

The Volume-Value Relationship in Shoulder Arthroplasty



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KEYWORDS

• Shoulder arthroplasty • Volume • Outcomes • Cost • Value

KEY POINTS

- High-volume surgeons and high-volume hospitals provide superior outcomes including reduced complications, shorter length of stay, and lower mortality rates.
- High-volume surgeons and hospitals may achieve lower costs for shoulder arthroplasty procedures.
- Evidence-based thresholds can be applied to benchmark volumes that yield favorable outcomes from the volume-value relationship in shoulder arthroplasty.

INTRODUCTION

As the US health care system shifts toward a value-based model of reimbursement, the need to optimize outcomes without restricting services is critical.^{1–3} Value in health care may be defined as a ratio of benefits gained (including patient outcomes and experience) to the overall cost.⁴ Thus, value is increased as outcomes are improved and costs are reduced. Orthopedic surgery is uniquely suited for a value-based model because of the predominance of elective surgery, high procedural costs, and rising volumes.^{2,4,5} High-volume surgeons and hospitals have been demonstrated to yield better outcomes delivered at a lower cost, and thus greater value, for several orthopedic procedures including total hip arthroplasty, total knee arthroplasty, spine arthrodesis, and total ankle arthroplasty.^{6–14} Improved outcomes in higher volume practices have been attributed to

surgeon experience and procedure-specific protocols, although many factors contribute to this complex relationship.^{15,16}

Improving value in shoulder arthroplasty has gained increasing importance as procedure volume increases. The procedure volume of shoulder arthroplasty in the United States has grown at a rate of 9.4% annually, with a sharp increase after Food and Drug Administration approval of reverse total shoulder arthroplasty (TSA) in 2003.^{17,18} This increase may be attributed to several factors, including the implementation of reverse TSA and its ability to effectively treat problems not otherwise treated with standard shoulder arthroplasty, improved implant design, increased availability, an aging patient population, and more surgeons trained in the procedure.^{18,19} Although the hospital length of stay (LOS) decreased significantly from 1993 to 2007, charges for the procedure increased.¹⁸ Data published by Hasan and colleagues²⁰

Disclosure Statement: The authors do not have any relevant commercial or financial conflicts of interest or any funding sources to disclose.

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Orthop Clin N Am 49 (2018) 519–525

<https://doi.org/10.1016/j.jocl.2018.05.012>

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Table 1
Thresholds for annual surgeon and hospital volume

	Surgeon			Hospital				
	Low	Medium	High	Low	Medium	High		
Hammond et al, ²⁹ 2003	<0.9	0.9–4.3	>4.3	<7.1	7.1–14.3	>14.3		
Jain et al, ²² 2004	<2	2–4	>4	<5	5–9	>9		
Lyman et al, ²⁸ 2005	—			<4	4–11.75	>11.75		
Singh et al, ²⁴ 2014	<8	8–17.5	>17.5	<20.5	20.5–26	>26		
Singh & Ramachandran, ²⁷ 2015	—			<5	5–9	10–14	15–24	>24
Scott et al, ²³ 2015	<2	2–5	>5	—				
Ramkumar et al, ²⁶ 2017	<5	5–14	>14	<4	4–14	>14		

analyzing the 1998 New York Statewide Planning and Research Cooperative System database reported that 78.2% of orthopedic surgeons performing shoulder arthroplasty only performed one to two of these procedures annually during the period studied. Thus, it was concluded that shoulder arthroplasty is performed primarily by low-volume providers. Additionally, Somerson and colleagues²¹ described the uneven distribution of high-volume shoulder arthroplasty surgeons, arbitrarily defined as those performing at least 11 procedures annually, suggesting a potential disparity in access.

To enhance the value of shoulder arthroplasty, an improvement of outcomes or a decrease in associated costs must occur. There are multiple reports in the literature expanding on the relationship between increased surgeon and hospital procedure volume and increased value for shoulder arthroplasty, by way of improved outcomes or decreased cost. This review article highlights these studies.

VOLUME THRESHOLDS

Among the studies investigating the volume-value relationship in shoulder arthroplasty, there is a lack of consensus in the thresholds used to categorize surgeons and hospitals as low, medium, and high volume. The surgeon and hospital volume thresholds reported in the literature are available in [Table 1](#).

Several methods were reported in the determination of thresholds for surgeon volume, with the primary technique using a linear distribution of procedures in each group and creating an equal distribution of surgeons in each group.^{22–24} In contrast, Ramkumar and colleagues²⁵ applied stratum-specific likelihood ratio (SSLR) analysis using a receiver operating characteristics, a technique previously used in the analysis of total knee arthroplasty volume.²⁶

The SSLR analysis method generates meaningful volume thresholds using risk stratification for any given dependent variable, from readmission rates to patient-reported outcome measures (PROMs) to revision rate, by providing cutoffs that are supported by a significant difference between adjacent groups.²⁶ Using these evidence-based thresholds, surgeons were stratified into low (<5), medium (5–14), and high (>14) volume. The upper threshold for low-volume surgeons ranged from 0.9 to 8 cases annually. The lower threshold for annual case-load for high-volume surgeons ranged from 4 to 17.5.

Similarly, there is a lack of consensus regarding the appropriate thresholds in defining low- and high-volume hospitals, with several studies dividing hospitals linearly to allocate an equal proportion of procedures or surgeons in each category.^{22,24,27} Lyman and colleagues²⁸ suggested that meaningful thresholds may be defined as low-volume hospitals performing shoulder arthroplasty procedures less than once per quarter and high-volume hospitals more than once per month. Ramkumar and colleagues²⁶ repeated the SSLR analysis for both annual hospital volume to generate statistically significant thresholds in terms of LOS and cost, which produced three strata, as follows: low (<4), medium (4–14), and high (>14) volume strata. The upper threshold for low-volume hospitals ranged from 4 to 20.5 annual cases. The minimum cutoff for high-volume hospitals ranged from 9 to 26 annual procedures.

There is currently no consensus regarding the most appropriate method of determining volume thresholds, or the cutoff values defining these thresholds, in shoulder arthroplasty. Standardized, evidence-based thresholds using SSLR analysis from larger scale population data for surgeon and hospital volume may be needed to fully evaluate the volume-value relationship

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