Preoperative Risk Factors for, and Incidence of Delayed Surgery in Elective Primary Total Knee Arthroplasty After Hospital Admission: The ACS-NSQIP

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A B S T R A C T

Background: Approximately 600,000 total knee arthroplasties (TKA) are performed every year in the United States and the number of procedures has increased substantially every year. These demands may further strain the government, insurers, and patients struggling with increasing healthcare spending. A delay in proceeding to surgery after hospital admission may affect the overall healthcare costs. To our knowledge, the current literature has not addressed the incidence of, and preoperative risk factors for, a surgical delay in TKA.
Methods: The ACS-NSQIP 2011 database was reviewed to identify patients undergoing elective primary total knee arthroplasty (TKA) using the Current Procedural Terminology (CPT) code 27447. 14,881 cases were no delay in proceeding to surgery after hospital admission while 139 cases were delayed for TKA. Risk factors or comorbidities contributing to surgical delay in TKA were identified. A univariate analysis of all patient parameters was conducted to measure the difference between the two cohorts. Finally, a multivariate logistic regression analysis was then conducted to identify risk factors or comorbidities for surgical delay.
Results: There were 139 cases of surgical delay in TKA (0.93%). Congestive heart failure (P = 0.017), bleeding disorder (P <0.0001), sepsis (P <0.0001), a prior operation in the past 30 days (P <0.0001), dependent functional status (P <0.0001), ASA class 3 (P = 0.046), and hematocrit <38% (P <0.0001) were independent risk factors for a surgical delay. Postoperative medical complication (2.2% vs 0.8%, P < 0.0001) in surgical delay was significantly higher than non-delayed cohort.
Conclusion: The optimization of preoperative modifiable risk factors appears to be one of the best strategies to reduce delayed surgery and therefore costs in TKA.

Approximately 600,000 total knee arthroplasties (TKAs) are performed every year in the United States [1–3] and the number of procedures has increased substantially every year between 1991 and 2013. TKA has been shown to markedly reduce pain, improving patients' functional status and their quality of life. The demand for primary TKA will reportedly grow to 3.48 million procedures per year by 2030 [2]. These demands may further strain the government, insurers, and patients struggling with increasing healthcare spending. It has been shown that hospital stay, operating room time, and supplies (medical and operative) account for the largest percentage of hospital expenses for TKA [4]. For this reason, many hospitals have applied a fast track protocol for TKA in

order to reduce the length of hospital stay [5]. Cram et al [1] reported that the length of hospital stay markedly declined from 7.9 days in 1991–1994 to 3.5 days in 2007–2010. Recent evidence from the National Inpatient Sample (NIS) Database of 2009 has shown that mean hospital costs and length of stay for TKA were 14,491 USD and 3.3 days, respectively [3]. Smith et al [6] identified pre-operative predictors that could forecast the length of hospitalization in total knee arthroplasty, and Dall et al [7] reported the influence of pre-operative factors on length of inpatient stay following primary total hip arthroplasty for osteoarthritis. In addition, recent studies have shown that patients' co-morbidities and in-hospital-complications after TKA directly affect overall hospital expenses [3,8]. Although several good strategies can be applied to reduce cost in TKA surgery [9–12], certain factors (age, sex, comorbidities) are not modifiable.

A delay in proceeding to surgery after hospital admission may affect the overall healthcare costs. To our knowledge, the current literature has not addressed the incidence of, and preoperative risk factors for, a surgical delay in TKA.

Table 1
Univariate Analysis of Patients Demographic Characteristics and Delay Surgery in Elective TKA.

Demographics	No Delayed Surgery (n = 14,881)	Delayed Surgery (n = 139)	P-Value
Age (years) (mean, SD)	67.29 (10.16)	70.06 (11.01)	**0.0014**
Gender female (%)	64.52	63.04	0.7186
Race			**0.0056**
Black (%)	6.58	7.25	
White (%)	79.57	69.57	
Other (%): Hispanic, Asia, etc.	13.85	23.19	
BMI (kg/m^2)			0.1173
<30 (%)	38.19	46.21	
30–40 (%)	46.74	43.18	
>40 (%)	15.07	10.61	
Functional status			**<0.0001**
Dependent	3.68	13.67	
Independent	96.32	86.33	

A delay in surgery after patient admission for elective total knee arthroplasty may be an important modifiable factor affecting total length of hospital stay and overall hospital cost for TKA. The aim of our study was to use the NSQIP database to identify the incidence and risk factors for surgical delay in TKA after hospital admission.

Methods

The 2011 American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database was reviewed to identify patients undergoing elective primary total knee arthroplasty (TKA) using the Current Procedural Terminology (CPT) code 27447. Incidence and preoperative risk factors for delayed surgery in elective primary TKA after planned hospital admission data within NSQIP were identified from January 1, 2011 to December 31, 2011. All patients older than 18 years old who underwent elective primary TKA were included. Our survey of the database identified 15,020 patients with CPT code 27447 (TKA). In 14,881 cases there was no delay in proceeding to surgery after hospital admission and in 139 cases, the TKA surgery was delayed. Patient characteristics were identified within the NSQIP database. Around 300 reported variables were divided into five categories: demographic characteristics, preoperative comorbidities, preoperative laboratory values, operative variables, and 30-day complications. Notable demographic data included age, gender, race, and functional status (Table 1). Comorbidities were meticulously defined including body mass index (BMI), alcohol use, smoking, recent weight loss, dyspnea, chronic obstructive pulmonary disease (COPD), congestive heart failure, hypertension, diabetes mellitus, esophageal varices, peripheral vascular disease, disseminated cancer, sepsis, and others. Preoperative laboratory values included hematocrit (HCT), international normalized ratio (INR), creatinine (Cr), electrolytes, albumin, and others. Relevant operative variables included operative time, American Society of Anesthesiologists (ASA) class, and others. The ACS-NSQIP is a HIPAA compliant de-identified database. The University of Iowa (UI) IRB deemed this study exempt from board review. No external sources of funding were received for this study.

Statistical Analysis

All data were analyzed within two categories: delayed and non-delayed surgery. Risk factors or comorbidities contributing to surgical delay in TKA were identified. A univariate analysis of all patient parameters was conducted to measure the difference between the two cohorts. A standard Student's t-test was used for continuous variables while the chi-squared test was applied for categorical variables. To improve accuracy of the multivariate logistic model, the NSQIP variables were pre-selected from the univariate analysis. A standard P-value of <0.05 was used to define variables eligible for inclusion into the multivariate

Table 2
Univariate Analysis of Patients Comorbidities and Delay Surgery in Elective TKA.

Comorbidities	No Delayed Surgery (n = 14,881)	Delayed Surgery (n = 139)	P-Value
Current alcohol drinker (%)	2.14	1.44	0.7725
Current smoking (%)	8.60	2.88	0.0135
Hypertension (%)	70.08	71.22	0.770
Diabetes (%)	18.14	24.46	0.055
Dyspnea (%)	9.72	10.07	0.888
COPD (%)	3.74	1.44	0.252
CHF (%)	0.13	1.44	**0.017**
Recent weight loss (%)	0.22	0.00	1.000
Esophageal varices (%)	0.03	0.00	1.000
PVD (%)	0.60	0.72	0.572
Disseminated cancer (%)	0.19	0.72	0.237
Sepsis (%)	0.27	3.65	**<0.0001**
Steroid use (%)	2.50	2.16	1.000
Bleeding disorder (%)	2.57	12.23	**<0.0001**
Dialysis (%)	0.16	1.44	**0.024**
Prior major operation within 30 days (%)	0.17	13.67	**<0.0001**
Laboratory Values			
Mean (SD) pre-op sodium (mEq/L)	139.4 (±2.79)	138.6 (±2.96)	**0.0005**
Mean (SD) pre-op BUN (mg/dL)	18.47 (±7.35)	16.30 (±9.49)	**0.0230**
Mean (SD) pre-op WBC (cells/mm^3)	7.07 (±2.17)	7.55 (±2.51)	**0.0262**
Mean (SD) pre-op Hct (%)	40.21 (±4.16)	36.42 (±5.27)	**<0.0001**
Mean (SD) pre-op INR	1.04 (±0.29)	1.14 (±0.60)	0.109
Mean (SD) pre-op Cr (mg/dL)	0.94 (±0.44)	1.03 (±1.07)	0.440
Mean (SD) pre-op albumin (g/L)	4.09 (±0.41)	3.78 (±0.55)	**<0.0001**
ASA Class			**0.046**
1 or 2: no or mild disturbance (%)	50.13	39.57	
3: severe disturbance (%)	48.13	58.27	
4: life threatening disturbance (%)	1.75	2.16	

logistic analysis. Also, variables with chart completion rates of less than 80% were excluded to avoid model skewing. Finally, a multivariate logistic regression analysis with a dependent variable of surgical delay was then conducted to identify risk factors or comorbidities for surgical delay. Results were reported as odd ratios and 95% confidence intervals.

Results

According to the ACS NSQIP 2012 data, the average age for elective primary TKA was 67.3 years, with a higher prevalence of females than males (64.7% and 35.3%, respectively). Overall, the incidence of a delay in surgery after patient admission for elective TKA was 0.9%, while 99.1% had no delay in surgery past the scheduled date. The median surgical delay for TKA was 3.0 days (1–365 days). Older patients tended to have a delay to TKA more often than younger patients (patients older than 70 years were significantly more likely to experience a surgical delay than patients younger than 67.2 years, $P < 0.05$). Compared to Caucasian patients, patients from different ethnicities showed a significant association with delayed surgery ($P < 0.05$). Similarly, patients who depended on assistive devices tend to have delayed surgery (13.7% of patients who experienced a delay were dependent on assistive devices while only 3.7% of patients who had no delay were assistive-device dependent, $P < 0.0001$). BMI and sex were not found to be statistically significant factors for delayed surgery. The univariate analysis identified

Table 3
Risk Factors for Delayed Surgery in TKA as Defined by Multivariate Logistic Regression.

Risk Factors for Delayed Surgery in TKA	Adjusted Odds Ratio (95% Confidence Interval)
CHF	14.10 (2.95–67.48)
Sepsis	11.32 (3.82–33.50)
Bleeding disorder	6.17 (3.39–11.23)
Prior operation within 30 days	65.77 (28.57–151.40)
Pre-op Hct: <38% vs >38%	2.81 (1.81–4.36)
ASA class 3 vs 1 and 2	1.91 (1.17–3.12)
Functional status: dependent vs independence	3.39 (1.82–6.32)