JSES International 4 (2020) 657–661

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

Trends in total shoulder arthroplasty from 2005 to 2018: lower complications rates and shorter lengths of stay despite patients with more comorbidities

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ARTICLE INFO

Keywords:
Total shoulder arthroplasty
Outcomes
Length of stay
Complications
NSQIP
ACS-NSQIP

Level of evidence: Level III; Retrospective Cohort Comparison Using Large Database; Epidemiology Study

Background: Total shoulder arthroplasty (TSA) is an increasingly common procedure. This study looked at trends in TSA using a nationwide registry, with a focus on patient demographics, comorbidities, and complications.

Methods: The American College of Surgeons National Surgical Quality Improvement Program database was queried for patients who underwent TSA from 2005 to 2018. Cohorts were created based on year of surgery: 2005-2010 (N = 1116), 2011-2014 (N = 5920), and 2015-2018 (N = 16,717). Patient demographics, comorbidities, operative time, hospital length of stay, discharge location, and complications within 30 days of surgery were compared between cohorts using bivariate and multivariate analysis.

Results: Bivariate analysis revealed significantly more comorbidities among patients in the 2015-2018 cohort compared with the 2005-2010 cohort, specifically American Society of Anesthesiologist class III or IV (57.0% vs. 44.3%, $P < .001$), morbid obesity (10.8% vs. 7.8%, $P < .001$), diabetes (17.8% vs. 12.1%, $P < .001$), and chronic obstructive pulmonary disease (6.7% vs. 4.1%, $P = .003$). The use of regional anesthesia has decreased (5.6% in 2005-2010 vs. 2.8% in 2015-2018, $P < .001$), as has operative time (Δ: −16 minutes, $P < .001$) and length of stay (Δ: −0.6 days, $P < .001$). There were also significant decreased rates of perioperative blood transfusion (OR [odds ratio], 0.46), non-home discharge (OR, 0.79), urinary tract infection (OR, 0.47), and sepsis (OR, 0.17), ($P < .001$ for all comparisons) between the 2005-2010 and 2015-2018 cohorts.

Conclusions: Between 2005 and 2018, patients undergoing TSA had increasingly more comorbidities but experienced lower rates of short-term complications, in the context of shorter hospitalizations and more frequent discharge to home.

Total shoulder arthroplasty (TSA) has become an increasingly popular treatment option for a variety of shoulder pathologies including glenohumeral arthritis, rotator cuff tear arthropathy, and proximal humerus fractures. In the United States, more than 66,000 patients underwent TSA in 2011 alone,[42] and there was a more than 2-fold increase in TSA volume between 2005 and 2013.[16] This trend is not unique to the United States, as England saw an even larger 5.6-fold increase in TSA volume between 1998 and 2017.[14] The use of TSA is expected to continue to rise, driven by an increasing prevalence of shoulder pathology and expanding operative indications in an aging population.[12]

The costs associated with TSA are typically lower than those of total hip and total knee arthroplasty, but are nonetheless significant, estimated at $40,015 in 2013.[43] Furthermore, the costs of TSA appear to be increasing more quickly than those of total hip and knee arthroplasty.[43] As such, TSA is a likely target for future bundled payment initiatives in a health care environment increasingly focused on cost containment and value-based care.[7,36,39]

Perioperative complications and hospital length of stay (LOS) are often significant components of medical expenses, with the initial hospitalization accounting for 88% of the total cost of TSA.[22,39] Interestingly, although patient comorbidities are commonly associated with increased complication rates and prolonged hospitalizations,[1,22,23,28] recent studies have actually shown

No institutional review approval was required for this retrospective study.

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https://doi.org/10.1016/j.jseint.2020.04.024

lower complication rates[8,9,34] and shorter average LOS[15,17] despite separate studies showing increasing medical comorbidities among patients undergoing TSA.[43] Similar findings have also been demonstrated among hip and knee arthroplasty patients.[20,32] To our knowledge, however, no single study has simultaneously assessed recent trends in medical comorbidities, perioperative complications, and hospitalization duration for TSA. Thus, the purpose of this study is to use prospectively collected data from a national registry to identify changes in the prevalence of comorbidities, 30-day postoperative complication rates, and average hospital LOS among patients who underwent TSA over a 13-year period.

Materials and methods

This retrospective cohort study is based on data from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database. In the study period from 2005 to 2018, 7,657,926 cases were submitted to NSQIP from over 700 hospitals, ranging from community hospitals to academic centers across the United States. Data entered into NSQIP are extracted from medical records by trained surgical clinical reviewers and undergo rigorous auditing, making NSQIP one of the most robust and reputable surgical databases available.[38,40]

For this study, TSA cases were identified in the NSQIP database by querying for Current Procedural Terminology code 23472, which requires both glenoid and proximal humeral replacement, between 2005 and 2018. Three cohorts were defined based on the year of surgery: 2005-2010, 2011-2014, and 2015-2018. Cases considered emergent (N = 107), cases with preoperative wounds classified as unclean (N = 108), and cases missing baseline patient demographic data (N = 411) were excluded. Patient demographic data used in this study include age, gender, height, weight, body mass index, American Society of Anesthesiologists (ASA) classification, functional status, and medical comorbidities (diabetes mellitus, hypertension, chronic obstructive pulmonary disease [COPD], smoking history, and preoperative steroid use). Operative data, including primary form of anesthesia (regional vs. general) and duration of surgery, as well as postoperative data, including LOS (defined as 0 for outpatient surgery), discharge destination (home vs. non-home), and 30-day postoperative complications, were also collected. Postoperative complications considered in this study include perioperative blood transfusion, cardiac complications, renal complications, respiratory complications, deep vein thrombosis, stroke/cerebrovascular accident, sepsis, wound infection, wound dehiscence, urinary tract infection, and death. Cardiac complications were either cardiac arrest requiring cardiopulmonary resuscitation or myocardial infarction. Pulmonary complications consisted of pneumonia, failure to wean from a ventilator within 48 hours, and unplanned reintubation. Renal complications included progressive renal insufficiency and acute renal failure. Orthopedic-specific complications, such as periprosthetic fracture or neurovascular injury, are not reliably entered into the NSQIP database and are therefore not included in this study.

All statistical analysis was performed using SPSS version 23 (IBM Corp., Armonk, NY, USA). Baseline patient demographic data, anesthesia type, complication rates, and discharge destination were compared between cohorts using Pearson's χ^2 tests. Complication rates were also compared by multivariate analysis, controlling for baseline patient demographics determined to be significantly different between the 3 cohorts on bivariate analysis. Operative duration and postoperative LOS were compared using multivariate comparison of means. Bonferroni corrections were used throughout, given the multiple group comparisons.

Results

A total of 23,757 patients in the NSQIP database underwent TSA between 2005 and 2018 and met inclusion criteria for this study: 1116 from 2005 to 2010, 5920 from 2011 to 2014, and 16,717 from 2015 to 2018 (Table I). In terms of age, patients in the most recent cohort (2015-2018) were more likely to be in the 60-80 age range, whereas in the earliest cohort, there were a greater proportion of patients less than 60 or greater than 80 years of age. The percentage of obese patients undergoing TSA has increased steadily over time, with 7.8% in the earliest cohort having a body mass index >40 as opposed to 10.8% of patients in the most recent cohort ($P < .001$). There was also a notable increase in the prevalence of patients with diabetes, from 12.1% in the earliest cohort to 17.8% in the most recent cohort ($P < .001$). A similar trend was also observed with COPD (4.1% in the earliest cohort vs. 6.7% in the most recent cohort, $P = .003$). The proportion of patients with ASA class III or IV has also steadily increased over time ($P < .001$).

The use of regional anesthesia as the primary type of anesthesia appears to have decreased over time, with 5.6% of patients in the earliest cohort receiving regional anesthesia vs. 2.8% in the most recent cohort (Table I). After adjusting for differences in baseline patient demographics and operative characteristics, average operative duration decreased from 125 ± 53 minutes in the 2005-2010 cohort to 108 ± 43 minutes in the 2015-2018 cohort ($P < .001$). LOS also decreased by an average of 0.6 days over that same time span ($P < .001$, Table II).

The overall incidence of complications trended down from 2.8% in the 2005-2010 cohort to 2.4% in the 2015-2018 cohort, though this was not statistically significant after adjusting for differences in patient demographics (Table III). There were, however, significant decreases in the rates of perioperative blood transfusion (OR [odds ratio], 0.46), urinary tract infection (OR, 0.47), and sepsis (OR, 0.17) between the 2005-2010 and 2015-2018 cohorts (Table IV). The incidence of non-home discharges also decreased significantly, from 11.7% in the 2011-2014 cohort to 9.4% in the 2015-2018 cohort. Discharge destination was not recorded in NSQIP for the 2005-2010 cohort (Table III).

Discussion

This study examined trends in patient-specific medical comorbidities; surgical characteristics like anesthesia type, operative duration, and short-term postoperative complications; LOS; and discharge destination among patients who underwent TSA over a 13-year period. Although Yang et al[43] conducted a similar study using a statewide data set, this is the first study to do so on the national level, including over 23,000 patients from numerous institutions, potentially providing more generalizable findings.

In terms of demographics, our results suggest that TSA has become increasingly popular among patients aged 60-80, whereas the incidence of TSA in patients less than 60 and greater than 80 years has not kept pace. These findings are similar to those reported by Padegimas et al,[30] who found the incidence of TSA in patients >55 years old to be increasing by on average 12.1% per year, as compared with 8.2% per year for patients ≤55 years old. This phenomenon is likely the result of multiple factors. For one, the baby boomer generation moved from their 40s and 50s into their 60s and 70s over the course of the study period, leading to an overall shift in the country's age structure.[13] It is also possible that younger patients with irreparable rotator cuff tears are opting for alternative treatment options, as evidenced by the rapid rise in the popularity of superior capsule reconstruction and to a lesser extent muscle tendon transfers, in the hopes of avoiding or at least delaying TSA.[37]

Table I
Comparison of patient and operative characteristics by year of index total shoulder arthroplasty

	All patients	Year of index surgery			*P* value
		2005-2010	2011-2014	2015-2018	
	N = 23,753 (%)	n = 1116 (%)	n = 5920 (%)	n = 16,717 (%)	
Age					**<.001***
<60	15.2	19.5	14.9	15.1	
60-70	38.2	33.2	37.0	38.9	
71-80	35.5	34.8	34.9	35.8	
>80	11.1	12.5	13.2	10.2	
Female %	55.7	57.3	56.3	55.4	.288
Body mass index (kg/m^2)					**.001***
Nonobese (<30)	49.4	53.9	50.7	48.7	
Obese I (30-34.9)	26.2	25.0	26.1	26.3	
Obese II (35-39.9)	14.0	13.4	13.5	14.2	
Obese III (≥40)	10.4	7.8	9.8	10.8	
Comorbidities					
Diabetes	17.2	12.1	16.6	17.8	**<.001***
Smoking history	10.7	9.1	10.1	10.9	.053
COPD	6.5	4.1	6.6	6.7	**.003***
Preoperative corticosteroid use	4.8	3.5	5.0	4.9	.090
Hypertension	66.9	68.0	66.9	66.9	.733
Primary anesthesia type					**<.001***
General	96.8	94.4	95.9	97.2	
Regional	3.2	5.6	4.1	2.8	
Dependent functional status	2.5	5.7	2.9	2.1	**<.001***
ASA class					**<.001***
I	1.7	2.3	2.1	1.5	
II	43.0	53.4	45.3	41.5	
III	52.5	41.9	50.0	54.2	
IV	2.8	2.3	2.7	2.8	

COPD, chronic obstructive pulmonary disease; *ASA*, American Society of Anesthesiologists.
* Significance defined as $P < .0045$ after Bonferroni correction; significant values are in bold.

Table II
Association of total shoulder arthroplasty with operative duration and postoperative length of stay by multivariate regression

	2005-2010	2011–2014			2015-2018		
	Mean ± SD	Mean ± SD	β	*P* value	Mean ± SD	β	*P* value
Multivariate comparison of means							
Operative duration (min)	125 ± 53	116 ± 48	**−9**	**<.001***	108 ± 43	**−16**	**<.001***
Length of stay (d)	2.2 ± 1.7	2.1 ± 2.7	**−0.1**	**<.001***	1.7 ± 3.6	**−0.6**	**<.001***

SD, standard deviation.
The unstandardized β represents the change in operative duration (min) or length of stay (d), relative to 2005-2010.
* Significance defined as $P < .0025$ after Bonferroni correction; significant values are in bold.

Patients in the 2015-2018 cohort tended to be sicker overall, with a higher average ASA class and increased incidence of morbid obesity, diabetes, and COPD. Interestingly, the overall complication rate was actually lowest in this cohort (2.36% vs. 2.77% in the 2011-2014 cohort vs. 2.78% in the 2005-2010 cohort), though the difference was not significant ($P = .172$). The rates of several specific postoperative complications, however, were significantly lower in the 2015-2018 cohort including sepsis, urinary tract infection, and postoperative blood transfusion. It is possible that the decrease in postoperative blood transfusion observed in this study is related to the growing popularity of using tranexamic acid during TSA. Indeed, a meta-analysis by Kuo et al[25] showed a risk ratio of 0.34 (95% confidence interval: 0.14-0.79) for transfusion after TSA when tranexamic acid was used.

These findings of decreased complications despite increased comorbidities are in stark contrast to previous research.[27] Johnson et al,[24] for instance, found patients with an ASA class greater than 2 to be 2.27 times more likely to suffer a surgical complication during short-term follow-up after TSA ($P < .001$). Metabolic syndrome and morbid obesity have also been associated with increased complication rates after shoulder arthroplasty (SA).[19,29] Diabetes has been shown to be an independent risk factor for wound complications, stroke, renal failure, and sepsis after SA.[18,31] Similarly, Lee et al[26] found COPD to be an independent risk factor for pneumonia and septic shock among patients undergoing TSA.

Given the increasing medical complexity of patients undergoing TSA in the setting of decreasing operative times, it is somewhat surprising that the use of regional blockade as the primary form of anesthesia appears to have decreased over time (5.6% in 2005-2010 vs. 2.8% in 2015-2018). Consistent with this study's finding, Herrick et al[21] reported that of 67,316 patients who underwent SA during 2010-2015, only 3.1% had a nerve block as the sole form of anesthesia. Interestingly, the authors of that study also found that relative to general anesthesia alone, the nerve block only approach was associated with decreased rates of pulmonary compromise, infection, blood transfusion, prolonged hospital stay, and intensive care unit stay, even after adjusting for medical comorbidities. Perhaps, the efficacy and growing popularity of combining general and regional anesthesia, in addition to the difficulty of converting from regional alone to general while in the beach chair position, have limited the utilization of regional anesthesia as the primary or only anesthesia for SA.[21,41]

The average hospital LOS and the percentage of patients with non-home discharge both decreased over the course of the study

Table III
Comparison of adverse outcomes by year of index TSA surgery

	All patients	Year of index TSA surgery			*P* value
		2006-2010	2011-2014	2015-2018	
	N = 23,753 (%)	n = 1116 (%)	n = 5920 (%)	n = 16,717 (%)	
Any complication	2.48	2.78	2.77	2.36	.172
Death	0.19	0.27	0.20	0.17	.725
Cardiac complications	0.31	0.18	0.25	0.34	.418
Renal complications	0.13	0.00	0.17	0.13	.362
Respiratory complications	0.66	0.81	0.63	0.66	.789
Deep vein thrombosis	0.36	0.18	0.34	0.38	.514
Stroke/cerebrovascular accident	0.09	0.09	0.14	0.07	.395
Sepsis	**0.16**	**5.17**	**0.17**	**0.12**	**.003***
Wound infection	0.43	0.18	0.47	0.42	.384
Wound dehiscence	0.06	0.09	0.08	0.05	.677
Urinary tract infection	**0.69**	**1.16**	**0.86**	**0.60**	**.001***
Perioperative blood transfusion	**2.39**	**3.05**	**4.80**	**1.50**	**.001***
Non-home discharge	**10.01**	N/A	**11.74**	**9.38**	**.001***

TSA, total shoulder arthroplasty; *N/A*, not available.
Readmission data were available for 22,614 (95.2%) patients.
* Significance defined as $P < .0038$ after Bonferroni correction; significant values are in bold.

Table IV
Multivariate analysis comparison of adverse outcomes by year of index total shoulder arthroplasty surgery

	Multivariate analysis			
	2011-2014 vs. 2006-2010		2015-2018 vs. 2006-2010	
	OR	*P* value	OR	*P* value
Sepsis	0.33	.034	**0.17**	**<.001***
Urinary tract infection	0.75	.373	**0.47**	**<.001***
Blood transfusion	1.54	.021	**0.46**	**<.001***
	2015-2018 vs. 2011-2014			
	OR	*P* value		
Non-home discharge	**0.79**	**<.001***		

OR, odds ratio.
* Significance defined as $P < .013$ after Bonferroni correction; significant values are in bold.

period. These trends seem to have begun even earlier, as Singh and Ramachandran[33] noted significant decreases in LOS and non-home discharge after TSA when comparing patient cohorts from 1998-2000 and 2009-2010. There was a statistically significant decrease in LOS from 2.2 (2005-2010) to 2.1 (2011-2014) that is interesting, but unlikely to be clinically significant as costs are typically incurred on admission and on a daily basis. Notably, the shorter average hospital stay and decrease in non-home discharge observed in the 2015-2018 cohort of this current study occurred despite increased rates of comorbidities, which is typically associated with increased LOS and a higher proportion of non-home discharge.[3,5,6,17,28] This phenomenon may be the result of an improved understanding of which patients are good candidates for outpatient TSA, improved care coordination, patient education, and advances in both multimodal pain management and regional anesthesia.[4,10,11] Although not evaluated in this study, patients discharged home, especially on the day of surgery, are generally younger and have fewer comorbidities. However, a study by Apostolakos et al[2] showed increased rates of short-term morbidity with non-home discharge, even after adjusting for comorbidities. Further studies are needed to corroborate these findings, as economic pressures continue to encourage short-stay or outpatient TSA, with an estimated cost savings per patient between $747 and $15,507.[35]

This study has several limitations that must be acknowledged. No distinction was made between anatomic and reverse TSA, as both are coded under Current Procedural Terminology 23472. Although the NSQIP database contains data on numerous postoperative medical complications, complications specific to orthopedic surgery such as prosthetic joint infection and implant failure are not tracked. In addition, only complications occurring within 30 days of the index surgery are included, creating a shortened picture of the entire recovery period. The database also does not track postoperative patient phone calls to the surgeon, office visits, or emergency room visits, all of which are relevant to LOS and discharge destination. Data from NSQIP are not randomized from the United States population, but are rather composed of submissions from larger institutions that are more likely to have an academic affiliation than the average US hospital. These hospitals, though not perfectly representative of the United States overall, are still diverse with respect to size, location, and academic status, making our results generalizable. Lastly, because of its retrospective nature, this study did not assess for causation behind the observed changes in patient-specific factors, surgical characteristics, and postoperative course. Despite these limitations, this remains one of the largest studies to assess trends in TSA over the past decade.

Conclusions

Between 2005 and 2018, patients undergoing TSA had increasingly more medical comorbidities yet experienced fewer perioperative complications, namely blood transfusion, urinary tract infections, and sepsis. In addition, the average hospital LOS decreased over the course of the study period, and patients were more frequently discharged home. These trends in TSA will likely continue to evolve as the population ages, operative techniques advance, our ability to identify optimal candidates for outpatient surgery improves, preoperative medical optimization is championed, and efforts to reduce health care costs intensify.

Disclaimer

Dr. William N. Levine is an unpaid consultant for Zimmer Biomet.

Dr. Charles M. Jobin is a paid consult and speaker or presenter for Acumed, LLC, Wright Medical and ZImmer Biomet. He is a paid

consultant for Consortium of Focused Orthopedists, DePuy Synthes, Integral Life Sciences and Integrated Shoulder Collaboration Inc. He also receives research support from Acumed. The other authors of this study authors, their immediate families, and any research foundations 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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