



# The effect of surgeon and hospital volume on shoulder arthroplasty perioperative quality metrics

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**Background:** There has been a significant increase in both the incidence of shoulder arthroplasty and the number of surgeons performing these procedures. Literature regarding the relationship between surgeon or hospital volume and the performance of modern shoulder arthroplasty is limited. This study examines the effect of surgeon or hospital shoulder arthroplasty volume on perioperative metrics related to shoulder hemiarthroplasty, total shoulder arthroplasty, and reverse shoulder arthroplasty. Blood loss, length of stay, and operative time were the main endpoints analyzed.

**Methods:** Prospective data were analyzed from a multicenter shoulder arthroplasty registry; 1176 primary shoulder arthroplasty cases were analyzed. Correlation and analysis of covariance were used to examine the association between surgeon and hospital volume and perioperative metrics adjusting for age, sex, and body mass index.

**Results:** Surgeon volume is inversely correlated with length of stay for hemiarthroplasty and total shoulder arthroplasty and with blood loss and operative time for all 3 procedures. Hospital volume is inversely correlated with length of stay for hemiarthroplasty, with blood loss for total and reverse shoulder arthroplasty, and with operative time for all 3 procedures. High-volume surgeons performed shoulder arthroplasty 30 to 50 minutes faster than low-volume surgeons did.

**Conclusions:** Higher surgeon and hospital case volumes led to improved perioperative metrics with all shoulder arthroplasty procedures, including reverse total shoulder arthroplasty, which has not been previously described in the literature. Surgeon volume had a larger effect on metrics than hospital volume did. This study supports the concept that complex shoulder procedures are, on average, performed more efficiently by higher volume surgeons in higher volume centers.

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

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**Keywords:** Shoulder arthroplasty; surgeon volume; hospital volume

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Since 1993, the rate of shoulder arthroplasty procedures has increased rapidly in the United States,<sup>20</sup> mirroring the aging population, increase in number of practicing orthopaedic surgeons, technologic advances, and expanding indications for these procedures. Whereas the total number of hip and knee arthroplasties remains an order of magnitude higher than shoulder arthroplasties, the annual incidence of shoulder arthroplasty is increasing by a greater percentage every year.<sup>11</sup>

There are several reasons that new outcome and efficiency data regarding shoulder arthroplasty are important. First, there have been several fundamental changes in the biomechanics of total shoulder replacement. In the past decade, we have seen the advent of anatomic systems instead of a standard “one size fits all” approach. Uncemented implants are now common, and subscapularis repair technique has undergone significant innovations.<sup>14</sup> The most radical development has been the widespread use of the reverse total shoulder,<sup>4,5</sup> which was approved by the Food and Drug Administration in 2004. There are no studies of reverse total shoulder arthroplasty and clinical volume despite the technical complexity of the procedure.

Second, shoulder arthroplasty is a relatively rare procedure. In 2003, Hasan and Matsen found that more than 75% of surgeons who perform shoulder arthroplasty perform 1 or 2 procedures per year.<sup>16</sup> Conversely, a 2004 study by Katz demonstrated that 75% of surgeons who perform total knee arthroplasty perform at least 13 procedures annually.<sup>18</sup> This trend may be of concern as the published complication rate of the reverse total shoulder arthroplasty varies from 1% to more than 65% even in the hands of experienced designing surgeons.<sup>39</sup> The reported intraoperative complications that the surgeon has to control for are myriad,<sup>7</sup> including neurologic injury,<sup>21</sup> intraoperative fracture,<sup>36,40</sup> acromial fracture,<sup>25</sup> hematoma,<sup>9,38</sup> and instability.<sup>41</sup>

Finally, a higher percentage of shoulder arthroplasty cases are revised compared with hip and knee arthroplasty,<sup>13</sup> and revision cases have a worse outcome than primary shoulder arthroplasty. In the largest and longest prospective cohort of reverse total shoulder arthroplasty, a French registry has demonstrated that conversion to reverse total shoulder arthroplasty, regardless of the reason for revision, is associated with worse outcomes than any other indication for reverse total shoulder arthroplasty.<sup>36</sup> Therefore, it is crucial that orthopaedic surgeons understand the factors for the optimal performance of primary shoulder replacement as individuals requiring a revision can expect generally compromised outcomes.

There is a body of literature supporting the concept that high-volume surgeons and hospitals perform hip and knee replacement in a safer, more expedient, and in some cases less expensive manner.<sup>24</sup> Given the relative infrequency of the procedure and the large study cohort required, similar studies of total shoulder arthroplasty are scarce<sup>15,17,22</sup> and absent concerning reverse total shoulder arthroplasty.

The purpose of this investigation was to determine the effect of surgeon and hospital volume on the perioperative performance of shoulder hemiarthroplasty (HA), total shoulder arthroplasty (TSA), and reverse total shoulder replacement (RSA). We test the hypothesis that the volume of shoulder arthroplasty cases influences length of stay, blood loss, and surgical time.

## Materials and methods

### Selection of the study cohort

In 2007, Institutional Review Board approval was obtained to commence prospective data collection for a multicenter institutional Shoulder Arthroplasty Registry within a large integrated health care system that serves more than 5 million individuals. Fifteen percent of members are older than 60 years, a good approximation of the U.S. population. A retrospective cohort study was performed with data including demographic information, comorbidities, ICD-9 codes, implant data, surgical metrics, and hospital readmissions. Data were extracted through electronic administrative databases and medical records systems and validated by the authors. A trained clinical content expert (M.F.B.), with extensive knowledge of the clinical definitions relevant to this study, reviewed and monitored the patients' electronic medical records quarterly.

The study population was composed of 1176 elective primary TSA, RSA, and HA procedures between January 2009 and December 2010. Patients with traumatic fractures of the shoulder and their sequelae were excluded from the study as these patients have a significantly higher short-term complication rate<sup>12</sup> and would bias the HA results.

### Definitions of variables

Patients were stratified into 2 groups including annual surgeon volume and annual hospital volume (2009-2010) according to their primary shoulder arthroplasty procedure. Surgeon volume was based on a simple tertial cut of the distribution of cases performed by individual surgeons. The cutoffs were made such that one third of the surgeons were in each group, regardless of the number of cases in each tertial. Hospital volume was cut off at tertial boundaries in the same manner.

Length of stay was calculated by admission and discharge dates. Incision time (cut to close) was used to determine operative time. Blood loss in milliliters was extracted from each patient's chart as recorded in the operative report of the surgeon and nursing notes. Length of stay was extracted from the electronic medical record and is the number of inpatient days a patient was admitted.

### Data analysis

Patient characteristics were presented as mean and standard deviation for TSA, HA, and RSA. Analysis of covariance was used for continuous variables, followed by Tukey adjusted multiple comparison to compare the mean difference among the 3

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