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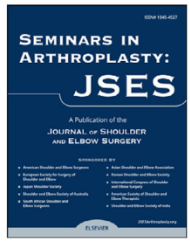

Arthroplasty costs excluding implants: anatomic total shoulder versus reverse shoulder arthroplasty

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ABSTRACT

Background: The incidence of reverse total shoulder arthroplasty (rTSA) has been rising exponentially in recent years. Compared to anatomic total shoulder arthroplasty (aTSA), rTSA incurs higher total hospital costs, largely due to implant prices. However, rTSA typically requires less operating room (OR) time and is a cementless procedure, potentially representing important cost savings. Our aim is (1) to evaluate the difference in total hospital costs for rTSA and aTSA excluding implant costs and (2) to identify cost factors between the two procedures. Our hypothesis is that rTSAs and aTSAs will have similar costs excluding implants due to offsetting personnel and supply costs.

Methods: Time-driven activity-based costing was utilized to determine the costs of rTSAs and aTSAs at our single-specialty hospital from January 2018 to 2020. Implant costs were subtracted from total hospital costs to determine costs excluding implants. Other demographic and cost parameters were also compared.

Results: Nine hundred twenty-one primary shoulder procedures were analyzed (577 rTSAs and 344 aTSAs). Patients undergoing rTSA were significantly older, had a larger American Society of Anesthesiologists classification, had a longer length of stay, and were more likely to have Medicare as the primary insurance. Additionally, patients undergoing rTSA had significantly less OR time and fewer home discharges ($P < .05$). However, excluding implants, supply costs and overall hospital costs were 0.86× and 1.01× the cost of aTSA, respectively ($P < .001$ and $P = .560$), indicating that there was no significant difference between rTSA and aTSA overall hospital costs when omitting implant costs. Implants accounted for 97% of the difference in overall hospital costs between rTSA and aTSA.

Conclusion: Excluding implants, rTSA and aTSA have similar hospital costs. The savings with rTSA attributed to decreased OR time and supplies (excluding implants) are offset by personnel costs and length of stay from the postanesthesia care unit through discharge. Decreasing rTSA implant prices to the level of aTSA would equate the costs for these two

This study was approved by the Institutional Review Board of the New England Baptist Hospital, Project Number - # 1629639.

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procedures. As the incidence of rTSA rises, strategies to decrease implant costs are important for decreasing overall health expenditures.

Level of evidence: Level IV; Retrospective Cost Analysis Without a Sensitivity Analysis

Anatomic total shoulder arthroplasty (aTSA) and reverse total shoulder arthroplasty (rTSA) are reliable and effective procedures for treating various shoulder pathologies, and demand has been increasing in the last ten years with projections of over 250,000 cases annually in 2025.[6,11,22] Although the outcomes achieved are favorable, efforts on decreasing medical expenditures are a pre-eminent concern as the country moves to payment models centered on value for the patient, defined as health outcomes achieved per dollar spent.[18] Within this landscape of value-based health care, health systems must focus on resource optimization and improving insight into high-volume procedure expenditures.

A previous study on aTSA and rTSA found implant prices to be the main driver of costs, comprising 57%-60% of total hospital costs.[15] A multicenter study found that variation in episode of care costs for aTSA and rTSA had no association with hospital or surgeon case volume but driven primarily by implant and personnel costs.[5] Total hospital costs for rTSA were shown to be higher than those for aTSA, principally due to increased implant costs.[4] Differences between rTSA and aTSA costs are largely overshadowed by implant costs, but due to the confidential nature of financial research, it is unclear how the two shoulder procedures compare withholding implant prices.

The aims of this study were (1) to compare the episode of care costs for aTSA and rTSA excluding implants and (2) to determine cost differences among different stages of the care process. Our hypothesis is that after omitting implant prices, the episode of care costs for aTSA and rTSA will be similar.

Methods

Study design

After institutional review board approval was obtained, we retrospectively identified financial data at our single-specialty orthopedic institution for patients who underwent elective, primary, unilateral aTSA or rTSA procedures during the study period of January 2018 through July 2020. Total in-hospital costs were identified for all cases, which composed of personnel and supply costs including implant costs. Implant costs were subtracted from total in-hospital costs to determine the study costs and were compared between aTSA and rTSA. Additional factors including age, sex, American Society of Anesthesiologists (ASA) classification, operating room (OR) time, discharge disposition, length of stay (LOS), and insurance type were also collected and compared. The episode of care was defined as the patient stay consisting of check-in day of surgery to point of discharge. Fiscal data are presented as indexed values to protect hospital proprietary financial information.

Time-driven activity-based costing

Episode of care costs were determined with the use of a third-party, commercial medical cost-analysis database, Avant-garde Health (Boston, MA, USA). Time-driven activity-based costing (TDABC) was used to determine granular patient costs, representing a modern, value-based cost accounting method created by Kaplan and Anderson.[10] TDABC has become the gold standard for cost determination studies, validated extensively in the orthopedic literature including shoulder arthroplasty and beyond.[1,4,5,7,9,10,15,17] The episode of care costs for this study included the day of surgery to discharge for the shoulder procedures and were calculated by taking the cost per minute of each personnel and multiplying it by the time utilized in the care of the patient and summing with the total supply costs including implants, medications, and other supplies (eg, OR consumables). Each patient care process was mapped and analyzed for all cases to calculate costs. Fixed costs were regarded as constants, and indirect costs were excluded from the study.

Statistical analysis

Chi-square and Student's t-tests were used to compare categorical and continuous data, respectively. To ensure hospital financial confidentiality, rTSA costs were indexed to aTSA costs. Statistical analyses were performed using SAS v9.4 (SAS Institute, Cary, NC, USA). Significance was defined as $P < .05$.
No external funding was received for this work.

Results

Nine hundred twenty-one primary shoulder procedures were included in this study with 577 rTSAs and 344 aTSAs (Table I). Patients undergoing rTSA were more often female (55.5% vs. 44.4%; $P = .003$), older (71 vs. 64.4; $P < .001$), and insured by Medicare (62.2% vs. 39.9%; $P < .001$). At the time of surgery, rTSA patients had a higher ASA classification (2.4 vs. 2.2; $P < .001$), longer LOS (1.9 vs. 1.6; $P < .001$), and higher rate of discharge to a skilled nursing facility (SNF)/inpatient rehab (11.4% vs. 3.8%; $P < .001$) but shorter operative times (161.2 vs. 165; $P = .039$).

Table II shows the cost variables of rTSA indexed to aTSA. Total personnel costs for rTSA were 1.03× that of aTSA

Table I — Patient demographic and hospital data.

Parameter	rTSA (n = 577)	aTSA (n = 344)	*P* value
Gender†			
Male	257 (44.5)	188 (54.6)	.003*
Female	320 (55.5)	156 (45.4)	
Age‡	71.0 ± 7.6	64.4 ± 8.3	<.001*
ASA‡	2.4 ± 0.5	2.2 ± 0.5	<.001*
OR time (minutes)‡	161.2 ± 30.3	165.0 ± 22.5	.039*
LOS‡	1.9 ± 0.9	1.6 ± 0.7	<.001*
Insurance type†			
Medicaid	3 (0.5)	0 (0)	<.001*
Medicare	353 (61.2)	134 (38.9)	
Private	193 (33.5)	197 (57.3)	
WC	28 (4.8)	13 (3.8)	
Discharge disposition†			
Home	511 (88.6)	331 (96.2)	<.001*
SNF	55 (9.5)	10 (2.9)	
Inpatient Rehab	11 (1.9)	3 (0.9)	

rTSA, reverse total shoulder arthroplasty; *aTSA*, anatomic total shoulder arthroplasty; *ASA*, American Society of Anesthesiologists; *OR*, operating room; *LOS*, length of stay; *WC*, workers' compensation; *SNF*, skilled nursing facility; *Rehab*, rehabilitation.

* Indicates significant *P*-Values: <.050.

† Represented as n (%).

‡ Represented as mean ± standard deviation.

Table II — Indexed cost variables.

Parameter	rTSA	aTSA	*P* value
Total personnel cost	1.03	-	.004*
Personnel Preop through OR cost	0.98	-	.014*
Personnel PACU through discharge cost	1.08	-	<.001*
Implant cost	1.16	-	<.001*
Supply cost excluding implants	0.86	-	<.001*
Total in-hospital cost including implants	1.09	-	<.001*
Total in-hospital cost excluding implants	1.01	-	.560

rTSA, reverse total shoulder arthroplasty; *aTSA*, anatomic total shoulder arthroplasty; *Preop*, preoperative; *OR*, operating room; *PACU*, postanesthesia care unit.

* Indicates significant *P*-Values: <.050.

(*P* = .004). Personnel costs for rTSA were 0.98× aTSA from the preoperative process through the OR (*P* = .014) but were 1.08× aTSA from the postanesthesia care unit through discharge (*P* < .001). Implant cost for rTSA was 1.16× aTSA (*P* < .001), but supply costs excluding implants were 0.86× aTSA (*P* < .001). Overall episode of care costs were higher for rTSA than those for aTSA when including implant costs (*P* < .001), but excluding implants, episode of care costs were not significantly different (*P* = .560). Implant costs accounted for 97% of the difference in overall hospital costs between rTSA and aTSA (Fig. 1).

Discussion

As the country moves toward value-based payment models, all invested members of the health care system must improve their understanding of the costs of major orthopedic procedures. Total episode of care costs for rTSA were more expensive than those for aTSA, driven primarily by implant costs. However, when excluding implant price, we found that aTSA and rTSA did not significantly differ in overall costs.

Consistent with previous literature, implant price was found to be the main driver of total episode of care costs for both aTSA and rTSA.[4,5,15] Our study found that 97% of the difference in overall episode of care costs between rTSA and aTSA was explained by implant cost. Implant price continues to be the greatest target for decreasing costs regardless of the arthroplasty procedure. Case volume is often postulated as leverage for negotiating reduced implant prices. However, this relationship may not apply to shoulder arthroplasty procedures. Despite previous literature showing rTSA implant costs to be 17% more expensive than aTSA,[4] rTSA was performed 1.67× more often than aTSA during our study period. This distribution of these procedures has stayed consistent over time at our institution.[4] This might indicate negotiating strategies based on volume to be of lesser benefit. Alternative strategies to implant cost negotiations include price capitation or reference pricing, which has been shown to decrease implant costs in total knee arthroplasty.[8] Other strategies to reduce cost have been explored in the literature, including preoperative planning to reduce the number and cost of sterilized trays and performing outpatient shoulder arthroplasty when appropriate for the patient.[20,21] The discrepancy in implant costs for these two shoulder procedures represents a potential opportunity for cost savings.

In our study, we found that patients undergoing rTSA were more often older and female compared with aTSA. Prior studies have shown that women sustain longer lengths of hospital stay and inferior functional outcomes after aTSA.[14,23] Further, women are over 3× more likely to be among the most expensive cost patients following aTSA.[15] While further investigation is warranted, possible explanations of the increased cost include nociceptive and psychosocial differences between men and women.[15] rTSA patients also had more often Medicare insurance and higher ASA scores than aTSA patients. The higher rate of Medicare insurance is most likely due to the increased age seen in the rTSA cohort (average age being above 65 years old compared to aTSA). This distribution of payer status does not affect the cost data, and thus, costs do not affect decision-making for this population. More likely, surgical indications of age are a more likely influence on surgical decision-making. Higher ASA scores have been identified as a predictor for readmission and linked to increased resource utilization and hospital costs following aTSA.[2,13,15] Patients who underwent rTSA also were discharged to SNFs more often than those who underwent aTSA. Discharge to nonhome facilities has a higher chance of adverse events for shoulder arthroplasty patients.[12] A previous study on 90-day outcomes for aTSA patients found an increased cost of $2402 for SNF discharge as compared to home discharge.[19] As compared to unmodifiable variables of age and sex, discharge disposition represents a modifiable risk factor for negative outcomes and increased costs and thus a potential target for cost-reduction strategies. Preoperative optimization of prospective risks may decrease rates of SNF discharges and reduce overall hospital costs.

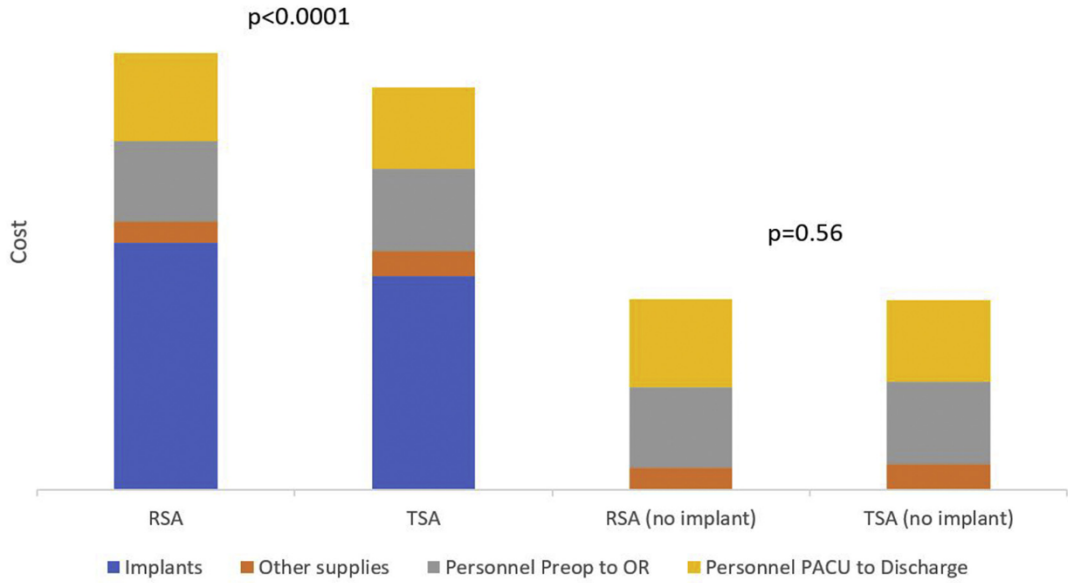

Figure 1 – Bar graph comparing total costs with and without implants. *rTSA*, reverse total shoulder arthroplasty; *aTSA*, anatomic total shoulder arthroplasty; *Preop*, preoperative; *PACU*, postanesthesia care unit; *OR*, operating room.

As shown by our results, personnel costs from the preoperative process to the OR were less expensive for rTSA patients (Table II). However, rTSA personnel costs were more expensive than aTSA from the postanesthesia care unit through discharge. This increase in costs is likely a reflection of the increased level and duration of care needed for these older patients with higher comorbidity burdens after surgery, as more comorbidities and a higher ASA score have been linked to increased resource utilization and hospital costs.[2,13,15] Postoperative personnel costs can be reduced by decreasing patient LOS. Pre-emptive measures to ensure reduced patient hospital stay are reasonable. Outpatient total shoulder arthroplasty has been shown to be a safe approach with select patients.[3] A judicious process for selecting the appropriate patients for outpatient surgery could reduce postoperative stay and personnel costs and thus overall episode of care costs.[21]

We found OR times for rTSA to be lower than those for aTSA, representing cost savings in personnel and supplies. The cementless technology of rTSA likely contributes to this decreased OR time. Though significant, the slight decrease in OR time of 4 minutes is not clinically relevant, as the time difference is outweighed by the increased personnel costs rTSA patients experience. The operational efficiency of arthroplasty procedures is influenced by institutional and surgeon factors and thus may differ from location to location. Multicenter collaborations may provide important information on the relationship of costs between rTSA and aTSA.

The strengths of this study include the relatively large sample size of 921 shoulder procedures with patient demographics including age, ASA, and LOS, as well as the use of the modern cost-accounting methodology, TDABC. TDABC has been validated in previous studies on upper- and lower-extremity arthroplasty, emerging as the premier cost-accounting methodology for analyzing granular patient costs.[1,4,7,15,17] The current study has several limitations. This was a retrospective study of prospectively collected data from a single-center, orthopedic specialty hospital, which may limit the generalizability of the results to academic medical or tertiary referral centers. Orthopedic specialty hospitals have greater OR shoulder arthroplasty efficiency than tertiary referral centers, which may further increase variation in costs between locations.[16] Our study utilized over 8 surgeons for the performed procedure, but past literature has shown overall costs to not be correlated with individual surgeon or institutional case volume.[5] Additionally, our study is limited because diagnosis was not included in the analysis, even though surgeons tend to have different selection criteria for the implant type in patients with indications that could be treated with either aTSA or rTSA. Therefore, a future study discussing cost differences in patients receiving aTSA vs. rTSA with overlapping indications is warranted. Another limitation includes our episode of care TDABC methodology not capturing post-discharge costs. rTSA patients more often went to SNFs than aTSA patients in our study, and this certainly influences total medical expenditures for this patient group. However, these costs play a lesser role in overall shoulder procedure costs than in total hip and knee arthroplasty due to the lower percentage of patients needing postacute care. Despite the limitations of this study, we believe the results to be an important insight to shoulder arthroplasty costs and serve as a reference point for targeting value-improving cost-containment strategies.

Conclusion

Episode of care costs for rTSA and aTSA excluding implant prices were similar. Consistent with previous studies, implant price was the main driver of overall costs and represented 97%

of the difference in costs between the two procedures. rTSA had shorter OR time, but these costs were offset by increased personnel costs due to longer in-hospital stay. Decreasing implant costs will reduce overall expenditures for all arthroplasty procedures; however, appreciation of the disparity in costs between rTSA and aTSA excluding implants is important for assessing strategies to improve value.

Disclaimers:

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Conflicts of interest: Eric Smith is a paid consultant for and receives research support from DePuy and Conformis. He is a board/committee member for the AAOS and AOA. Jonathan Levy is a paid consultant for DJO Orthopaedics and Globus Medical. He receives royalties from DJO Orthopaedics and Innomed. Andrew Jawa is a paid speaker and consultant for DJO Global, is a paid consultant for Ignite Orthopedics, receives royalties from OBERD and DePuy Synthes, and has equity in Boston Outpatient Surgical Suites. The other 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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