J Shoulder Elbow Surg (2015) 24, 754-759

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Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Predictors of length of stay after elective total shoulder arthroplasty in the United States

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Background: Total shoulder arthroplasty (TSA) is an increasingly used treatment of glenohumeral arthritis and proximal humerus fractures. However, patient-specific characteristics affecting length of hospital stay postoperatively have not been elucidated.

Methods: All patients undergoing primary unilateral TSA between 2005 and 2011 were isolated from the National Surgical Quality Improvement Program database. Patient demographics, medical comorbidities, and selected surgical variables were extracted, and length of stay was established as the primary end point of interest. Risk factors were expressed as odds ratios (ORs) with 95% confidence intervals by bivariate and multivariable analysis.

Results: A total of 2004 patients were identified; the average age was 68.8 years, and 57% were women. Mean length of stay after TSA was 2.2 days (standard deviation, 1.7), and 91% of cases received hospital discharge in <3 days. Multivariable logistic regression analysis identified renal insufficiency (OR, 11.35; $P = .0002$), increased age (OR, 2.13; $P = .011$), longer operative time (OR, 1.94; $P = .0041$), and American Society of Anesthesiologists class ≥3 (OR, 1.86; $P = .0016$) as the most significant risk factors for length of stay. Gender also influenced length of stay; women were more likely to stay ≥4 days (OR, 0.44; $P < .0001$).

Conclusions: Perioperative risk stratification and preoperative counseling are paramount for patients undergoing TSA, particularly for those individuals with cardiac and renal disease or of advancing age. These variables may effectively predict prolonged hospital stay after TSA.

Level of evidence: Epidemiology Study, Database Analysis.

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Keywords: Total shoulder arthroplasty; length of stay; morbidity; risk factors

Shoulder arthroplasty was first conceived in 1893 by French surgeon Jules-Émile Péan as a rubber, platinum, and wood prosthesis for a patient with a tuberculoid shoulder.[28] Since its modern description by Neer for the treatment of comminuted proximal humeral fractures,[31,32] the indications for shoulder arthroplasty have expanded

Some authors are employees of the U.S. Federal Government and the United States Army. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of William Beaumont Army Medical Center, the Department of Defense, or the United States government.

The American College of Surgeons National Surgical Quality Improvement Program and its participating hospitals 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.

IRB approval for this study was not necessary.

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1058-2746/$ - see front matter Published by Elsevier Inc. on behalf of Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2014.11.042

dramatically, and total shoulder arthroplasty (TSA) has evolved as a reliable treatment option for painful glenohumeral arthritis and other degenerative conditions.[6,42] Subsequent studies have demonstrated the efficacy of TSA in terms of both improved range of motion and pain relief; however, the complication rate remains relatively high, ranging from 4.8% to 12%, including significant medical complications, secondary instability, periprosthetic fracture, and infection.[4,5,11] Jain et al[24] found that the rates of both mortality and postoperative complications were correlated with surgeon and hospital volume. In addition, the authors found that low-volume surgeons had an increased length of hospital stay.

However, no study has previously correlated length of hospital stay after TSA with specific patient factors. Prolonged hospital stay may have important financial repercussions in health care spending and resource utilization,[36] and this has been associated with an increase in major postoperative morbidity and mortality in arthroplasty,[27] trauma,[15] and spine surgery.[18] The current study sought to identify specific patient and surgical risk factors for increased length of hospital stay after TSA with use of a national patient database. We hypothesize that older age and cardiopulmonary comorbidities will be associated with an increased length of stay after TSA.

Materials and methods

After Institutional Review Board exemption, the National Surgical Quality Improvement Program (NSQIP) database was obtained from the American College of Surgeons. In prior large-scale cross-sectional investigations evaluating a variety of orthopedic surgical procedures,[2,3,34,35] the NSQIP has been validated as a reliable source of perioperative surveillance data derived from nearly 250 participating hospitals within the United States. As a part of a national quality improvement initiative, patients are prospectively enrolled and observed for 30 days after index surgery, during which a variety of specific objective outcomes are collected to further assess risk-adjusted quality of care based on these clinical end points.

The current analysis isolated all patients in the NSQIP undergoing *Current Procedural Terminology* code 23472 for TSA between 2006 and 2011. Only patients with primary unilateral TSA were considered, and any individuals with hemiarthroplasty, resurfacing arthroplasty, bilateral TSA, or revision TSA were excluded. Demographic and other patient-based parameters were collected, including age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, and individual medical comorbidities. Furthermore, surgical variables, such as mode of anesthesia and total operative time, were identified. For the purposes of the study, the primary outcome of interest was length of hospital stay after elective TSA. Both bivariate χ^2 analysis and multivariate logistic regression analysis were used to evaluate variables contributing to increased duration of hospital stay. Specific patient-based and surgical risk factors included the following: presence of specific medical comorbidities, BMI (<29.9, 30.0-39.9, and ≥40 kg/m^2), gender, ASA class (1 or 2 vs. ≥3), age (<60, 60-69, 70-79, and ≥80 years old), and operative time. Operative time analysis was delineated by comparing cases that were exceeded more than 1 standard deviation above the average time with those that did not.

For bivariate analysis, any factors with a $P < .2$ were carried forward into multivariate logistic regression to further control for other identified parameters. For both bivariate and multivariable analysis, specific factor risk was defined with odds ratios (ORs) with 95% confidence intervals (CIs). Statistical significance was achieved if a P value was below .05 and 95% CI exclusive of 1.0.

Table I Demographics and length of stay

Characteristic	Value	Patients for whom characteristic was determined (N)
Age, y, mean ± SD	68.8 ± 11.1	2004
Sex, N (%)	—	1998
Male, N (%)	859 (43.0)	—
Female, N (%)	1139 (57.0)	—
Body mass index, kg/m^2, mean ± SD	30.3 ± 6.4	1987
Operative time, min, mean ± SD	122.9 ± 51.2	2004
Length of stay	—	2004
≥4 days, N (%)	181 (9.0)	—
≤3 days, N (%)	1823 (91.0)	—

Results

Between the years of 2006 and 2011, 2004 patients underwent primary unilateral TSA in the NSQIP database. The average age of patients was 68.8 (standard deviation [SD], 11.1) years, and 57% were women. The average BMI was 30.3 (SD, 6.4), and the mean operative time was 122.9 (SD, 52.1) minutes. Mean length of stay after TSA was 2.2 days, with a hospital stay of 3 days or less in 91% of patients. Conversely, only 9% of patients stayed 4 days or more after TSA (Table I).

Bivariate analysis isolated numerous significant predictors for length of stay (Table II). Renal insufficiency (OR, 13.71 [95% CI, 3.04, 61.72]; $P = .0007$), cardiac disease (OR, 8.22 [95% CI, 2.19, 30.88]; $P = .0018$), and ASA classification ≥3 (OR, 2.34 [95% CI, 1.70, 3.24]; $P < .0001$) were the most significant factors for increased length of stay. Multivariable logistic regression analysis identified significant independent factors for length of stay (Table III). Renal insufficiency (OR, 11.35 [95% CI, 1.68, 76.49]; $P = .0002$), increased age (OR, 2.13 [95% CI, 1.11, 4.07]; $P = .011$), and longer operative time (OR, 1.94 [95% CI, 1.23, 3.04]; $P = .0041$) were significant risk factors for length of stay.

Discussion

As the annual number of TSA procedures steadily climbs,[1,7,11,29] a substantive analysis of length of hospital

Table II Results of bivariate χ^2 analyses evaluating the influence of risk factors on length of stay

Risk factor	*P* value	OR (95% CI)
Length of stay		
Age continuous	<.0001	1.04 (1.02, 1.05)
Age ≥80 vs. <60	<.0001	3.23 (1.89, 5.53)
Gender male vs. female	<.0001	0.38 (0.27, 0.55)
BMI ≥40 vs. <30	.0268	1.97 (1.20, 3.22)
Operative time >174 minutes	.0044	1.75 (1.19, 2.58)
ASA classification ≥3	<.0001	2.34 (1.70, 3.24)
Diabetes mellitus	.0004	1.91 (1.33, 2.74)
COPD	.0013	2.41 (1.41, 4.11)
Cardiac disease (MI/CHF)	.0018	8.22 (2.19, 30.88)
Hypertension	.0269	1.45 (1.05, 2.11)
Renal insufficiency	.0007	13.71 (3.04, 61.72)

ASA, American Society of Anesthesiologists; *BMI*, body mass index; *COPD*, chronic obstructive pulmonary disease; *MI*, myocardial infarction; *CHF*, congestive heart failure; *OR*, odds ratio; *CI*, confidence interval.

Table III Significant predictors for length of stay as determined by multivariate logistic regression analysis

Risk factor	*P* value	OR (95% CI)
Length of stay		
Age ≥80 vs. <60	.011	2.13 (1.11, 4.07)
Gender male vs. female	<.0001	0.44 (0.29, 0.66)
Operative time >174 minutes	.0041	1.94 (1.23, 3.04)
ASA classification ≥3	.0016	1.86 (1.27, 2.74)
Renal insufficiency	.0126	11.35 (1.68, 76.49)

ASA, American Society of Anesthesiologists; *OR*, odds ratio; *CI*, confidence interval.

stay is imperative to assess the cost-effectiveness of the private health care system in the United States. This is the first known study to correlate length of hospital stay after TSA with specific patient characteristics and medical comorbidities. The increased relative costs and consumption of limited health care resources associated with prolonged postoperative hospitalization underscore the importance of research into the determinants of length of stay after TSA, particularly modifiable factors.

TSA is a significantly less morbid and less expensive procedure than total knee arthroplasty (TKA) and total hip arthroplasty (THA). An analysis of nearly 40,000 TKAs and THAs compared with 994 TSAs between the years 1994 and 2001 revealed that TSAs had no in-hospital deaths, whereas the incidence of in-hospital deaths in THA and TKA were 0.18% and 0.16%, respectively. In addition, TSAs had shorter lengths of stay, lower hospitalization costs, and lower complication rates.[10] These findings were closely correlated in a large 2009 analysis of the Veterans Affairs health system, which demonstrated that although TSAs had slightly longer operative time compared with THA and TKA, TSAs had shorter hospitalizations, fewer readmissions, decreased mortality, and lower complication rate.[12]

The length of stay after TSA has decreased in recent years. In one analysis, the average length of stay before 1995 was 9.5 days, but it decreased to 4.5 days thereafter.[33] In 1994, Milne and Gartsman[30] similarly reported that average length of stay after TSA was 5 days. Twelve years later, Lyman et al[29] reviewed 1307 TSAs in New York State during a 3-year period and found that the average length of stay was 3.9 days in a low-volume center (1-15 TSAs/year), 3.1 days in a medium-volume center (16-47 TSAs/year), and 3.6 days in a high-volume center (48 or more TSAs/year). The larger centers had a lower rate of readmission within 60 days (4.6%) compared with middle (6.5%) and lower volume centers (9.5%).

Individual surgeon and hospital volume may also affect length of stay and hospitalization cost. Jain et al[24] revealed that surgeons who did only 1 TSA per year had a longer length of hospital stay compared with a higher volume surgeon (4 vs. 3.3 days). Likewise, hospitals that did less than 5 TSAs per year had longer lengths of stay compared with those that did 10 or more per year (4.1 vs. 3.3 days). In a similar trend, the reported mean hospital cost for TSA also varied on hospital volume and year. Low-volume hospitals had an average adjusted hospital cost of $9257, whereas middle-volume and high-volume hospitals had costs of $8206 and $9364, respectively. The authors concluded that health care resources may be conserved if TSAs are done at higher volume medical centers.[29] Furthermore, a 2003 study of 1868 TSAs and hemiarthroplasties in the state of Maryland demonstrated that higher volume surgeons, compared with lower volume surgeons, had roughly $1000 decreased hospitalization costs, had 50% fewer complications, and were 3 times more likely to have a hospitalization <6 days.[20] The longer lengths of stay and increased hospital costs in the older data reflect improving arthroplasty design, more facile surgical specialists, and a more in-depth focus on the length of hospitalizations.

In the present analysis, a longer length of operative time was related with length of stay (OR, 1.94 [CI: 1.23, 3.04]; $P = .0041$). In a previous evaluation of this data set, our institution has found that a longer operative time for TSA also has increased the risk of a major local complication, including peripheral nerve injury and deep wound infection.[43] Longer operative time may potentially be a reflection of the surgeon's experience, the case's complexity, or an intraoperative complication. In addition to shorter lengths of stay reported by higher volume hospitals and surgeons, these cases also yielded roughly a 50% decrease in mortality and complication rates.[24]

Whereas TSA is an effective treatment of glenohumeral arthritis in the elderly, longer hospitalizations, more nonfatal medical complications, and an increased need for intensive patient care are required in the older cohort.[13,16] In the present analysis, advanced age (≥80 years vs. <60 years) was correlated with increased length of stay (OR, 2.13 [95% CI, 1.11, 4.07]; $P = .011$). Ricchetti et al[33] compared age with postoperative complications, failing to demonstrate a significant difference in postoperative complications or mortality in elderly patients stratified by age. The difference in these findings may be reflective of a more diverse population of patients in this analysis. The authors discovered that the population of older patients had a decreased incidence of homebound discharge, which can be correlated with increased hospital stay in our study.

Ricchetti et al[33] also correlated patient-specific systemic complications with increased length of stay after TSA. Similarly, our analysis demonstrated that increased prevalence of medical comorbidities, as represented by an ASA classification ≥3 (OR, 1.86 [CI, 1.27, 2.74]; $P = .00160$) and renal insufficiency (OR, 11.35 [CI, 1.68, 76.49]; $P = .0126$), was significantly associated with an increased length of stay. These findings are consistent with previous studies evaluating morbidity and mortality rates in patients undergoing shoulder arthroplasty.[11,12,20,23,24,38,39] In an analysis for shoulder, hip, and knee arthroplasty, the likelihood of a non-homebound disposition of a patient postoperatively was 1.45 times greater with obesity and 1.3 with diabetes mellitus.[22] Furthermore, Griffin et al[17] found that obesity led to dramatically increased hospital cost after TSA ($38,103.88 in morbidly obese patients vs. $33,521.66 in the control) as well as increased hospital length of stay. In addition, after TSA, a higher preoperative comorbidity status has been associated with increased in-house mortality, postoperative complications, length of stay, and hospital costs.[22] The resultant effect of a patient's medical comorbidities on hospital length of stay in this analysis cannot be overemphasized.

Gender also influenced length of stay in the present study, with males typically requiring a shorter length of stay (OR, 0.44 [95% CI: 0.29, 0.66]; $P < .0001$). This has previously not been identified as a risk factor for length of stay in the literature, although disparities in clinical outcomes after total joint arthroplasty have been noted by gender. Judge et al[25] found that women had worse functional outcomes within 6 months of TKA. In a separate review of TKA, women had both lower functional scores and activity levels postoperatively.[8] Women are also more likely to have pain at 1 to 2 years postoperatively after TKA.[37] In univariate analysis of 4019 primary shoulder arthroplasties, female gender was associated with a higher rate of thromboembolic events.[39] It is possible that poorer outcomes associated with total joint replacement and potentially higher medical complication rates result in longer hospital stay after TSA.

Several studies have examined health care costs associated with length of hospital stay after total joint arthroplasty, with the main focus centered on cost reduction.[9,21] In large, expenses related to hospital accommodations and continued inpatient care represent a significant contributor to overall medical costs and may account for up to 23% to 28% of final billing after TKA.[26] In addition, an estimated average 3% to 5% could be saved per patient when the hospital stay is decreased by a single day.[9,21,41] Whereas certain demographic factors are nonmodifiable (e.g., age), greater efforts should attempt to mitigate or to optimize other patient-specific factors that contribute to increased length of stay.

There are 3 primary limitations of our study. First, we are unable to discern relative differences in length of stay between TSA and reverse TSA because they are collectively organized under a common *Current Procedural Terminology* code during the period of this study. Second, because of inherent limitations in the NSQIP database, the role of specific intraoperative and immediate postoperative medical complications on length of stay could not be fully elucidated. Third, the power of the study is inadequate to evaluate certain risk factors, namely, BMI, on length of stay. Other factors that were also not accounted for in this study were the use of peripheral nerve catheters,[14,40] surgical indication, and disposition at discharge.[19] These data would further enhance preoperative planning and potentially limit health care expenditures, and they should be a target of further investigation. In addition, future research should be collected prospectively to more accurately determine factors that affect length of stay after TSA.

Conclusion

Among a large, diverse cohort of 2004 patients, several surgical and patient-related variables influence length of stay after TSA. In addition to increased length of operative time, certain modifiable and nonmodifiable patient factors are also important predictors of increased length of stay after TSA, including renal disease, ASA class >3, advanced age of the patient, and female gender. Careful aggregate risk assessment for increased length of inpatient stay may inform preoperative patient counseling and help guide strategies for reducing health care resource utilization after TSA.

Disclaimer

The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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