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The hospital cost of two-stage reimplantation for deep infection after shoulder arthroplasty

Yaser M.K. Baghdadi, MD, Hilal Maradit-Kremers, MD, MSc, Taylor Dennison, MD, Jeanine E. Ransom, BA, John W. Sperling, MD, MBA, Robert H. Cofield, MD, Joaquin Sánchez-Sotelo, MD, PhD *

Department of Orthopedic Surgery, Mayo Clinic, Rochester, MN, USA

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Background: The cost of treating infection after hip and knee arthroplasty is well documented in the literature. The purpose of this study was to determine the cost of two-stage reimplantation for deep infection after shoulder arthroplasty.

Methods: Between 2003 and 2012, 57 shoulders (56 patients) underwent a two-stage reimplantation for deep periprosthetic shoulder infection; implants placed at reimplantation included anatomic total shoulder arthroplasty (a-TSA) in 58%, reverse total shoulder arthroplasty (r-TSA) in 40%, and hemiarthroplasty (HA) in 2%. During the same timeframe, 2953 primary shoulder arthroplasties (2589 patients) were performed at the same institution (a-TSA in 55%, r-TSA in 28%, and HA in 17%). Total direct medical costs were calculated by using standardized, inflation-adjusted costs for services and procedures billed during hospitalization and were adjusted to nationally representative unit costs in 2013 inflation-adjusted dollars.

Results: The mean hospital cost (per shoulder) for two-stage reimplantation was $35,824 (95% CI: 33,363 to 38,285) and was significantly higher than for primary procedures (mean: $16,068; 95% CI: 15,823 to 16,314). Both Part A and Part B costs were significantly higher in two-stage reimplantation ($p < 0.001$). For part A (hospital services), the mean cost for two-stage reimplantation was $29,851 (95% CI: 27,741 to 31,960), compared to $13,508 (95% CI: 13,302 to 13,715) for primaries. For part B (professional costs), mean costs were $5973 (95% CI: 5493 to 6453) versus 2560 (95% CI: 2512 to 2608) *respectively*.

Conclusions: The hospital cost of two-stage reimplantation for the treatment of an infected shoulder arthroplasty is about two times higher than the cost of a primary shoulder arthroplasty.

Deep periprosthetic infection after shoulder arthroplasty is a devastating complication. In 2011, there were approximately 65,000 shoulder arthroplasties performed in the United States,[6,17] and the volume of this procedure is expected to continue to grow.[5,8] As a result, the number of revisions due to failures is also anticipated to increase.[5,19] The overall estimated rate of deep infection after shoulder arthroplasty is approximately 1%.[15] Taking into account the rising number of shoulder arthroplasties being performed, the cost of managing the infected shoulder arthroplasty is expected to grow as well.

The financial burden associated with the treatment of periprosthetic hip and knee infections has been well-analyzed in the literature.[4,7,10,12,13,20] It has been shown that the cost of revisions for periprosthetic hip and knee infections in the United States rose from $320 million to 566 million between 2001 and 2009.[10] By 2020, this is expected to be around $1.62 billion.[10] The financial burden associated with the treatment of an infected shoulder arthroplasty is likewise expected to be substantial.[15] The characteristics of periprosthetic shoulder infections are unlike those of the hip and knee, and previous reports suggest that they have a higher morbidity and costs compared with periprosthetic infections of other joints.[3,14]

In North America, two-stage reimplantation is the most common treatment strategy used for the infected shoulder arthroplasty. To our knowledge, there is limited available information in the specific costs of treating a deep periprosthetic shoulder infection. The purpose of this study was to estimate the hospital cost of two-stage reimplantation for the treatment of deep infection after

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* Corresponding author. Joaquin Sánchez-Sotelo, MD, PhD, Department of Orthopedic Surgery, Mayo Clinic, 200 1st Street SW, Rochester, MN 55905, USA.
E-mail address: sanchezsotelo.joaquin@mayo.edu (J. Sánchez-Sotelo).

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shoulder arthroplasty as compared to the cost of an uncomplicated primary shoulder arthroplasty.

Materials and methods

Study cohort

This study was performed after approval from our institutional review board (IRB). Our institutional joint registry database[2] was utilized to identify all patients who underwent primary shoulder arthroplasty and all patients who underwent two-stage reimplantation for a periprosthetic shoulder joint infection between 2003 and 2012. The study cohort included 2953 primary procedures performed in 2589 patients, and 57 two-stage reimplantation procedures performed in 56 patients.

In the primary arthroplasty group, there were 1575 female patients (53%) and 1378 male patients (47%), with mean body mass index (BMI) of 30 ± 6 kg/m^2, and mean age of 68.1 ± 12.3 years. The types of procedures performed in this group included an anatomic (non-reverse) total shoulder arthroplasty (a-TSA) in 1608 (55%) shoulders, a reverse shoulder arthroplasty (r-TSA) in 837 (28%) shoulders, and a hemiarthroplasty (HA) in 508 (17%) shoulders (Table I).

In the two-stage reimplantation group, there were 17 female patients (30%) and 40 male patients (70%) with mean BMI of 31 ± 7 kg/m^2 and mean age of 62.9 ± 10.2 years. At the time of reimplantation, the types of procedures performed included an a-TSA in 33 (58%) shoulders, a r-TSA in 23 (40%), and a HA in one (2%) shoulder.

Cost data

Cost data for each hospitalization episode were obtained from an institutional research database that includes line item details (date, type, frequency, and billed charge) and standardized, inflation-adjusted costs for all services and procedures billed to patients treated at our institution.[1,9,11,12] Given the discrepancies between billed charges and true resource use, bottom-up micro-costing valuation techniques were employed to generate standard inflation-adjusted estimates of the costs in constant dollars.[1,9,11,12] As described previously,[1,9,11,12,16] the overall utilization and its value are grouped into Part A (e.g. room and board, radiology, physical therapy, implants, other supplies, etc.) and Part B (i.e., professional costs, examinations and consultations, diagnostic and therapeutic procedures). Costs were adjusted to nationally representative unit costs in 2013 inflation-adjusted dollars. Additionally, costs related to each hospital stay were categorized further into room and board, pharmacy and medications, laboratory and pathology tests, and implants.[1,9,11,12,16]

Statistical analyses

The total direct medical costs during hospitalization were compared between the two study groups, primary shoulder arthroplasty (n = 2953 shoulders) and two stage reimplantation (n = 57 shoulders). For primary arthroplasty procedures, costs were estimated per hospital episode. For patients who had two-stage shoulder reimplantation procedures, costs from the 2 hospitalization episodes were combined and costs were expressed as costs per shoulder. Thus, the cost estimates for two-stage procedures are the total from 2 hospitalizations. As appropriate, data were expressed as means with standard deviations (SD), means with 95% confidence intervals (95% CI), medians with interquartile range (IQR) or frequencies with percentages. The statistical significance was set at a p-value of <0.05.

Results

Overall cost

The mean overall hospital cost (per shoulder) for the treatment of patients with two-stage shoulder arthroplasty reimplantation was $35,824 (95%CI: $33,363 to 38,285) and was more than double (approximately 2.2-fold higher) compared to a mean of $16,068 (95%CI: $15,823 to $16,314) for the treatment with primary shoulder arthroplasty ($p < 0.001$).

The cost difference between primary and two-stage reimplantation groups was evident for both Part A (hospital services) and Part B (professional services) costs. For Part A (hospital services), the costs were significantly higher for two-stage reimplantation procedures with a mean of $29,851 (95%CI: $27,741 to $31,960) compared to $13,508 (95%CI: $13,302 to $13,715) for primary shoulder arthroplasty ($p < 0.001$). For Part B (professional costs), the mean costs were also significantly higher for treating patients with two-stage reimplantation (mean: $5973; 95%CI: $5493 to $6453) compared to patients having primary arthroplasty (mean: $2560; 95%CI: $2512 to $2608) ($p < 0.001$) (Table II).

Length of stay and cost categories

For the two-stage reimplantation group, patients were hospitalized twice, leading to a significantly longer length of stay in the hospital (median: 5 days; IQR: 4 to 7 days) compared to patients who had undergone primary shoulder arthroplasty (median: 2 days; IQR: 1 to 3 days) ($p < 0.001$). Extended hospital stay (2 hospitalizations) for the two-stage reimplantation resulted in a significantly higher costs for room and board utilization with a mean of $6894 (95% CI: 5926 to 7861) compared to $2547 (95% CI: 2450

Table I
Description of the study cohort

Variable	Primary shoulder arthroplasty				Two-stage shoulder arthroplasty reimplantation			
	a-TSA	r-TSA	HA	Overall*	a-TSA	r-TSA	HA	Overall
Patients	1384	786	483	2589	32	23	1	56
Shoulders	1608 (54.5%)	837 (28.3%)	508 (17.2%)	2953 (100.0%)	33 (58.0%)	23 (40.0%)	1 (2.0%)	57 (100.0%)
Female	808	499	268	1575 (53%)	7	9	1	17 (30%)
Male	800	338	240	1378 (47%)	26	14	–	40 (70%)
Mean age	67.1 (±11.5)	72.9 (±9.0)	63.6 (±16.5)	68.1 (±12.3)	61.1 (±10.2)	65.8 (±10.0)	57	62.9 (±10.2)
Mean BMI (±SD)	31.0 (±6.0)	30.0 (±6.0)	30.0 (±7.0)	30.0 (±6.0)	32.0 (±7.0)	31.0 (±6.0)	22.0	31.0 (±7.0)
Median LOS in days (IQR)	2 (1 to 3)	2 (1 to 3)	2 (1 to 3)	2 (1 to 3)	6 (4 to 8)	5 (3 to 6)	3	5 (4 to 7)

LOS, length of hospital stay; *BMI*, body mass index.
* Sixty-four patients had multiple surgery types.