## RESEARCH ARTICLE

# Short-Term Complications and Readmission Following Total Shoulder Arthroplasty: A National Database Study

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## Abstract

**Background:** The incidence of total shoulder arthroplasty (anatomic and reverse) is increasing as indications expand. The purpose of this study is to identify predictors of short-term complications and readmission following total shoulder arthroplasty for patients with glenohumeral osteoarthritis.

**Methods:** The American College of Surgeons National Surgical Quality Improvement Program was used to identify 12,982 patients who underwent total shoulder arthroplasty (anatomic or reverse) from 2011-2016. Demographic data, postoperative complications, and readmission within 30 days were analyzed. Multivariable logistic regression was used to determine independent risk factors for complications and for readmission occurring within 30 days of surgery.

**Results:** The mean age of the cohort was 69.1 years, 56.1% were female. Mean American Society of Anesthesiologists (ASA) classification score was 2.6. The postoperative complication rate was 5.6% and the readmission rate was 2.8% within 30 days of surgery. Independent predictors for any complication included preoperative dependent functional status (OR 1.8, $P<0.001$), ASA class 3 (OR 3.6, $P=0.021$) and 4 (OR 8.5, $P<0.001$), age 70-79 (OR 1.4, $P=0.019$) age ≥ 80 years (OR 2.3, $P<0.001$, and female gender (OR 1.6, $P=0.001$). Independent predictors for readmission included congestive heart failure (OR 3.4, $P=0.002$) and ASA class 4 (OR 14, $P = 0.013$). Independent functional status was associated with decreased odds of readmission (OR 0.4, $P<0.001$).

**Conclusion:** Patients with age greater than 70 years, congestive heart failure, and ASA class 3 and 4 are at increased risk for postoperative complications and readmission. Preoperative risk stratification and medical optimization are important in these patients.

**Level of evidence:** III

**Keywords:** ASA Classification, NSQIP, Postoperative complications, Readmission, Total shoulder replacement

## Introduction

The rate of total shoulder arthroplasty (TSA) utilization has steadily risen in the United States (1). This trend is expected to persist in the context of an aging United States population, with the number of TSA procedures projected to increase by 755.4% by 2030 for patients older than 55 years in the U.S. (2).

With annual healthcare expenditure in the U.S. now eclipsing $3.5 trillion and rising, and as implementation and refinement of bundled payment models across orthopaedics continues, provision of value-based care is a major priority (3,4).

Previously reported short-term complication and

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readmission rates for TSA vary substantially across both database studies and case series (5–10). A range of conditions have been associated with adverse outcomes. Peripheral vascular disease has been shown to be an independent predictor for any postoperative complication while age and dependent functional status have been shown to be independent predictors of unplanned 30-day readmission and severe adverse events (7, 10, 11). Furthermore, a history of cardiac disease has also been shown to be a strong predictor of major morbidity or mortality (5,10,12). However, the literature is lacking data on national trends from the past several years, and with perpetual growth in TSA utilization rates it is unclear whether patient-related factors such as age, comorbid illness, and ASA class continue to predict adverse outcomes.

Given the rise of value-based care in the context of bundled payment, the purpose of this study was to quantify the contemporary 30-day rates of postoperative morbidity and mortality after TSA using a large sample of patients. We hypothesized that an increased burden of comorbid medical conditions would be associated with increased risk of complications and readmission after TSA.

## Materials and Methods
### Data Source
This retrospective study included patient information from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database, from 2011 to 2016. Institutional Review Board approval was not required, as the NSQIP database contains deidentified patient information. The NSQIP and participating hospitals have not verified the statistical validity of the data analysis herein, and are not responsible for the conclusions derived by the authors of this study. Within the NSQIP database, data on surgical patients is prospectively collected. Data includes the surgical procedure performed, preoperative risk factors, and complications within 30 days of surgery. Clinical staff undergo chart review and contact patients after surgery to ensure the accuracy of data collection, and a 95% success rate in inter-rater reliability and data catchment has been demonstrated (13).

### Cohort Selection
Patients who underwent total shoulder arthroplasty between 2011-2016 were identified from the NSQIP database using Current Procedural Terminology (CPT) code 23472 for TSA. Patient demographic information and comorbid conditions were identified and extracted. The demographics in this study include age, sex, and body mass index (BMI, derived from height and weight). Medical comorbidities were also extracted. Additional data collected included American Society of Anesthesiologists (ASA) class, preoperative functional status, and length of hospital stay. Functional status is defined as the ability to perform activities of daily living (ADLs)—such as bathing, feeding, dressing, toileting, and mobilizing—during thirty days prior to surgery (14). Patients are characterized as either "dependent" or "independent", whereby dependent patients require

partial or full assistance in executing ADLs.

### Postoperative outcome variables
Postoperative complications included myocardial infarction, cardiac arrest, pulmonary embolism, deep venous thrombosis, stroke/cerebrovascular accident, renal failure, sepsis, septic shock, surgical site infection, pneumonia, urinary tract infection, reintubation, death, or readmission within 30 days. We also elected to include the rate of blood transfusion in our complication rate, which diverged from prior NSQIP studies in which rate of blood transfusion was neither extracted nor included in the reported complication rates (7, 10).

### Statistical analysis
All data were summarized using descriptive statistics. Group comparisons were performed with Student's t-tests for continuous variables and chi-square tests for categorical variables. Univariate and multivariable logistic regression models were constructed to assess the association of demographic data or comorbid illness with post-operative complications and readmission. Variables included in the multivariable logistic regression were age, body mass index, operative time, length of hospital stay, diabetes, smoking, dyspnea, chronic obstructive pulmonary disease, renal failure, dialysis, bleeding disorder, transfusion, ASA class, functional status, and gender. Results are presented as odds ratios (ORs) with 95% confidence intervals (CIs). Significance was set at $P < 0.05$. Statistical analysis was performed using SPSS, version 23, software (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.).

## Results
### Sample Characteristics
We identified 12,982 patients who underwent primary TSA from 2011 to 2016. Mean patient age was 69.1 years, with 43.9% male patients and 56.1% female [Table 1]. As categorized by ASA classification, most patients were ASA 2 (43.9%) or ASA 3 (51.4%), with a mean ASA classification of 2.6 [Table 1].

| Table 1. Characteristics of patients undergoing primary TSA | |
|---|---|
| **Demographic data of patients undergoing primary total shoulder arthroplasty (N=12,982)** | |
| **Variable** | **%** |
| **Age** | |
| Average (years) | 69.1 |
| <60 | 15.3 |
| 60-69 | 34.3 |
| 70-79 | 36.4 |
| ≥80 | 14.0 |
| **BMI** | |
| <18.5 | 0.9 |

| Table 1. Continued | | |
|---|---|---|
| | 18.5-24.9 | 16.2 |
| | 25-29.9 | 32.3 |
| | 30-34.9 | 25.9 |
| | 35-39.9 | 13.9 |
| | ≥40 | 10.3 |
| ASA Class | | |
| | 1 | 1.8 |
| | 2 | 43.9 |
| | 3 | 51.4 |
| | 4 | 2.8 |
| Sex | | |
| | Male | 43.9 |
| | Female | 56.1 |
| Functional Status | | |
| | Independent | 96.8 |
| | Dependent | 3.2 |
| Diabetes | | 17.4 |
| CHF | | 0.5 |
| Renal Failure | | 0.1 |
| Bleeding Disorder | | 2.8 |
| Length of stay | Average (days) | 2.0 |
| Readmission rate | | 2.8 |

### Postoperative Complications

The overall 30-day readmission rate was 2.8%, and the postoperative complication rate was 5.6%. The most common complications were blood transfusion (3.5%) urinary tract infection (0.7%) pneumonia (0.5%) deep venous thrombosis (0.3%) and pulmonary embolism (0.3%). Death occurred in 0.2% of patients [Table 2]. Independent predictors for any complication included preoperative dependent functional status (OR 1.8, *P<0.001*), ASA class 3 (OR 3.6, *P=0.021*) and 4 (OR 8.5, *P<0.001*), age 70-79 (OR 1.4, *P=0.019*) and ≥ 80 years (OR 2.3, *P<0.001*, and female gender (OR 1.6, *P<0.001*) [Table 3]. Independent predictors for readmission included congestive heart failure (OR 3.4, *P=0.002*) and ASA class 4 (OR 14, *P=0.013*) [Table 4]. Independent functional status was associated with decreased odds of readmission (OR 0.4, *P<0.001*).

### Discussion

In this study, the largest multicenter study on this topic to date, we found that patients ≥ 70 years of age are at significantly increased 30-day risk for complications and patients ≥ 80 years are at increased risk for hospital readmission. This reiterates the need for careful risk

| Table 2. Complications for patients undergoing primary TSA | |
|---|---|
| Complications in patients undergoing primary total shoulder arthroplasty (N=12,982) | |
| Complication | Incidence (%) |
| Death | 0.2 |
| DVT | 0.3 |
| PE | 0.3 |
| Transfusion | 3.5 |
| MI | 0.2 |
| UTI | 0.7 |
| Pneumonia | 0.5 |
| Stroke/CVA | 0.1 |

| Table 3. Logistic regression for predictive factors of non-readmission complications | | | |
|---|---|---|---|
| Logistic regression for complications in patients undergoing primary total shoulder arthroplasty (N=12,982) | | | |
| Variable | OR | 95% CI | *P value* |
| Age | | | |
| Age <60 | 1 (Reference) | - | - |
| Age 60-69 | 0.98 | 0.7-1.3 | 0.916 |
| Age 70-79 | 1.4 | 1.1-1.9 | 0.019 |
| Age ≥80 | 2.3 | 1.7-3.2 | <0.001 |
| BMI | | | |
| <18.5 | 1 (Reference) | | |
| 18.5-24.9 | 0.9 | 0.5-1.8 | 0.859 |
| 25-29.9 | 0.7 | 0.4-1.3 | 0.267 |
| 30-34.9 | 0.7 | 0.4-1.3 | 0.272 |
| 35-39.9 | 0.6 | 0.3-1.1 | 0.088 |
| ≥40 | 0.5 | 0.3-1.0 | 0.052 |
| ASA Class | | | |
| 1 | 1 (Reference) | - | - |
| 2 | 1.9 | 0.7-5.7 | 0.231 |
| 3 | 3.6 | 1.2-10.5 | 0.021 |
| 4 | 8.5 | 2.8-26.0 | <0.001 |
| Female | 1.6 | 1.3-1.9 | <0.001 |
| Diabetes | 1.1 | 0.9-1.4 | 0.251 |
| CHF* | 0.9 | 0.3-2.2 | 0.819 |
| Renal Failure | 6.3 | 1.3-31.0 | 0.024 |
| Bleeding Disorder | 2.1 | 1.5-3.0 | <0.001 |
| Dependent Functional Status | 1.8 | 1.3-2.5 | <0.001 |

* Congestive heart failure

| Table 4. Logistic regression for predictive factors of readmission | | | |
|---|---|---|---|
| **Logistic regression for readmission in patients undergoing primary total shoulder arthroplasty (N=12,982)** | | | |
| **Variable** | **OR** | **95% CI** | **P value** |
| Age | | | |
| Age <60 | 1 (Reference) | - | - |
| Age 60-69 | 0.9 | 0.6-1.3 | 0.578 |
| Age 70-79 | 1.0 | 0.7-1.5 | 0.826 |
| Age ≥80 | 1.7 | 1.1-2.5 | 0.014 |
| BMI | | | |
| <18.5 | 1 (Reference) | | |
| 18.5-24.9 | 1.0 | 0.4-2.9 | 0.991 |
| 25-29.9 | 0.9 | 0.3-2.7 | 0.920 |
| 30-34.9 | 1.1 | 0.4-3.0 | 0.905 |
| 35-39.9 | 0.8 | 0.3-2.2 | 0.614 |
| ≥40 | 1.3 | 0.4-3.7 | 0.647 |
| ASA Class | | | |
| 1 | 1 (Reference) | - | - |
| 2 | 4.9 | 0.6-38.7 | 0.128 |
| 3 | 7.5 | 0.96-58.8 | 0.054 |
| 4 | 14.0 | 1.7-113.4 | 0.013 |
| Female gender | 1.0 | 0.8-1.2 | 0.699 |
| Diabetes | 1.2 | 0.9-1.6 | 0.150 |
| CHF* | 3.4 | 1.6-7.2 | 0.002 |
| Bleeding Disorder | 1.8 | 1.2-2.9 | 0.010 |
| Independent Functional Status | 0.4 | 0.3-0.6 | <0.001 |

* Congestive Heart Failure

assessment to minimize complications in the elderly population, and for bundled care to reflect the elevated likelihood of an adverse event. Patients who undergo TSA increasingly fall into the > 70 age bracket (15, 16). Dillon *et al* showed that female patients age 65-74 saw the highest growth in TSA utilization between 2005-2013 (an 11% increase per year) followed by women ages 75-84 (16). Relatedly, we found that females were at increased risk of complication. We have re-demonstrated increased risk in patients with CHF, and in those characterized pre-operatively as functionally dependent or ASA class 3 or 4. There was no significant difference between BMI groups and adverse event rates. Overall, our 30-day complication rates are in keeping with previously reported NSQIP figures, which reported on data from 2006-2011 (10), 2011-2013 (5), and 2009-2014 (7).

In concordance with our findings, multiple studies have found the American Society of Anesthesiologists (ASA) classes 3 and 4 to be an important predictive

tool in the early postoperative window. This has been demonstrated across previous NSQIP studies, case series, as well as data derived from a prospectively collected institution-wide total joint registry (5-7, 17,18). An increased ASA is not simply related to an increased risk of medical complication. In a series of 452 shoulders, Johnson *et al* found that patients with ASA class > 2 had twice the odds of having surgical complications and had three times the odds of prosthesis failure (19). While it is not unexpected that the rate of adverse outcomes is higher in patients with a more severe ASA class, the findings of this study are in agreement with this trend. Interestingly, renal failure has not been previously demonstrated in the NSQIP literature to be a factor for either complications or readmission (5, 7, 10). We also found dependent functional status to be strongly associated with complications. This has been previously shown to predict hospital readmission and our findings corroborate this, as we have shown that independent functional status is associated with lower odds of readmission (11). Congestive heart failure and hypertension have also been shown to be independent factors associated with readmission (5, 10, 12, 20).

We found older age to be associated with both increased odds of complications and readmission after TSA. Waterman and colleagues found advanced age to be a predictor for mortality but not for other adverse events (10). Several articles did not find age to be an independent predictor of readmission or surgical complications, while others were limited by lack of age subgroup analysis (5-7). In a prospectively collected database of 5,494 shoulder arthroplasties, Wagner *et al* found that reoperation rates decreased in a linear fashion with older ages (21). While older age was associated with a decreased risk of revision, patients >70 years of age did have a higher risk for thromboembolic events as compared to those < 70 years (21). In contrast, previous analysis of the Nationwide Inpatient Sample yielded no increased incidence of short-term post-op pulmonary embolism, infection, or cardiac complications between patients aged 51-79 and those ≥ 80 years (22). Despite the heterogeneity of the literature, providers must be mindful of the increasing body of literature which shows that age is an independent predictor of adverse events. This is particularly relevant as the incidence rate of shoulder arthroplasty in elderly patients continues to rise (15).

We found that female sex was associated with higher odds of complications but not of readmissions. Female sex was not a risk factor for readmission or adverse events in prior studies, from NSQIP analyses to case series (5, 6, 10). In fact, Lovy *et al* found that male sex was a significant risk factor for unplanned readmission and severe adverse events (7). While Knapp *et al* and Okoroha *et al* found comparable overall complication profiles between males and females, women underwent surgery at an older age, were more likely to be functionally dependent and more likely to have an ASA score of 3 or greater (23, 24). Women were also more likely to have worse pre-operative range of motion and outcome scores

than male patients (24). This reinforces the need for careful preoperative evaluation and discussion, as well as discharge planning.

BMI was not a predictor of 30-day adverse outcomes in our cohort. In most prior NSQIP studies, increased BMI has not been a significant factor for 30-day readmission or severe adverse events (5, 7, 10). In contrast, Wagner *et al's* analysis of an institutional joint registry found that increasing BMI was associated with an increased risk of revision, reoperation, revision for mechanical failure, and superficial infection at a mean follow-up time of eight years. The risk of revision increased in a linear fashion with increasing BMI—a 5% increased risk per 1 unit of BMI (25). An elevated risk of complications has also been found in superobese patients (BMI ≥ 50) (26). These studies—in concert with our findings—demonstrate that the 30-day window may not capture the impact of BMI on the complications burden, whether mechanical or medical. This is important to appreciate when counseling patients, estimating risks, and constructing policy decisions or reimbursement schedules for bundled care.

The identification of risk-predicting comorbid conditions can assist providers in pre-operative optimization, and inform both policy makers and payers when weighing risk stratification for cost containment. In a cost analysis of primary TSA, Kennon and colleagues found that 1-unit increase in ASA score was associated with a slight $429 increase in index cost (17). This is likely reflective of increased pre-operative clearance testing and optimization (echocardiography, etc.). In contrast, postoperative readmissions had a substantial impact on cost, with readmission costs averaging 81% of the index arthroplasty cost (17). An understanding of the costs of each element of care and detailed information on the frequency of and reasons for readmission and reoperation are keys to developing bundled-payment initiatives. Amelioration of pre-operative risk can conceivably diminish the complication burden for patients with elevated risk scores or high-risk conditions, and thus minimize the massive costs associated with negative sequelae. In doing so providers can improve value for patients, where value is defined as the health outcomes achieved that matter to patients, relative to the cost of achieving those outcomes (3).

This study was not without limitations. While to our knowledge this is the largest NSQIP study to analyze short-term complications after TSA, our study did not investigate reoperation rates, or factors related to an extended length of hospital stay. Despite the growing interest surrounding performing outpatient TSA in carefully selected patients  our analysis of the NSQIP database did not extend to this level of granularity (27).

As with any retrospective study, this study is limited by the accuracy of data entered into the database. There may be selection bias present as a result of systematic data entry errors (28, 29). Furthermore, alternative methods of handling missing data in the NSQIP database have been shown to significantly alter results (30). However, the NSQIP database has been shown to be a reliable database with a 95% success rate in data capture and inter-rater reliability for all variables (13). Reverse TSA has been shown to have increased rates of certain complications when compared with anatomic TSA, but these two procedures could not be differentiated in the NSQIP database because they share a CPT code (8, 9. While it is likely that complications occurred outside of the short-term timeframe utilized in this study, 30 days is the timeframe utilized by the Hospital Readmissions Reduction Program of the Affordable Care Act, for reduced reimbursement penalties (11). The NSQIP database is not a perfectly scaled representation of the population of the United States, but there has been a steady and significant increase in the number of participating institutions over previous years (14). Nevertheless, the results of this study, the largest multicenter study to date on this topic, show which comorbidities place patients at the highest risk of short-term complications following TSA.

Patients greater than 70 years of age are at significantly increased 30-day risk for complications and readmission. Female sex, ASA class 3 or 4, patient functional status, and the presence of CHF or renal failure must also be considered. We did not find differences in short-term outcomes between BMI groups. These findings highlight the importance of preoperative medical optimization and patient shared-decision making prior to undergoing TSA.

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