ORIGINAL ARTICLE

Risk factors for and timing of adverse events after total shoulder arthroplasty

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Background: Total shoulder arthroplasty (TSA) is a likely target for future bundled payment initiatives, necessitating accurate preoperative risk stratification. The purpose of this study was to identify risk factors for unplanned readmission and severe adverse events, to risk stratify TSA patients based on these risk factors, and to assess timing of complications after TSA.
Methods: Data were collected from patients undergoing TSA from 2009 to 2014 in the American College of Surgeons National Surgical Quality Improvement Program. Bivariate and multivariate analyses of risk factors for severe adverse events or readmission were assessed. Patients were risk stratified, and timing of severe adverse events and cause of readmission were evaluated.
Results: The analysis included 5801 TSA patients; 146 (2.5%) suffered severe adverse events, and 158 (2.7%) had a 30-day unplanned readmission. The most common severe adverse events were reoperation (40%), thrombolic event (deep venous thrombosis or pulmonary embolism; 14%), cardiac event (10%), and death (8.2%). Pneumonia (8.9%) and thrombolic event (7.6%) were the most common medically related causes, whereas dislocation (7.6%) and postoperative infection or wound complication (5.1%) were the most common surgical causes for readmission. Multivariate analysis identified inflammatory arthritis ($P = .026$), male gender ($P = .019$), age ($P < .001$), functional status ($P = .024$), and American Society of Anesthesiologists class 3/4 ($P = .01$) as independent predictors for unplanned 30-day readmission and all but inflammatory arthritis for severe adverse events ($P \leq .05$ for all). Patients with ≥3 risk factors had an 11.56 ($P = .002$) and 3.43 ($P = .013$) times increased odds of unplanned readmission and severe adverse events occurring within 2 weeks after surgery, respectively, compared with patients with 0 risk factors.
Conclusions: Patients at high risk of TSA complications and readmission should be identified preoperatively to improve outcomes and to lower costs. Bundled payment initiatives must account for both patient- and procedure-related risk factors.
Level of evidence: Level IV; Case Series Using Large Database; Treatment Study
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Keywords: Total shoulder arthroplasty; readmission; length of stay; risk factors; complications; bundled payment

Total shoulder arthroplasty (TSA) is a cost-effective treatment for many conditions affecting the shoulder, with proven pain relief, improved function, and greater overall satisfaction in the short and long (>5 years) terms.[4,5,9,19,21] As a result, the volume of TSA has increased from 18,000 cases in 1998 to 68,000 cases in 2011.[26] The Centers for Medicare and

Medicaid Services have established a goal of tying 90% of all provider payments to pay-for-performance (P4P) payment models by the end of 2018. To address this, payers and providers are focusing on programs that encourage high-quality care at an affordable cost.[25] One such model is the Medicare Hospital Readmissions Reduction Program, whereby any hospital with a higher than acceptable rate of 30-day readmissions for certain procedures will receive lower reimbursements. Another is Medicare's Bundled Payments for Care Improvement (BPCI) model, in which providers are given a fixed payment for total hip or knee arthroplasty (total joint arthroplasty [TJA]) procedures covering the 3 days before admission, the surgery, and the 90-day postoperative period. Given the early successes of the BPCI model and the Hospital Readmissions Reduction Program for TJA, remaining major orthopedic procedures such as TSA are likely future targets.[14]

Readmission after TSA has been shown to increase episode costs by approximately $15,000, highlighting a savings opportunity for payers and critical metric for providers to improve on.[29] Given that Medicare's Comprehensive Care for Joint Replacement model—a mandatory bundle for TJA—includes almost all perioperative, medical, and surgical complications and readmissions, future bundles for other orthopedic procedures such as TSA are likely to follow suit. In this context, understanding modifiable drivers of complications and unplanned readmission as well as identifying when such events occur will be critical for orthopedic surgeons and hospitals to improve outcomes and to make fixed-price payment models feasible for TSA. The purpose of this study was to use the American College of Surgeon's National Surgical Quality Improvement Program (ACS NSQIP) database—a high-quality, nationally representative sample of patients in the United States—to identify risk factors for unplanned readmission and severe adverse events in TSA patients and to analyze the timing of these complications.

Methods

The ACS NSQIP is a national surgical database that prospectively collects patient data from >370 participating institutions. All data are validated with strict adherence guidelines including routine audits to ensure high-quality data. Data from medical records, operative reports, and patient interviews are collected up to 30 days postoperatively by trained clinical reviewers. In addition, the NSQIP provides patient demographics such as age, sex, race, smoking status, and functional status, among others, as well as patient medical comorbidities including diabetes, cardiac disease, pulmonary disease, renal disease, cancer, and American Society of Anesthesiologists (ASA) class. Preoperative and intraoperative variables including days from admission to operation, operative time, type of anesthesia, and days from operation to discharge are included as well.

Adverse events within 30 days of operation are tracked by the NSQIP and were classified into the following categories for analysis: severe adverse events and unplanned readmission. Severe adverse events included death, myocardial infarction, cerebrovascular accident, renal failure, pulmonary embolism, venous thromboembolism, sepsis, septic shock, unplanned intubation, paraplegia, deep wound infection, organ/space infection, and return to operating room. Minor adverse events included superficial wound infection, urinary tract infection, and pneumonia. Infectious complications including deep wound infection, superficial wound infection, organ/space infection, and sepsis or septic shock were also compiled for separate analysis. Although the ACS NSQIP data collection goes back to 2007, readmission was first captured in 2011 and cause for readmission in 2012.

We queried the ACS NSQIP database to identify all patients who underwent primary TSA from 2011 to 2014 using the *Current Procedural Terminology* (CPT) code 23472. Exclusion criteria included polytrauma, incomplete data, and any CPT codes suggestive of revision (Table S1, online only). Etiology of TSA was classified by postoperative *International Classification of Diseases, Ninth Revision* diagnosis codes corresponding to inflammatory joint condition, fracture, or other etiology categories for analysis (Table S1, online only). Similar to prior studies analyzing the NSQIP, chronic heart failure in the 30 days before surgery, myocardial infarction within 6 months of surgery, previous percutaneous coronary intervention, and history of angina within 1 month of surgery were combined into history of cardiac disease.[3]

Statistical analysis was conducted using SAS software (version 9.3; SAS Institute, Cary, NC, USA) with a 2-tailed α of .05. Bivariate analysis was conducted to compare demographics, comorbidities, intraoperative variables, predischarge outcomes, and 30-day outcomes between the readmitted and not readmitted TSA cohorts. Categorical analysis was conducted with χ^2 and Fisher exact test where appropriate. Continuous variables were analyzed using Student t-test or Mann-Whitney U test after testing for normality and equal variance. Multivariate logistic regression models included only predictors that yielded a P value of .20 or less from bivariate analysis. Severe or minor adverse events before discharge and procedure etiology predictors were included in the multivariate logistic regression model regardless of P value from bivariate analysis. All variables were assessed for confounding and interaction where appropriate. Final models were assessed for goodness of fit using the Hosmer-Lemeshow test.

Results

There were 5801 TSA patients identified with a 2.5% (146) severe adverse event rate and a 2.7% (158) 30-day unplanned readmission rate. TSA patients with adverse events tended to be older ($P < .001$), to be functionally dependent ($P < .001$), to be ASA class 3/4 ($P < .001$), and to suffer from pulmonary disease ($P = .021$), hypertension ($P = .007$), and bleeding-causing disorders ($P = .004$) (Table I). Patients undergoing TSA with traumatic arthropathy etiology were more likely to experience 30-day severe adverse event (odds ratio [OR], 2.01; $P = .017$) or unplanned readmission (OR, 1.86; $P = .015$) compared with osteoarthritis controls (Table II). Hospital length of stay was also significantly longer for TSA patients who suffered 30-day complications (2.1 vs. 3.5 days; $P < .001$).

Leading causes of 30-day severe adverse events included reoperation (25%), thrombolic event (8.6%), myocardial