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Original Article

Operative Time Affects Short-Term Complications in Total Joint Arthroplasty

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ABSTRACT

Background: Increased operative time has been associated with increased complications after total joint arthroplasty (TJA). The purpose of the present study was to investigate the effect of operative time on short-term complications after TJA while also identifying patient and operative factors associated with prolonged operative times.

Methods: The American College of Surgeons National Surgical Quality Improvement Program database was queried from 2011-2013 to identify all patients who underwent primary total hip or knee arthroplasty. Patients were stratified by operative time, and 30-day morbidity and mortality data compared using univariate and multivariable analyses.

Results: We identified 99,444 patients who underwent primary TJA. The overall incidence of complications after TJA was 4.9%. Overall complications were increased in patients with operative times >120 minutes (5.9%) as compared to patients with operative times <60 minutes or 60-120 minutes (4.6% and 4.8%, respectively; $P < .001$). Wound complications, including surgical site infection, were also increased for procedures lasting >120 minutes. In a multivariable analysis, operative time exceeding 120 minutes remained an independent predictor of any complication and wound complication, with each 30-minute increase in operative time beyond 120 minutes further increasing risk. Patient age ≤65 years, male sex, black race, body mass index ≥30 kg/m^2, and an American Society of Anesthesiologists classification of 3 or 4, predicted operative times >120 minutes.

Conclusion: We found that operative time >120 minutes was associated with increased short-term morbidity and mortality after primary TJA. Younger age, male sex, black race, obesity, and increased comorbidity were risk factors for operative time exceeding 120 minutes.

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Disclosure: The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

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Ethical Review Committee Statement: This study received an exemption by the institutional review board at the University of Iowa.

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As the demand for total joint arthroplasty (TJA) continues to increase [1-3], the importance of reducing complications while maintaining patient safety has become a national focus [4,5]. Numerous studies have identified patient demographic factors, comorbidities, and hospital characteristics associated with complications after TJA, including advanced age, obesity, diabetes, kidney disease, smoking, prolonged operative time, and low-volume total joint hospitals [6-12]. Although recognizing these factors is important, continued efforts to optimize modifiable patient and hospital factors to decrease complications after TJA are imperative.

Operative time has often been associated with increased complications after TJA [13-17]. However, independently evaluating operative time poses several challenges, as both intrinsic and extrinsic patient, surgeon, and hospital factors have been shown to significantly affect operative time [18-20]. In addition, associations

with operative times reported in the current literature are often compared as means, limiting practical implementation, or are derived from anesthesia times that may not accurately reflect the true "skin to skin" operative time. Despite the complex interplay and notable methodologic shortcomings, operative time remains an important quality measure used in the Centers for Disease Control and Prevention (CDC)'s National Nosocomial Infections Surveillance (NNIS) system [21].

Although operative time remains an important quality measure at the national level, the ability to apply the findings reported in the current literature remains unsatisfying. The purpose of the present study was to investigate the effect of operative time on short-term morbidity and mortality after primary TJA using logical time cutoffs that can be applied by those interested in quality improvement. We hypothesized that increased operative time would increase short-term morbidity and mortality after TJA. As a secondary aim, we reported patient demographic characteristics and comorbidities associated with prolonged operative times using a large, prospectively maintained national database.

Methods

This study received an exemption from the University of Iowa Institutional Review Board.

Data Collection

The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database was the source of the data for this study. The NSQIP database collects data from nearly 500 hospitals across the United States, and the details of the ACS NSQIP data collection process have been previously detailed [22,23]. In brief, trained surgical clinical reviewers prospectively collect preoperative data and 30-day postoperative morbidity and mortality data at participating institutions, with internal auditing systems that ensure high-quality data with reported disagreement rates <1.8% [23,24]. Current Procedural Terminology codes 27130 (arthroplasty, acetabular, and proximal femoral prosthetic replacement, with or without autograft or allograft) and 27447 (arthroplasty, knee, condyle, and plateau; medial and lateral compartments, with or without patellar resurfacing) were used to identify all patients undergoing primary total hip (THA) or knee (TKA) arthroplasty between 2011 and 2013. Patients with preoperative sepsis, nonclean wound classification, or undergoing non-primary, emergent, or bilateral TJA procedures were excluded. After meeting inclusion and exclusion criteria, 99,444 patients were available for analysis.

Categorization of Operative Time Data

Within the ACS NSQIP, data for the duration the patient is in the room, anesthesia time, and total operation time are collected. For the purpose of this study, total operation time was used as it most closely reflects the "skin to skin" time of the procedure and will be referred to as operative time throughout the study.

Before categorization, data were censored through Winsorization to limit spurious operative time outliers. Briefly, Winsorization allowed extreme values, including those outside of the first and 99th percentile, to be substituted by the first and 99th percentile values, respectively. Following Winsorization, the cohort was further assessed using quantiles. The middle 50% of the data, corresponding to the 25th and 75th percentile, was selected after rounding to the nearest 30-minute time interval. The 75th percentile cutoff corresponds to the procedure-specific time cutoff for the CDC's NNIS surveillance system. Times above the rounded 75th percentile and below the rounded 25th percentile were also categorized. Using this method, categories for univariate analysis were created using operative times <60 minutes, 60-120 minutes, and >120 minutes. Operative times were further categorized into 30-minute time intervals for multivariable analysis.

Patient and Operative Variables

Preoperative patient demographic characteristics, comorbidities, and laboratory values are available within the ACS NSQIP database, as are operative variables. In addition, the type of procedure performed, specifically THA or TKA, was considered an operative variable for the purpose of this study (Table 1). Individual variables are further defined within the ACS NSQIP User Guide [23].

Patient Outcomes

The ACS NSQIP database contains strictly defined morbidity and mortality data that is collected for thirty days postoperatively. The ACS NSQIP User Guide contains a complete list of individual complications with definitions that are collected postoperatively [23]. Individual complication and mortality rates after TJA were calculated and categorized by operative time (Table 2). Readmission data have only been recorded within the ACS NSQIP database since 2012, and thus readmission rates were determined using a subgroup analysis. In addition to individual complications, the composite category "wound complication" was created, specifically including the individual complications wound dehiscence, superficial wound infection, deep wound infection, and organ space infection, the latter of which are defined by adopted CDC criteria [25]. The composite category "overall complications" was also created and included all individual complications and mortality. In the event that a single patient had multiple individual complications within a composite category, this was counted only once during calculation of the composite category.

Statistical Analysis

After categorizing patients by operative time, univariate analysis allowed comparison of preoperative characteristics using the previously defined operative time categories. Unadjusted complication and mortality rates were also compared and categorized by operative time.

A multivariable logistic regression analysis was performed to adjust for confounding and mediating variables using the composite category "overall complications" as the dependent variable. Variables with <80% chart completion were excluded from the model. Patient demographic characteristics, preoperative comorbidities, and operative variables with univariate P values <.1 were included in the multivariable model. Although not significant in the univariate analysis, sex was included in the model based on historical data [14,26]. Using similar methods, multivariable models using the composite category "wound complication" and operative time greater than or less than 120 minutes were used as dependent variables to determine predictors of wound complication and operative time >120 minutes, respectively. Adjusted Odds ratios (ORs) and associated 95% confidence intervals (CIs) were calculated for all models.

Statistical methods included chi-square tests for categorical variables and analysis of variance for continuous variables. All statistical analysis was performed using SAS software (version 9.3; SAS Institute, Cary, NC). A P value of <.05 was considered statistically significant for all univariate and multivariable analyses.