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Comparative analysis of anatomic and reverse total shoulder arthroplasty: in-hospital outcomes and costs

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Background: The rate of shoulder arthroplasty has continued to increase at an exponential rate during the past decade in large part owing to approval by the Food and Drug Administration of reverse shoulder arthroplasty. Whereas reverse shoulder arthroplasty has resulted in expanded surgical indications, there are numerous reports of relatively high complication rates. The increased prevalence of both anatomic and reverse shoulder arthroplasty underscores the need to elucidate whether perioperative outcomes are influenced by type of total shoulder arthroplasty. The purpose of this study was to determine the impact of shoulder arthroplasty type, anatomic or reverse, with respect to perioperative adverse events, in-hospital death, prolonged hospital stay, nonroutine disposition, and hospital charges in a nationally representative sample.

Methods: By use of the Nationwide Inpatient Sample database from 2011, the first year that reverse total shoulder arthroplasty received a unique *International Classification of Diseases, Ninth Revision* procedure code, an estimated 51,052 patients undergoing total shoulder arthroplasty were separated into anatomic total shoulder arthroplasty (58%) and reverse total shoulder arthroplasty (43%). Comparisons of early outcome measures between anatomic and reverse total shoulder cohorts were performed by bivariate and multivariable analyses with logistic regression modeling.

Results: Compared with anatomic shoulder arthroplasty recipients, patients undergoing reverse shoulder replacement were at higher risk for in-hospital death, multiple perioperative complications, prolonged hospital stay, increased hospital cost, and nonroutine discharge.

Conclusion: Despite the expanding indications for reverse shoulder arthroplasty, it is an independent risk factor for inpatient morbidity, mortality, and hospital costs and should perhaps be offered more judiciously and performed in the hands of appropriately trained shoulder specialists.

Level of evidence: Level III, Retrospective Cohort Design, Treatment Study.

Keywords: Nationwide Inpatient Sample; shoulder arthroplasty; reverse shoulder arthroplasty; perioperative complications

IRB: The data are de-identified and commercially available online. No IRB approval was required.

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Shoulder arthroplasty has evolved into a frequent surgical procedure during the last decade. Since 2004, total shoulder arthroplasty (TSA) has increased by approximately 3000 cases each year in the United States compared with an annual increase of fewer than 400 cases each year prior.[30] This trend is expected to continue[15] and is likely due to a multitude of factors, including improved implant design and surgical technique,[9] increased density of shoulder and elbow specialists, expanding elderly population, and Food and Drug Administration approval of reverse total shoulder arthroplasty (RTSA) in November 2003.[30]

Anatomic total shoulder arthroplasty (ATSA) is frequently employed as a treatment modality for patients with symptomatic degenerative glenohumeral joint disease with an intact rotator cuff and maintained glenoid.[16,38,49] RTSA has broader indications, and its use has been categorized as "salvage surgery"[31] because it most commonly follows failed hemiarthroplasty, failed ATSA, or cases of rotator cuff insufficiency with or without glenohumeral arthritis.[4-6,21] Other indications for RTSA include rheumatoid arthritis, acute displaced proximal humerus fracture, comminuted proximal humerus fracture, and shoulder girdle tumors.[53] Overall, complications occur in roughly 10% of ATSA patients,[12,22] whereas RTSA has reported complication rates of 19% to 75%.[1,11,21,55] The expansive indications for RTSA highlight the importance of this technique and the complexity of diagnoses untreatable by traditional ATSA.

The purpose of this study was to elucidate the impact of shoulder arthroplasty type, either anatomic or reverse, with respect to perioperative adverse events, in-hospital death, prolonged hospital stay, nonroutine disposition, and hospital charges in a large cohort of individuals admitted to hospitals within the United States participating in the Nationwide Inpatient Sample (NIS). Accounting for confounding factors, our null hypothesis is that there would be no significant differences in inpatient outcomes and hospital costs between ATSA and RTSA patients.

Materials and methods

This study was exempt from approval by our Institutional Review Board as all data used in this project were de-identified before use.

The NIS is a survey of hospitals that is annually conducted by the federal Healthcare Cost and Utilization Project and sponsored by the Agency for Healthcare Research and Quality. It is the largest publicly available all-payer inpatient discharge database in the United States,[32] consisting of a random sample from all hospital discharges from selected hospitals in 46 participating states for 2011[34] (Alabama, Delaware, Idaho, and New Hampshire were absent). Every year since 1988, this survey has been updated yearly to include demographic, clinical, and resource use data.[20] In 2011, data were collected from 7 to 8 million hospital stays from 1045 hospitals in the United States. This figure represents approximately 20% of the hospitals and more than 97% of the U.S. population. Discharge weight files are provided by the NIS to arrive at valid national estimates.[34]

This database is a dynamic health care tool because it records up to 25 medical diagnoses and 15 procedures, which can be identified through *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes. Further, the database includes patient and hospital characteristics and inpatient outcomes, including discharge disposition, length of stay, and total hospitalization charges.[23,39] A review of the literature indicates that this has been employed in a variety of ways to analyze data associated with a cornucopia of diagnoses across the medical landscape.[3,8,14,17,34,35]

We used the NIS to identify adult patients undergoing TSA between January 1, 2011, and December 31, 2011. Discharges with a procedure code (ICD-9-CM) for ATSA (81.80) and RTSA (81.88) were included in the sample. Concurrent medical comorbidities and perioperative complications were identified by ICD-9-CM diagnosis codes and the Clinical Classifications Software categories.[19,26,35]

This study considered 5 outcome variables: (1) perioperative complications, (2) in-hospital death, (3) prolonged hospital stay, (4) nonroutine discharge, and (5) increased hospital cost. Prior work has defined a prolonged hospital stay, and increased hospital cost was defined as an average length of stay or hospital cost greater than the 75th percentile.[19,26,35] Discharge disposition status was characterized as routine (home) or nonroutine (short-term hospital, skilled nursing facility, intermediate care, another type of facility, home health care, against medical advice, and death).

Using a unique identifier number assigned by the NIS to each hospital, we were also able to derive the hospital volume by counting the number of RTSAs and ATSAs performed at each hospital during 2011.[27] Hospital volume was then categorized into 3 groups by patient-based tertiles (for RTSA: low-volume: <15 procedures; intermediate-volume: 15-34; high-volume: ≥35; for ATSA: low-volume: <18; intermediate-volume: 18-38; high-volume: ≥39).

Normal distribution of the data was assumed because of the large sample size. In bivariate analysis, the ATSA and RTSA groups were compared by Pearson χ^2 test for categorical data and independent samples *t* test for continuous data. We then performed multivariable binary logistic regression analyses to determine whether RTSA was a risk factor for complications, mortality, prolonged hospital stay, nonroutine discharge, and higher hospital charges. The aforementioned models were adjusted for age, gender, race, and comorbidities and reported as an odds ratio (OR) with respect to 95% confidence interval (CI). Statistical significance was set at $P < .05$. SPSS version 22.0 (SPSS, Chicago, IL, USA) was used for all statistical analyses and data modeling.

Results

In 2011, there were an estimated 51,052 TSAs performed with 29,359 ATSAs (58%) and 21,693 RTSAs (43%) (Table I). Compared with RTSA, recipients of ATSA tended to be younger (67 ± 12 years vs 73 ± 11 years; $P < .001$), to be male (50% male vs 36% male; $P < .001$), to rely on private insurance (31% vs 15%; $P < .001$), and to live in the North-East (17% vs 15%; $P < .001$) or West (22% vs 18%; $P < .001$).

Of the patients presenting for ATSA, 89% had a primary diagnosis of osteoarthrosis and 4.6% had a primary diagnosis of rotator cuff arthropathy. Of the patients presenting