.9, N (%)	10,107 (57.7)	-
30.0–39.9, N (%)	6187 (35.3)	-
≥40.0, N (%)	1220 (7.0)	-
Operative time, min, mean ± SD	97.6 ± 42.9	17,638
≤141 minutes	15,467 (87.7)	
>141 minutes	2171 (12.3)	
ASA classification, N (%)	-	17,628
1–2 – No or mild disturbance, N (%)	10,018 (56.8)	-
3–4 – Severe or life Threatening disturbance, N (%)	7610 (43.2)	-
Medical co-morbidities, N (%)	-	
Diabetes	1993 (11.3)	-
Smoking (current smoker within one year)	2460 (13.9)	-
Regular alcohol use[a]	423 (3.7)	-
Chronic obstructive pulmonary disease	769 (4.4)	-
Cardiac issues (congestive heart failure/myocardial infarction) [b]	73 (0.4)	-
Hypertension	10,299 (58.4)	-
Peripheral vascular disease	96 (0.5)	-
Renal insufficiency	54 (0.3)	-
Steroid use	600 (3.4)	-
Prealbumin ≤3.5	701 (8.6)	-
Type of anesthesia	-	17,640
General	10,457 (59.3)	-
Spinal/epidural	6435 (36.5)	-
Other	748 (4.2)	-

[a] EtOH more than two drinks per day in the 2 weeks before admission.
[b] Congestive heart failure (CHF) within 30 days before surgery/chronic CHF with new signs or symptoms in 30 days before surgery; history of MI within past 6 months before surgery. ASA, American Society of Anesthesiologists.

Table 2
Total Number (N) of Major/Minor Systemic Complications and Major/Minor Local Complications.

Characteristic	N (%)
Major systemic complications	
Pulmonary embolism	55 (0.31%)
Other systemic complication	52 (0.29%)
Postoperative sepsis	83 (0.47%)
Septic shock	21 (0.12%)
Cerebrovascular accident	30 (0.17%)
Acute renal failure	12 (0.07%)
Cardiac arrest requiring CPR[a]	21 (0.12%)
Myocardial infarction	43 (0.24%)
Minor systemic complications	
Urinary tract infection	255 (1.45%)
Deep venous thrombosis	89 (0.51%)
Pneumonia	74 (0.42%)
Renal insufficiency	25 (0.14%)
Major local complications	
Deep wound infection	90 (0.51%)
Peripheral nerve injury	19 (0.11%)
Perioperative fracture	22 (0.12%)
Graft/prosthesis failure	12 (0.07%)
Minor local complications	
Superficial wound infection	146 (0.83%)
Wound dehiscence	25 (0.14%)

[a] Cardiopulmonary resuscitation (CPR).

Univariate linear and logistic regression was performed to evaluate the association of itemized patient- and surgery-based risk factors with the following selected endpoints: patient mortality, presence of one or more complications, development of a major and/or minor systemic or local complication, and duration of hospital stay. Specifically, age (binned as <60, 60–69, 70–79 and ≥80 years-old), sex, BMI (≤29.9, 30.0–39.9, and ≥40 kg/m^2), American Society of Anesthesiologists (ASA) classification (ASA 1 or 2 compared to 3 or 4), mode of anesthesia, and presence of diabetes or cardiac disease were among considered patient-based risk factors. The presence of cardiac disease was defined as congestive heart failure within thirty days before surgery, congestive heart failure with new signs or symptoms within 30 days before surgery, or a history of myocardial infarction within six months before surgery. Renal insufficiency was classified as a pre-operative serum creatinine >2.0. Total surgical time was the sole surgical characteristic considered in this analysis. Risk factors with $P < 0.2$ after initial univariate/chi-square analysis were carried forward into multivariate logistic regression analysis to independently assess for the effect of given risk factors on the aforementioned clinical endpoints. Risk was quantified utilizing odds ratios (OR) and 95% confidence intervals (CI) during both univariate and multivariate tests. For the purposes of this study, a *P*-value of less than 0.05 and 95% CI excluding of 1.0 after multivariate testing were required to identify a statistically significant, independent risk factor.

Table 3
30-Day Mortality, Any Complication, Major/Minor Systemic Complication and Major/Minor Local Complication Rates by Individual Patient (N).

Characteristic	Value	
	N	%
Mortality	61	0.35%
Any complication	867	4.9%
Major systemic	261	1.5%
Minor systemic	424	2.4%
Major local	143	0.8%
Minor local	169	1.0%
Mortality or major complication	414	2.35%

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Results

From 2006 to 2011, 17,640 patients who underwent primary unilateral THA were identified in the NSQIP database. The mean age of patients was 65.0 (±12.4) years. The majority of patients were non-smoking (86.1%) and female (55.7%), and it is noteworthy that 7.0% were morbidly obese (BMI ≥40) (Table 1). Among the cohort, 43% were designated as American Society of Anesthesiologists (ASA) class 3 or higher. The most common medical comorbidities were hypertension (58.4%) and diabetes mellitus (11.3%) (Table 1). Mean surgical time was 97.6 (±43) minutes. Statistical analyses were performed comparing surgical times that exceeded the mean by one standard deviation (141 minutes) and those that were finished in less than 141 minutes. Seventy-two percent of patients had a length of stay ≤3 days. Postoperatively, 68% of patients were discharged to home while 31% were transferred to a rehabilitation or skilled care facility.

There was a 0.35% 30-day mortality rate. During this same perioperative period, 1074 complications were recorded in 867 (4.9%) patients (Table 2). There were 317 major systemic complications in 261 individuals (1.5%) and 443 minor systemic complications in 424 (2.4%) patients. When examining major systemic complications, the most common were cardiovascular (38%) and septic (33%) in source. The most common minor systemic complications were urinary tract infection (1.45%) and deep venous thrombosis (0.51%). There were 143 major local (0.8%) and 169 minor local (1.0%) complications in 143 and 169 patients, respectively (Table 3). The major local complications consisted of deep wound infection (0.51%), perioperative fracture needing surgical treatment (0.12%) and peripheral nerve injury (0.11%). Minor local complications included both superficial wound infection (0.83%) and wound dehiscence (0.14%). There were a total of 84 complications other than mortality in 39 (64%) of the 61 patients who died. The most frequent complications among those who died were unplanned intubation [n = 18 (30%)], cardiac arrest [n = 16 (26%)], and pneumonia [n = 10 (16%)]. In the first 30 days following primary THA, 2.35% of patients (N = 414) either died or experienced a major complication.

Univariate analysis identified multiple risk factors for mortality, any complication, major systemic complication, minor systemic complication, major local complication, minor local complication, and length of stay ≥4 days that were then analyzed in multivariate testing (Table 4). Significant independent predictors of mortality maintaining odds ratios exceeding 2.0 were age ≥80 (OR 19.80, 95% CI 5.89, 66.51), age ≥70–79 (OR 7.94, 95% CI 2.33, 27.00), renal insufficiency (OR: 5.79; 95% CI: 1.20, 27.90), cardiac disease (OR: 3.75; 95% CI: 1.05, 13.39) and ASA classification ≥3 (OR: 2.93; 95% CI: 1.44, 5.98, Table 5). Age ≥80 years, cardiac disease, operative time >141 minutes, ASA classification ≥3, chronic obstructive pulmonary disease and diabetes were important predictors of developing any postoperative complication, as well as a major systemic complication. Morbid obesity (BMI ≥40) (OR: 2.62, 95% CI: 1.62, 4.22) and operative time >141 minutes (OR: 2.40, 95% CI: 1.64, 3.50) were the most powerful predictors for developing a major local complication. The most important factors associated with minor local complications, in descending order of magnitude, were BMI ≥40, chronic obstructive pulmonary disease, operative time >141 minutes and diabetes. Age ≥60 years, male sex, operative time >141 minutes, ASA classification ≥3, diabetes mellitus, COPD, cardiac disease, renal insufficiency, steroid use and general anesthesia were significant risk factors for length of stay ≥4 days (Table 5).

Table 4
Results of Univariate/Chi-Square Analyses for the Influence of Risk Factors on Mortality, Any Complication, Major/Minor Systemic Complications, Minor Local Complications and Length of Stay.

	Mortality	Any Complication	Major Systemic Complication	Minor Systemic Complication	Major Local Complication	Minor Local Complication	Length of Stay
Risk Factor	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age (years)	1.12 (1.09, 1.16)	1.03 (1.02, 1.04)	1.04 (1.03, 1.05)	1.05 (1.04, 1.06)	1.00 (0.99, 1.02)	1.01 (0.99, 1.02)	1.030 (1.027, 1.033)
60–69 vs 59 or less	1.4 (0.3, 6.2)	1.1 (0.9, 1.4)	1.3 (0.9, 1.8)	1.5 (1.1, 2.0)	0.9 (0.6, 1.4)	0.8 (0.5, 1.2)	1.1 (1.001, 1.2)
70–79 vs 59 or less	10.0 (3.0, 33.5)	1.7 (1.4, 2.0)	2.2 (1.5, 3.1)	2.8 (2.1, 3.7)	0.8 (0.5, 1.3)	1.1 (0.7, 1.6)	1.8 (1.6, 1.9)
80 or greater vs 59 or less	26.5 (8.1, 86.7)	2.7 (2.2, 3.3)	3.3 (2.3, 4.8)	4.4 (3.2, 5.9)	1.3 (0.8, 2.1)	1.2 (0.8, 1.9)	3.0 (2.7, 3.3)
Sex							
Male vs female	1.6 (0.96, 2.6)	0.8 (0.7, 0.96)	1.3 (1.04, 1.7)	0.7 (0.6,0.9)	0.8 (0.6, 1.1)	0.8 (0.6, 1.1)	0.77 (0.72, 0.82)
Body mass index, kg/m^2 mean	0.93 (0.88, 0.96)	1.03 (1.02, 1.04)	1.015 (0.997, 1.033)	1.00 (0.99, 1.02)	1.05 (1.03, 1.07)	1.06 (1.04, 1.08)	1.001 (0.996, 1.006)
30.0–39.9 vs BMI <30	0.7 (0.4, 1.2)	1.4 (1.2, 1.6)	1.4 (1.1, 1.8)	1.2 (0.97, 1.5)	1.3 (0.9, 1.9)	2.0 (1.4, 2.8)	1.0 (0.9, 1.05)
≥40.0 vs BMI <30	0.4 (0.1, 1.9)	1.7 (1.4, 2.2)	1.2 (0.7, 1.9)	0.9 (0.6, 1.4)	3.6 (2.3, 5.6)	3.9 (2.5, 6.2)	1.2 (1.04, 1.3)
Operative time, min, mean ± SD							
>1 standard deviation above mean	1.6 (0.8, 3.0)	1.7 (1.4, 2.0)	2.3 (1.7. 3.0)	1.2 (0.9, 1.6)	2.7 (1.9, 3.9)	2.0 (1.4, 2.9)	1.7 (1.6, 1.9)
ASA classification							
≥3 (severe or life threatening disturbance) vs ≤2 (no or mild disturbance)	6.8 (3.4, 13.3)	2.3 (2.0, 2.6)	3.0 (2.3, 3.9)	2.6 (2.2, 3.2)	1.9 (1.3, 2.6)	1.5 (1.1, 2.1)	2.1 (2.0, 2.3)
Medical co-morbidities							
Diabetes	2.6 (1.4, 4.6)	1.9 (1.6, 2.3)	2.4 (1.8, 3.2)	2.0 (1.5, 2.5)	1.6 (1.02, 2.5)	2.1 (1.4, 3.0)	1.6 (1.5, 1.8)
Smoking (current smoker within one year)	0.7 (0.3, 1.6)	1.0 (0.8, 1.2)	1.1 (0.7, 1.5)	0.7 (0.5, 1.0)	1.4 (0.9, 2.2)	1.0 (0.6, 1.5)	0.9 (0.8, 1.01)
Regular alcohol use	1.2 (0.3, 5.1)	1.1 (0.8, 1.7)	1.3 (0.6, 2.6)	1.0 (0.5, 1.8)	0.8 (0.2, 2.4)	1.0 (0.4, 2.8)	0.9 (0.7, 1.1)
COPD	2.4 (1.03, 5.6)	2.3 (1.8, 2.9)	2.4 (1.6, 3.6)	2.4 (1.7, 3.4)	1.3 (0.6, 2.7)	2.3 (1.4, 3.9)	1.8 (1.6, 2.1)
Cardiac issues (congestive heart failure/myocardial infarction)	12.9 (4.0, 42.3)	3.8 (2.1, 7.2)	7.2 (3.3, 15.9)	3.7 (1.6, 8.5)	1.7 (0.2, 12.3)	2.9 (0.7, 12.1)	2.9 (1.8, 4.6)
Hypertension	3.6 (1.9, 7.2)	1.7 (1.5, 2.0)	1.9 (1.4, 2.5)	2.0 (1.6, 2.5)	1.3 (0.9, 1.9)	1.7 (1.2, 2.4)	1.5 (1.4, 1.6)
Peripheral vascular disease	3.1 (0.4, 22.4)	2.0 (1.01, 4.0)	1.4 (0.3, 5.8)	2.2 (0.9, 5.6)	2.6 (0.6, 10.8)	1.1 (0.2, 7.9)	1.8 (1.2, 2.7)
Renal insufficiency	11.4 (2.7, 48.0)	2.4 (1.04, 5.7)	6.9 (2.7, 17.5)	1.6 (0.4, 6.4)	1.1 (0.1, 18.6)	0.9 (0.1, 15.7)	7.5 (4.1, 13.8)
Steroid use	3.1 (1.3, 7.3)	1.9 (1.4, 2.6)	1.1 (0.6, 2.1)	2.6 (1.8, 3.7)	1.0 (0.4, 2.5)	1.4 (0.7, 2.9)	1.6 (1.4, 1.9)
Prealbumin (≤3.5 g/dL vs > 3.5 g/dL)	8.9 (4.4, 18.2)	2.4 (1.8, 3.1)	2.9 (1.9, 4.4)	2.0 (1.3, 2.9)	2.9 (1.5, 5.3)	2.5 (1.4, 4.3)	2.8 (2.4, 3.2)
Type of anesthesia							
General vs spinal/epidural	1.3 (0.8, 2.3)	1.2 (1.03, 1.4)	1.5 (1.1, 2.0)	1.1 (0.9, 1.4)	1.4 (0.99, 2.05)	0.8 (0.6, 1.1)	1.2 (1.1, 1.3)

ASA, American Society of Anesthesiologists; BMI, body mass index; MI, myocardial infarction; CHF, congestive heart failure; OR, odds ratio.

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Table 5
Significant Risk Factors for Mortality, Any Complication, Major and Minor Systemic Complications, Minor Local Complications and Length of Stay as Determined by Multivariate Logistic Regression Analysis.

Dependent Variable	Risk Factor	*P*-Value	OR (95% CI)
Mortality	Age 70–79 versus ≤59	0.003	7.94 (2.33, 27.00)
	Age ≥80 versus ≤59	<0.0001	19.80 (5.89, 66.51)
	Male	0.01	1.89 (1.13, 3.18)
	ASA classification ≥3	0.003	2.93 (1.44, 5.98)
	Cardiac disease	0.04	3.75 (1.05, 13.39)
	Renal insufficiency	0.02	5.79 (1.20, 27.90)
Any complication	Age ≥80 versus ≤59	<0.0001	2.38 (1.89, 2.99)
	Male	0.04	0.86 (0.74, 0.99)
	BMI ≥40.0 versus ≤29.9	0.009	1.62 (1.25, 2.10)
	Operative time >141 min	<0.0001	1.65 (1.38, 1.99)
	ASA classification ≥3	<0.0001	1.55 (1.32, 1.81)
	Diabetes	0.0004	1.41 (1.16, 1.70)
	COPD	<0.0001	1.7 (1.31, 2.20)
	Cardiac disease	0.01	2.31 (1.21, 4.40)
	Steroid use	0.01	1.45 (1.06, 1.97)
Major systemic complication	Age ≥80 versus ≤59	<0.0001	2.90 (1.92, 4.38)
	Male	0.01	1.37 (1.06, 1.77)
	Operative time >141 min	<0.0001	2.26 (1.68, 3.05)
	ASA classification ≥3	<0.0001	1.97 (1.47, 2.65)
	Diabetes	0.002	1.62 (1.18, 2.21)
	COPD	0.01	1.71 (1.11, 2.63)
	Cardiac disease	0.002	3.52 (1.55, 8.00)
Minor systemic complication	Age 70–79 versus ≤59	0.003	2.15 (1.57, 2.95)
	Age ≥80 versus ≤59	<0.0001	3.04 (2.16, 4.30)
	Male	0.007	0.75 (0.61, 0.92)
	ASA classification ≥3	<0.0001	1.77 (1.41, 2.23)
	Steroid use	0.0008	1.90 (1.30, 2.78)
Major local complication	BMI ≥40.0 versus ≤29.9	<0.0001	2.62 (1.62, 4.22)
	Operative time >141 min	<0.0001	2.40 (1.64, 3.50)
	ASA classification ≥3	0.01	1.54 (1.07, 2.22)
Minor local complication	Male	0.04	0.72 (0.52, 0.99)
	BMI ≥40.0 versus ≤29.9	<0.0001	3.13 (1.96, 5.00)
	Operative time >141 min	0.001	1.84 (1.26, 2.68)
	Diabetes	0.03	1.54 (1.03, 2.29)
	COPD	0.01	2.02 (1.16, 3.50)
Length of stay	Age 70–79 versus ≤59	0.001	1.58 (1.42, 1.75)
	Age ≥80 versus ≤59	<0.0001	2.51 (2.23, 2.83)
	Male	<0.0001	0.79 (0.74, 0.85)
	Operative time >141 min	<0.0001	1.81 (1.64, 2.00)
	ASA classification ≥3	<0.0001	1.62 (1.50, 1.75)
	Diabetes	<0.0001	1.30 (1.17, 1.45)
	COPD	<0.0001	1.38 (1.18, 1.61)
	Cardiac disease	0.04	1.64 (1.01, 2.68)
	Renal insufficiency	<0.0001	6.13 (3.22, 11.67)
	General anesthesia	<0.0001	1.17 (1.10, 1.26)
	Steroid use	0.03	1.22 (1.02, 1.45)

OR, odds ratio; BMI, body mass index; ASA, American Society of Anesthesiologists.

Discussion

The improvement of THA quality of care through the identification of modifiable patient-based and surgical characteristics remains a continuing priority [21]. This is especially important as THA is performed more frequently in patients with substantial co-morbidities, longer life expectancy, and greater prevalence of obesity [6,12]. In the United States, diabetes affects 27% of individuals 65 years or older [22], while the prevalence of obesity [body mass index (BMI) ≥30] is currently 34.3% and that of morbid obesity (BMI ≥40) has increased 428% in the last three decades to 6.0% [23]. Though it is continually debated, there is evidence to support an association between obesity and an increased prevalence of hip osteoarthritis [24–27]. Obese individuals with hip osteoarthritis have more pain, worse function, lower health-related quality of life and greater disease severity [24]. As the prevalence of obesity continues to escalate, the proportion of obese patients undergoing THA will also rise [6,28]. The prevalence of ASA 3/4 classification (43.2%) and BMI ≥30 (42.3%) in the present work was comparable to recent prospectively collected datasets which have specified medical co-morbidities within THA populations, although the prevalence of diabetes mellitus (11.3%) was slightly higher [29–32]. These investigations have reported prevalence rates of diabetes (8.6%–9.4%) [29–31], ASA 3/4 classification (38%–52%) [28,29], and BMI ≥30 (36%–42.8%) [31,32].

Likewise, the 0.35% 30-day mortality rate is comparable to previous reports that include both unilateral and bilateral THAs (0.29%–1.0%) [28,12,14,33]. A study of the joint registry of Australia and Norway on primary total knee and hip arthroplasties found early postoperative mortality was increased for the first twenty-six days (95% confidence interval, 21–46 days) [34]. Additionally, patients in each age group to include 50–60; 61–70 and 71–80 who had a primary total knee or hip arthroplasty had excess mortality that was highest in the first ten postoperatively, low from day 11 to day 20, and almost negligible from day 21 to 30 [34]. In a review of 6272 primary THA, Aynardi et al [35] found the 30 day postoperative mortality was 0.13%, and the risk extended to the 90 day period at 0.41%. Our study found that age ≥80, age 70–79, renal insufficiency, cardiac disease, ASA classification ≥3 and male sex were important predictors of mortality (Table 5). Prior efforts maintained that age ≥70 was the most important predictor of 30-day mortality following THA [33,36]. In the current study, cardiovascular complications were the most frequent cause of death, and multivariate analysis identified elevated 30-day mortality rates in patients with a history of coexistent disease similar in scope to the work of Aynardi and Jacovides et al [7]. These results underscore the necessity of careful preoperative evaluation and optimization in patients ≥70 years old with significant medical co-morbidities, and specifically renal and cardiac conditions, in order to mitigate perioperative mortality.

This study analyzed prospectively gathered data from over 17,000 patients and is three times larger in scale than the previously largest investigation evaluating risks of prolonged surgical times and BMI on complications following primary THA [10]. Comparisons with previous reports of systemic and local complication rates evaluating BMI as a risk factor, are limited by the following: inclusion of both primary and revision arthroplasty procedures, differences in the duration of follow-up, variable classifications of major or minor complications and that incidence is reported by rates of complication rather than individual patient, which fails to account for patients with multiple complications [9,10,32]. The 30-day post-operative complication rate for primary THA patients was 4.9% and provides a benchmark utilizing this complication classification system (Table 3). Increased age and history of coexistent diseases have been cited as risks for postoperative complications in studies detailing major/minor systemic and local complication rates for hip and knee arthroplasty procedures [8,9]. The elevated risk of increased age [8,9] on the development of postoperative complications in primary THA has been reported. Additionally, the potential elevated risk of perioperative complications associated with increasing BMI after primary THA is of considerable concern [1,37]. Even though BMI does not predict adiposity directly, it is strongly correlated with the percentage of body fat within sex and age groups [38].

In the current study, increased THA surgical time of >141 minutes significantly increased the chance of any complication, of major systemic complication and of major/minor local complication. To address the increased surgical demand and resource utilization, surgeons might strive to decrease operative times in order to increase volume [39]. There may also be a corresponding physiologic benefit to expedited procedures as well as improvements in THA implant survivorship and decreased venous thromboembolism rates [40,41].

Primary unilateral THA patients had major and minor systemic complication rates of 1.5% and 2.4%, respectively (Table 3). Postoperative sepsis/septic shock (0.59%), myocardial infarction/cardiac arrest requiring cardiac pulmonary resuscitation (0.36%), and pulmonary embolism (0.31%) were the most common major systemic complications. Previous studies of THA patients have reported slightly higher four to six-week rates of acute myocardial infarction (0.5%–0.9%)

and pulmonary embolism (0.8%) than those encountered presently [28,42]. However, the current study corroborates recent findings that postoperative sepsis following primary THA is a common complication and is significantly increasing in Medicare beneficiaries [6].

Multivariate analysis established that cardiac disease, age ≥80 years, operative time >141 minutes, ASA classification ≥3, COPD, diabetes and male sex were significant risk factors for developing major systemic complications (Table 5). These results confirm previous single center reports that lower extremity arthroplasty cases with increased age and preexistent co-morbidities increase the risk of sustaining a major systemic complication when examining all cases of lower extremity arthroplasty. However, no previous investigation has identified prolonged surgical time, COPD, diabetes, and/or male sex as significant risk factors and these remain novel contributions from this study.

Major and minor local complications occurred in 0.8% and 1.0% of patients, respectively (Table 3). The most common major local complications were deep wound infection (0.51%), perioperative fracture necessitating surgical treatment (0.12%), and peripheral nerve injury (0.11%), while the most common minor local complications were superficial wound infection and wound dehiscence. A single, high-volume institution reported comparable in-hospital complication rates for periprosthetic fracture and peripheral nerve injury [10]. Multivariate analyses determined that patients with BMI ≥40 (OR: 2.62, 95% CI: 1.62, 4.22) had the greatest risk for developing one or more major local complications, and that operative time >141 minutes and ASA classification ≥3 were also significant predictors (Table 5). In addition to these predictor variables, COPD, diabetes and female sex also significantly elevated risk for developing minor local complications (Table 5).

The 30-day periprosthetic hip infection rate of 0.51% and superficial wound infection rate of 0.83% are of considerable importance because they are three times greater in frequency than the next most common major or minor complication. Also, these complications may lead to the need for revision total hip arthroplasty, thereby imposing potentially greater perioperative mortality/morbidity and decreased patient functional outcomes and a higher financial burden on the healthcare system [1,36,43,44]. A report on periprosthetic THA infection using Medicare claims implicated obesity as a risk factor but was hindered by underreporting of this diagnosis in only 4% of patients and the inability to utilize BMI data [11]. A BMI ≥40 in THA patients has been significantly associated with prolonged wound drainage, and subsequently an increased rate of wound infection of 42% with each day of prolonged drainage [45]. The current investigation's results and the burgeoning obesity epidemic highlight the need to evaluate medical and surgical treatments for weight loss, especially in patients with a BMI ≥40 considering THA.

Additionally, multivariate analysis accounting for BMI and other variables revealed that operative times >141 minutes were found to significantly increase risk of both major and minor local complications. THA procedure duration may reflect the level of surgical experience, availability of surgical assistance, or case complexity, but this finding highlights the importance of maximizing surgical efficiency in the operating room in order to improve outcomes.

The current study found 72% of all patients had a length of stay of ≤3 days, commensurate with trends previously reported in the literature [6]. Longer operative times, higher ASA co-morbidity ratings, diabetes mellitus, COPD, and increased age have all been previously reported to increase length of hospital stay after THA [29].

Limitations of the current study include that several potential variables such as the severity of individual case complexity, the extent of/management for perioperative hyperglycemia, type of deep venous thrombosis chemoprophylaxis, surgeon experience and hospital volume were not included in the NSQIP dataset and subsequently cannot be controlled. These aforementioned factors have been proposed to influence the risk of complications among THA patients and would have been useful in this analysis. The reliance on data derived from a 20% sample of surgical caseload at the hospital-level may also create the potential for miscoding, errors in reporting, or underreporting that could adversely impact our findings, although we seek to emphasize that the NSQIP maintains strict training and auditing procedures intended to mitigate this possibility [17]. Additionally, because this study was not conducted in a prospective cohort with strict indications and definitions of specific complications, we cannot rule out the possibilities of sample selection bias and information bias. Furthermore, we recognize that some variables such as operative time had to be dichotomized for the purposes of statistical testing even though, in clinical practice, such factors exist on a continuum. As a result, conclusions regarding operative time cannot be adjusted for case complexity, surgical approach or surgeon experience and this may impede immediate translation to clinical practice. Lastly, although our overall rates of post-operative morbidity, including major/minor systemic and major/minor local complications are important, these results do not extend beyond the 30-day post-operative period. Therefore, the effect of risk factors on the rate of mid-term and long-term patient complications cannot be ascertained.

In this study, among 17,640 patients treated with primary unilateral THA, 30-day post-operative mortality was documented in 0.35% and complications occurred in 4.9%. This effort identified age ≥70, renal insufficiency, cardiac disease, ASA classification ≥3, and male sex as significant predictors for mortality following such surgery. Age ≥80 years, ASA classification ≥3 and cardiac disease were predictors of developing any postoperative complication, as well as major systemic complications. BMI ≥40 and operative time >141 minutes demonstrated some of the more robust associations with major or minor local complications. This work establishes individual patient-based risk factors to quantify perioperative morbidity and mortality rates after THA and may better inform preoperative surgical counseling. The present effort also elucidates risk factors that warrant heightened medical management in the perioperative period, thereby reducing complication risk and improving outcomes.

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