

# Risk Factors for Readmission and Revision Surgery Following Rotator Cuff Repair

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**Abstract** Risk factors for revision surgery and hospitalization following rotator cuff repair (RCR) have not been clearly identified. We hypothesized patient factors and surgeon and hospital volume independently contribute to the risk of readmission within 90 days and revision RCR within one year. Using the SPARCS database, we included patients undergoing primary RCR in New York State between 1997 and 2002. These patients were tracked for readmission within 90 days and revision RCR within 1 year. A generalized estimating equation was developed to determine whether patient factors, surgeon volume, or hospital volume were independent risk factors for the above outcome measures. The total annual number of RCR increased from 6,656 in 1997 to 10,128 in 2002. Ambulatory cases increased from 57% to 82% during this time period. Independent risk factors for readmission within 90 days included increasing age and increased number of comorbidities. Independent risk factors for revision RCR included increasing age, increased comorbidity, and lower surgeon volume. Hospital volume had a minimal effect on either outcome measure. The shift toward out-patient surgery mirrors the shift from open to arthroscopic rotator cuff repair. The finding that surgeon volume is a predictor of revision RCR reflects the findings in other orthopaedic procedures.

**Level of Evidence:** Level II, prognostic study. See the Guidelines for Authors for a complete description of levels of evidence.

## Introduction

Rotator cuff disorders are the most common cause of disability related to the shoulder [21]. Surgical repair of the rotator cuff has proven an effective treatment option with good to excellent short- and mid-term results in both functional improvement and pain relief [2, 7, 19–21]. However, most of the current literature on the rotator cuff focuses on the individual practices of relatively few specialists and says little about the population as a whole [11]. A growing body of evidence recently suggested there is substantial variation in the diagnosis and treatment of rotator cuff disease [5, 9, 23]. Several authors report the rate of shoulder procedures varied as much as 10-fold from state to state and that rotator cuff repair had the highest regional variation [5, 23]. This variation between geographic areas, institutions, and individual providers can be due to differences in patient-, hospital-, or physician-related factors. The importance of each of these factors in predicting outcome after surgical repair has not been fully elucidated.

Surgeon volume and hospital volume patterns have been implicated as determining factors with regard to patient readmission rates, length of stay, and operative time [9]. Multiple studies in the orthopaedic literature suggest increased surgeon and hospital volume is associated with improved outcome [6, 15, 16, 22]. With specific regard to rotator cuff repair (RCR), several studies suggest increased surgeon volume is the most important predictor of decreased complication rate and length of stay following surgery [9, 10, 13]. In these three studies, hospital- or

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patient-related factors did not appear to have a large effect on these outcome measures in these studies. However, evidence also suggests patient-related factors external to the shoulder (ie age, comorbidity, insurance type) influence shoulder function and outcomes of rotator cuff repair [1, 4, 11, 12, 19, 21]. The current literature is therefore controversial and the relative contributions of each variable to the risk of adverse outcomes are not clear.

The first step in this study was to describe the epidemiology of rotator cuff repair and to test the hypothesis that patients undergoing inpatient or ambulatory RCR over the time period studied were meaningfully different. Next, based on the literature we presumed patient factors and surgeon volume influenced risk of readmission within 90 days of surgery and rotator cuff reoperation within one year. We hypothesized increasing age, comorbidities, and inpatient status at baseline adversely affect these outcome measures, while increasing surgeon volume results in a direct and predictable decrease in the risk of revision surgery and readmission after RCR.

## Materials and Methods

The Statewide Planning and Research Cooperative System (SPARCS) database from New York State Department of Health, a census of all hospital discharges and ambulatory surgery admissions within the state of New York, was used to identify primary rotator cuff repairs performed in New York State on both an inpatient and outpatient basis. SPARCS has been operational since 1982, providing over 20 years of hospital discharge data for New York State. However, unique patient identifiers have not been available until recently. Therefore, this study was restricted to SPARCS records for the years 1997 to 2002. Rotator cuff repairs were identified using ICD-9-CM codes for inpatient admissions (ICD-9-CM 83.6, 83.61, 83.62, and 83.63) and CPT-4 codes for outpatient surgery (CPT-4 23120, 23410, 23412, 29827). Using these criteria we identified 52,485 rotator cuff repairs performed in New York State (Table 1).

All primary rotator cuff repairs were tracked across admissions for readmission within 90 days, rerepair of the rotator cuff within 1 year, and any shoulder reoperation within 1 year. Data were also collected on patient age in years, gender, insurance status (private, Medicare, Medicaid, HMO, self pay, worker's compensation, no charge, and other source), and year of surgery. Comorbidities were calculated using the Deyo modification of the Charlson comorbidity index, which uses ICD-9-CM diagnosis and procedure codes to identify preadmission comorbidities in administrative databases [3]. Hospital and surgeon volume were calculated by identifying all rotator cuff repairs performed by each surgeon and at each hospital between 1997

and 2002. The average rotator cuff repairs performed per month were calculated and quartiles were identified based on clinical judgment of relative frequency.

We computed descriptive statistics (means and standard deviations) for continuous variables (age) and frequency counts and percentages for discrete variables (gender, insurance status). We compared rates of readmission and revision RCR between inpatient and outpatient surgery. A generalized estimating equation (GEE) was used to calculate the independent risks of readmission and revision surgery associated with patient age, sex, insurance status, comorbidities, hospital volume, surgeon volume, and inpatient or outpatient index surgery. Odds ratios (OR) and p values were calculated using these GEE models. All analyses were performed using the SAS System 9.1 (Cary, NC). A critical p value of 0.05 was used for all hypothesis tests.

## Results

There were 52,485 primary rotator cuff repairs performed in New York State between 1997 and 2002 (Table 1). The total annual number of RCRs steadily increased during the study period, from 6,656 in 1997 to 10,128 in 2002. Ambulatory surgeries comprised 72.6% of total cases with the proportion of outpatient cases rising from 57% in 1997 to 82% in 2002. Nearly 50% of RCRs were performed by surgeons who perform less than 1 RCR per month and in hospitals that perform fewer than 6 RCR per month. Surgeons who do two or greater RCRs per month performed 26.5% of cases, and 32.8% of cases were performed in hospitals that perform 10 or greater RCRs per month. The total number of readmissions within 90 days of surgery was 2,235 (4.3%), which was much more common ( $p < 0.00001$ ) among those who had inpatient surgery. Nearly 4% of patients had revision RCR within 1 year.

Inpatient surgery at index case was more likely in patients who were older ( $59.8 \pm 12.8$  years for inpatient,  $54.5 \pm 13.4$  yrs for outpatient,  $p < 0.0001$ ), female (30.7% of all females, 24.9% of all males,  $p < 0.0001$ ), with greater than one comorbidity (66.6% of patients with 2 comorbidities and 83.8% of patients with three comorbidities were inpatients following initial surgery), and with government ( $p < 0.0001$ ) or self-pay insurance types ( $p < 0.0001$ ). Low volume surgeons had an increased proportion of inpatients compared with high volume surgeons (32.5% of patients of low volume surgeons, 23.9% of patients of high volume surgeons,  $p < 0.0001$ ). There were minimal differences in rates of ambulatory or inpatient procedures based on hospital volume alone (29.6% inpatient rate at low volume hospitals, 30% inpatient rate at high volume hospitals,  $p = 0.04$ ) (Table 1).

Independent risk factors for readmission within 90 days included increasing age (OR 1.12,  $p < 0.01$  per 10-year

**Table 1.** Patient demographics comparing inpatient and outpatient cases or rotator cuff repair (RCR)

Variable	Inpatient 14,385 (27.4%)	Outpatient 38,100 (72.6%)	Total 52,485	p Value
<i>Year</i>				
1997	2,864 (43%)	3,798 (57%)	6,656 (12.7%)	< 0.0001
1998	2,732 (35.8%)	4,898 (64.2%)	7,630 (14.5%)	
1999	2,513 (29.4%)	6,038 (70.6%)	8,551 (16.3%)	
2000	2,345 (24.8%)	7,114 (75.2%)	9,459 (18%)	
2001	2,128 (21.1%)	7,933 (78.9%)	10,061 (19.2%)	
2002	1,803 (17.8%)	8,325 (82.2%)	10,128 (19.3%)	
Age (years)	59.8 ± 12.8	54.5 ± 13.4	56.0 ± 13.5	< 0.0001
<i>Gender</i>				
Male	7,390 (24.9%)	22,307 (75.1%)	29,697 (56.6%)	< 0.0001
Female	6,994 (30.7%)	15,786 (69.3%)	22,780 (43.4%)	
<i>Primary source of reimbursement</i>				
Private insurance	3,402 (24.3%)	10,615 (75.7%)	14,017 (26.7%)	reference
Medicare	4,841 (33.7%)	7,247 (19.0%)	12,088 (23.0%)	< 0.0001
Medicaid	395 (2.7%)	662 (1.7%)	1,057 (2.0%)	< 0.0001
HMO	2,319 (22.6%)	7,960 (77.4%)	10,279 (19.6%)	0.002
Worker's Comp	2,124 (24%)	6,737 (76%)	8,861 (16.9%)	0.61
Other source	616 (15.2%)	3,444 (84.8%)	4,060 (7.7%)	< 0.0001
Self pay	677 (36.6%)	1,175 (63.4%)	1,852 (3.5%)	< 0.0001
<i>Comorbidity index</i>				
No comorbidity	11,319 (24.3%)	35,356 (75.7%)	46,675 (88.9%)	< 0.0001
1 comorbidity	2,656 (51%)	2,548 (49%)	5,204 (9.9%)	
2 comorbidities	379 (66.6%)	190 (33.4%)	569 (1.1%)	
3+ comorbidities	31 (83.8%)	6 (16.2%)	37 (0.1%)	
<i>Surgeon volume categories*</i>				
< 6 RCR/yr	3,677 (32.5%)	7,652 (67.5%)	11,329 (21.6%)	< 0.0001
6 RCR/yr – 1 RCR/mo	3,381 (29%)	8,293 (71%)	11,674 (27.4%)	
1 RCR/mo – 2 RCR/mo	4,005 (25.7%)	11,591 (74.3%)	15,596 (29.7%)	
2+ RCR/mo	3,322 (23.9%)	10,564 (76.1%)	13,886 (26.5%)	
<i>Hospital volume categories*</i>				
< 3 RCR/mo	3,324 (29.6%)	7,899 (70.4%)	11,223 (21.4%)	0.04
3 RCR/mo – 6 RCR/mo	4,146 (28.8%)	10,238 (71.1%)	14,384 (27.4%)	
6 RCR/mo – 10 RCR/mo	1,738 (18%)	7,920 (74.3%)	9,658 (18.4%)	
10+ RCR/mo	5,177 (30%)	12,043 (70%)	12,043 (32.8%)	
<i>Outcomes</i>				
Readmissions within 90 days	1,120 (7.8%)	1,115 (2.9%)	2,235 (4.3%)	< 0.0001
Revision RCR within 1 year	577 (4%)	1,433 (3.8%)	2,010 (3.8%)	0.18
<i>Within 1 year</i>				

\*Highest volume category used as reference category.

increase), each comorbidity (OR 1.34 for one comorbidity, 1.84 for two or more comorbidities,  $p < 0.01$ ). Hospital and surgeon volume were not independently associated with readmission within 90 days (Table 2).

Independent risk factors for revision RCR within 1 year included increasing age (OR 1.10,  $p < 0.01$  per 10-year increase) each comorbidity (OR 1.28 for one comorbidity, 1.57 for two or more comorbidities,  $p < 0.01$ ), and

decreasing surgeon volume (OR 1.25 for lowest volume versus highest,  $p < 0.01$ ) (Table 2).

## Discussion

Previous reports suggest surgeon volume is more important than patient-related factors (age, gender, insurance type,

**Table 2.** Generalized estimating equation models for revision rotator cuff repair within 1 year and readmission within 90 days

	Rotator cuff reoperation within 1 year		Readmission within 90 days	
	OR	p Value	OR	p Value
Age (per decade)	1.10 (1.06, 1.14)	< 0.01	1.12 (1.09, 1.15)	< 0.01
Female	1.03 (0.94, 1.13)	0.53	1.02 (0.95, 1.08)	0.63
Inpatient at baseline	1.00 (0.91, 1.11)	0.93	1.06 (0.98, 1.13)	0.13
<i>Comorbidity</i>				
None	Reference	< 0.01	Reference	< 0.01
One	1.28 (1.12, 1.48)		1.34 (1.22, 1.47)	
Two or more	1.57 (1.11, 2.23)		1.84 (1.48, 2.28)	
<i>Hospital volume</i>				
< 3 RCR per month	1.07 (0.94, 1.22)	0.30	0.91 (0.83, 1.00)	0.31
3 RCR per month to 6 RCR per month	0.98 (0.85, 1.14)	0.80	0.95 (0.86, 1.05)	
6 RCR per month to 9 RCR per month	0.85 (0.74, 0.97)	0.02	0.99 (0.91, 1.08)	
9+ RCR per month	Reference		Reference	
<i>Surgeon volume</i>				
< 6 RCR per year	1.25 (1.08, 1.44)	< 0.01	0.91 (0.83, 1.00)	0.14
6 RCR per year to 1 RCR per month	1.31 (1.15, 1.50)		0.96 (0.88, 1.05)	
1 RCR per month to 2 RCR per month	1.05 (0.91, 0.49)		0.92 (0.84, 1.01)	
2+ RCR per month	Reference		Reference	

Models adjusted for insurance status.

comorbidity) or hospital volume in determining the risk of adverse outcomes and hospitalization following rotator cuff repair [9, 10, 13]. However, recent data indicate patient-related factors extrinsic to the shoulder have a major role in predicting adverse outcomes and hospitalization following RCR. Our data suggest both patient-related factors and surgeon volume have important effects on the risk of readmission within 90 days of RCR and revision RCR within 1 year. Hospital volume has little effect on these outcome measures.

Limitations of our study pertain to the use of an administrative database. Information on type and location of rotator cuff tear, size of tear, duration of symptoms (acute, subacute, chronic), and surgical approach (open, mini-open, arthroscopic) were not available through SPARCS.

Patient-oriented outcome measures including the reason for readmission (ie, retear, stiffness, infection) and reoperation are not directly recorded in this administrative data set. As such, adverse outcomes are inferred by looking at reoperation and readmission rates across the study population. Similarly, level of surgeon experience with rotator cuff repair is inferred from surgeon volume data alone. Variation in individual surgeon's indications for RCR based on personal experience could not be adequately assessed in this population-wide study. While these limitations decrease the applicability of this study to individual clinical situations, global trends affecting the entire population of patients undergoing RCR in New York State are easily identified through SPARCS. Judicious use of such an administrative

data set can provide large amounts of information not obtainable through other sources or study designs.

Care must also be taken in generalizing the findings in the present study across geographic regions. It is possible the patient-, surgeon-, and hospital-related factors unique to the New York State demographic are not entirely reflective of the population as a whole. Furthermore, administrative databases, while providing information on a very large number of patients, lack a laterality indicator for orthopaedic surgery, so it is unknown if reoperations are on the same shoulder or the contralateral shoulder. Given most subsequent surgery within such a short study period is on the same joint rather than the opposite joint, our findings are likely not compromised by this limitation.

The concept that patient factors external to the shoulder influence shoulder function and outcome of rotator cuff surgery has been previously suggested by several investigators [1, 4, 11, 12]. Our results confirm patient-related factors are major risk factors for adverse outcomes and hospitalization following RCR. In the generalized estimating equation, these factors had the highest independent risk of adverse outcome in all three categories (readmission, revision RCR). Specifically, older age and increased comorbidities appeared at highest risk for adverse outcomes in these models. Several studies in the shoulder literature support these results. Rozencwaig et al. [19] reported shoulder function negatively correlated with the number of comorbidities in patients with severe glenohumeral arthritis. A multipractice study on patients undergoing RCR similarly reported an inverse relationship between

medical and social comorbidity and shoulder function [11]. Tashjian et al. [21] reported medical comorbidities had a negative impact on patient-reported preoperative baseline pain, function, and general health status associated with rotator cuff tears.

In a study most similar to our own, Green et al. [9] performed a retrospective analysis, hypothesizing that variation in readmission rates, length of stay, and operating time associated with rotator cuff repair are largely explained by physician practices (ie, volume), and not hospital- or patient-related factors. Their conclusions suggest variation in length of stay and operative time are largely explained by physician practices (ie, volume), while readmission rates cannot be explained by surgeon volume alone. Our results are somewhat consistent with their findings, demonstrating low volume surgeons in New York State have a notably increased proportion of inpatients compared with high volume surgeons following primary RCR. However, the demographic factors of age, gender, comorbidity and insurance type also play a large role in determining ambulatory versus inpatient status following surgery. We did not specifically look at length of stay data to compare directly with their results. With regard to risk of readmission following RCR, we agree multiple responsible factors, not primarily or exclusively linked to surgeon volume, lead to increased readmission rates following surgery. Taking it one step further, our data demonstrate patient factors are the most important risk factors for readmission within 90 days.

Previous literature helps to support the findings that low surgeon volume is a risk factor for revision rotator cuff repair. Several studies in the nonorthopaedic literature document that increased volume is generally associated with better outcomes [3, 6, 15]. In the orthopaedic literature, increased physician volume has shown similar effects as hospital volume on improving outcomes [15, 16, 22]. With specific regard to shoulder surgery, two volume and outcome studies suggest patients of surgeons with a high procedure volume had fewer complications and a shorter length of stay in the hospital compared with patients of surgeons with a lower procedure volume [10, 13]. However, our results also demonstrate hospital volume is not a risk factor for revision RCR. Of note, the rate of ambulatory versus inpatient surgery in New York state appears independent of hospital volume, and seems to rely only patient and surgeon factors.

Work by Dunn et al. [5] may also help to explain these results. High- and low-volume surgeons vary in their perceptions on the indications for rotator cuff surgery and their perceived surgical outcomes [5]. This difference in perception may also be reflected in their approach to revision rotator cuff repair. In response to different hypothetical clinical vignettes, selected surgeons with higher operative volume were more likely to choose operative management

while those with low volume chose nonoperative management. The data from our regression analysis, however, run contrary to our apparent dichotomy if surgeon decision making were the driving factor. Further research is needed to identify the factors that drive high-volume surgeons towards operative management, low-volume surgeons towards conservative treatments, and to determine the outcomes and appropriateness of their respective decisions.

The demographic trends observed for New York state illustrate the rapid transition from inpatient to ambulatory surgery that has occurred in rotator cuff surgery. As the total number of RCRs increases yearly, the proportion of ambulatory cases has shown a similar rise from 57% of cases in 1997 to 82% of cases in 2002. This trend is supported by previously published results that outpatient RCR can be performed safely and effectively in the appropriately selected patients with a 43% reduction in overall total cost. This paradigm shift towards ambulatory surgery should be viewed favorably by the health care community at large. However, we found almost 50% of RCRs in New York state are performed by surgeons who do less than one RCR per month. Several studies from the nonorthopaedic and orthopaedic literature document physicians drive resource utilization, at least partially through length-of-stay decision making [8, 9, 17, 18]. This has a major impact on total cost [9, 17]. With specific regard to RCR, there is a linear trend for a higher proportion of routine discharge following rotator cuff repair with increasing surgeon volume, coupled with higher likelihood of extended length of stay with low-volume surgeons [14]. This suggests the large number of low volume surgeons in NY state places these patients at risk for prolonged length of stay. We have already shown there is an increased proportion of inpatients among low volume surgeons compared with high volume surgeons in NY state. Future research should focus on those factors most responsible for the prolonged length of stay among patients of low volume surgeons.

Overall, our data suggest patient-related factors and surgeon volume independently influence the risk of readmission and revision RCR following primary rotator cuff repair. With greater understanding of the risk factors for adverse outcomes and hospitalization following RCR, further research will hopefully lead to the goal of improved patient outcomes and decreased cost.

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