JSES Open Access 3 (2019) 194–198

Contents lists available at ScienceDirect

JSES Open Access

journal homepage: www.elsevier.com/locate/jses

The effect of age on short-term postoperative complications following arthroscopic rotator cuff repair

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ARTICLE INFO

Keywords:
Rotator cuff repair outcomes
complications
ACS-NSQIP
rotator cuff repair age
arthroscopy
adverse events

Level of evidence: Level III, Retrospective Cohort Design Using Large Database, Treatment Study

Hypothesis: The purpose of this study was to assess short-term outcomes, including the rates of medical complications, non-home discharge, overnight hospital stay, and 30-day readmission, associated with patient age at the time of rotator cuff repair.

Methods: This study used National Surgical Quality Improvement Program data from 2005 to 2016 to analyze patients who underwent arthroscopic rotator cuff repair (ARCR). Patients were stratified into age cohorts of younger than 55 years, between 55 and 65 years, or older than 65 years. Outcomes including postoperative complications, discharge destination, and readmission were compared between the age cohorts using multivariate analysis.

Results: We identified 23,974 patients undergoing ARCR: 8344 patients (34.8%) were younger than 55 years, 9166 (38.4%) were aged between 55 and 65 years, and 6434 (26.8%) were older than 65 years. Older patients were more likely to be female patients and to have a lower body mass index, more medical comorbidities, shorter operative duration, dependent functional status, and higher American Society of Anesthesiologists classification. Patients older than 65 years had a higher rate of total complications (odds ratio [OR], 1.99; $P = .003$), respiratory complications (OR, 2.99; $P = .023$), urinary tract infections (OR, 6.94; $P < .001$), overnight hospital stay (OR, 1.49; $P < .001$), and unplanned hospital readmission (OR, 1.50; $P = .040$) relative to patients younger than 55 years. There was no increase in complication rates for patients aged between 55 and 65 years.

Conclusions: Patients older than 65 years have nearly double the odds of having a postoperative complication following ARCR and nearly 3 and 6 times the odds of having a respiratory complication and a urinary tract complication, respectively. Thorough preoperative optimization, including respiratory and urinary care, may be able to decrease complications in select, high-risk patients.

The incidence of rotator cuff disease in the United States continues to increase, and it represents one of the most common musculoskeletal conditions treated by orthopedic surgeons.[6,31] The volume of arthroscopic rotator cuff repair (ARCR) has increased dramatically in the past 2 decades, and the majority of surgical procedures are now performed arthroscopically.[10,30] Long-term studies have demonstrated the efficacy of ARCR in significantly improving pain, range of motion, and patient-related outcome measures.[17,23]

ARCR is performed almost exclusively as an outpatient procedure, with cost-effective analyses supporting this practice.[8,18] Repairs are commonly performed safely in elderly populations with multiple comorbidities including diabetes and hypertension.[9] Despite an elderly population, complications in the perioperative period have been shown to occur at a rate of approximately 1% to 2% and include but are not limited to rerupture, surgical-site infection, and unplanned readmission.[1,22] Investigations to identify relevant factors for increased risk have demonstrated open rotator cuff repair to significantly increase perioperative risk relative to arthroscopic repair.[13,24]

As the incidence of ARCR continues to rise dramatically with the aging population, minimizing complications to both protect patients and decrease health care costs is important. To this end, the use of multicenter databases may help stratify patients most at risk of complications.[7,16] Specifically, elderly patients undergoing shoulder surgery have been found to be at increased risk of perioperative complications and readmission.[26,29] Although prior investigations have studied perioperative ARCR complications, none

Institutional review board approval was not required for this retrospective treatment study.

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https://doi.org/10.1016/j.jses.2019.07.010

Table I
Comparison of baseline patient characteristics in rotator cuff repair patients by age

	All patients	Age group			*P* value
		<55 yr	55-65 yr	>65 yr	
n	23,974	8344	9196	6434	
Female, %	41.8	37.8	42.4	46.0	<.001*
BMI, %					<.001*
Non-obese (<30 kg/m^2)	53.7	50.8	51.8	60.3	
Obese I (30-34.9 kg/m^2)	26.3	27.0	26.6	25.0	
Obese II (35-39.9 kg/m^2)	12.2	12.8	13.0	10.0	
Obese III (≥40 kg/m^2)	7.8	9.4	8.6	4.7	
Comorbidities, %					
Diabetes mellitus	15.1	9.7	17.1	19.1	<.001*
Smoking history	15.4	22.7	14.7	7.1	<.001*
COPD	3.0	1.6	2.9	5.1	<.001*
Hypertension	45.7	27.7	49.2	63.9	<.001*
Preoperative corticosteroid use	1.8	1.3	1.9	2.3	<.001*
Anesthesia type, %					.541
General	92.4	92.5	92.2	92.6	
Regional	7.6	7.5	7.8	7.4	
Operative duration, %					<.001*
<60 min	25.3	25.3	24.9	25.8	
60-120 min	56.6	55.7	56.5	58.1	
>120 min	18.1	19.0	18.6	16.1	
Dependent functional status, %	0.5	0.3	0.4	0.8	<.001*
ASA class, %					<.001*
I	68.6	81.0	67.5	54.1	
II	30.5	18.5	31.7	44.3	
III or IV	0.9	0.5	0.8	1.6	

BMI, body mass index; *COPD*, chronic obstructive pulmonary disease; *ASA*, American Society of Anesthesiologists.
* Statistically significant, defined as $P < .05$.

have stratified postoperative complications respective to patient age cohorts.[15,20] As ARCR is increasingly performed in an aging population, understanding the complication profile of patients in older cohorts is important for risk stratification and patient counseling.

By use of a multicenter registry, the purpose of this study was to assess the impact of patient age on short-term complications, overnight hospital stay, and unplanned hospital readmission regarding ARCR. We hypothesized that patients older than 65 years would have increased rates of short-term complications and unplanned hospital readmission.

Materials and methods

This study was a retrospective cohort study of using American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) data from 2005 to 2016. This registry has aggregated patient data from over 600 participating sites as of 2016. These sites range from community hospitals to academic medical centers. Trained surgical clinical reviewers manually enter data into this registry, and all data are also periodically audited to ensure accuracy.[12,27] All data are deidentified prior to dissemination. ACS-NSQIP data have been used previously to assess perioperative complications after a variety of orthopedic procedures, including shoulder arthroscopic procedures.[2–4]

All patients undergoing ARCR were identified using Current Procedural Terminology code 29827. Patients were excluded if their surgical procedure was considered emergent, an unclean wound classification was noted, baseline demographic characteristics were missing, or the ARCR was performed in conjunction with another open shoulder procedure (eg, total shoulder arthroplasty). Once eligible patients were identified, the entire sample was split into 3 cohorts based on age: younger than 55 years, between 55 and 65 years, and older than 65 years. These age range brackets were selected to remain consistent with prior rotator cuff cohort literature.[19]

The baseline patient characteristics assessed included patient sex, body mass index (calculated from patient height and weight and stratified according to the World Health Organization classification system), type of anesthesia used (general vs. regional), operative duration, American Society of Anesthesiologists class, functional status (dependent vs. independent), and medical comorbidities including a history of diabetes mellitus, cigarette use, chronic obstructive pulmonary disease, hypertension, and preoperative corticosteroid use.

Bivariate analysis using the Pearson χ^2 test was performed to compare baseline patient characteristics as well as 30-day outcomes. Outcome variables found to be statistically different by age on bivariate analysis were carried forward to a multivariate analysis. All baseline patient characteristics with $P > .20$ on bivariate analysis were adjusted for in the multivariate models. Independent predictors of adverse outcomes in patients older than 65 years were identified using a multivariate regression with selected outcomes as the outcome variables and baseline patient characteristics as covariates. All statistical analyses in this study were performed using SPSS software (version 25; IBM, Armonk, NY, USA).

Results

In total, 23,974 patients undergoing ARCR were identified in this study. Of these patients, 8344 (34.8%) were younger than 55 years, 9196 (38.4%) were aged between 55 and 65 years, and 6434 (26.8%) were older than 65 years (Table I). As patient age increased, patients were more likely to be female patients; to have a lower body mass index, shorter operative duration, dependent functional status, and higher American Society of Anesthesiologists class; and to have a medical history of diabetes mellitus, cigarette use, chronic obstructive pulmonary disease, hypertension, and preoperative corticosteroid use ($P < .001$ for all comparisons).

On bivariate analysis, an increased rate of any complication was found as age increased, increasing from 0.46% in patients younger than 55 years to 0.52% in those aged between 55 and 65 years and 1.13% in those older than 65 years ($P < .001$) (Table II). This difference was also found on multivariate analysis when we compared patients older than 65 years vs. those younger than 55 years (odds ratio [OR], 1.99; $P < .003$). Similarly, we found increased rates of death ($P = .005$), cardiac complications ($P = .002$), respiratory complications ($P = .002$), urinary tract infections ($P < .001$), nonhome discharge to an acute or subacute care facility ($P = .001$), overnight hospital stay ($P < .001$), and 30-day unplanned hospital readmission ($P < .001$). On multivariate analysis, patients older than 65 years relative to those younger than 55 years had increased rates of respiratory complications (OR, 2.99; $P = .023$), urinary tract infections (OR, 6.94; $P = .001$), overnight hospital stay (OR, 1.49; $P < .001$), and unplanned 30-day hospital readmission (OR, 1.50; $P = .040$).

When patients older than 65 years were isolated and selected complications (any complication, respiratory complications, and urinary tract infections) were used as the outcome variables, the only baseline patient characteristic that was predictive of these adverse outcomes was dependent functional status (Table III). Dependent functional status was independently predictive of both aggregate complications (OR, 8.98; $P < .001$) and urinary tract infections (OR, 1.50; $P = .002$).

Table II
Comparison of adverse outcomes after rotator cuff repair by age

	Age group, %			Bivariate analysis: *P* value	Multivariate analysis			
	<55 yr (n = 8344)	55-65 yr (n = 9196)	>65 yr (n = 6434)		55-65 yr vs. <55 yr		>65 yr vs. <55 yr	
					OR	*P* value	OR	*P* value
Any complication	0.46	0.52	1.13	<.001*	0.95	.825	1.99	.003*
Death	0.00	0.00	0.08	.005*	—	—	—	—
Cardiac complications	0.02	0.04	0.15	.002*	1.70	.654	5.25	.152
Renal complications	0.01	0.01	0.03	.578	0.45	.607	2.75	.461
Respiratory complications	0.10	0.12	0.31	.002*	0.85	.736	2.99	.023*
Deep vein thrombosis	0.11	0.13	0.17	.338	1.35	.516	1.56	.399
Stroke or cerebrovascular accident	0.00	0.01	0.06	.083	—	—	—	—
Sepsis	0.02	0.01	0.02	.968	0.69	.799	2.21	.631
Surgical-site infection	0.19	0.10	0.12	.232	0.41	.053	0.61	.323
Urinary tract infection	0.05	0.12	0.42	<.001*	2.08	.227	6.94	.001*
Wound dehiscence	0.01	0.00	0.00	.544	—	—	—	—
Non-home discharge	0.52	0.40	0.85	.001*	6.44	.074	0.85	.523
Overnight hospital stay	7.06	9.32	11.87	<.001*	1.12	.001*	1.49	<.001*
Blood transfusion	0.02	0.01	0.06	.253	0.67	.786	0.67	.777
30-d readmission	0.78	0.99	1.55	<.001*	1.08	.655	1.50	.040*

OR, odds ratio.
* Statistically significant, defined as $P < .05$.

Discussion

Using a national, collected registry including over 20,000 patients who underwent an ARCR, we found age older than 65 years to be a significant independent risk factor for perioperative complications. Patients older than 65 years had approximately twice the OR of patients younger than 55 years of experiencing any complication. This included a significantly increased risk of pulmonary complications, urinary tract infections, overnight admission, and unplanned hospital readmission within 30 days.

Although increased age has previously been associated with perioperative risk in shoulder arthroscopy,[21] the specific impact on patients undergoing ARCR has not been clearly established. The results of our study indicate that although elderly patients are at increased risk of all complications, they are particularly at risk of urinary and pulmonary complications. Those elderly patients at the most significant risk appear to be those who are dependent in their functional status. Bohl et al[5] demonstrated that an increased surgical time of just 15 minutes significantly increases the risk of urinary tract infections and readmission in total joint arthroplasty patients. Although the length of surgery was not the primary outcome of this study, these results indicate that retention and urinary symptoms should be closely assessed following shoulder arthroscopy and that minimizing operative time may benefit all patients but particularly elderly patients. Our results emphasize the importance of appropriately screening patients, considering preoperative dependent functional status as an independent risk factor, and optimizing patients' urinary and respiratory status prior to surgery to minimize the risk of perioperative complications. Beyond standardized preoperative clearance, a subset of dependent patients may benefit from more advanced optimization. Specifically, a potentially modified clearance protocol may be necessary to best treat dependent patients, in whom complications occurred almost an order of magnitude more frequently than in independent patients. Further research and collaboration with medical colleagues, however, will be necessary to provide better insight.

Various surgical procedures have been associated with a significantly higher complication rate in older patients. Daubs et al,[11] for instance, noted that patients older than 69 years had significantly more complications after adult spinal deformity

Table III
Independent risk factors for adverse outcomes by multivariate logistic regression in patients older than 65 years undergoing rotator cuff repair

Variable	Any complication		Respiratory complications		Urinary infection	
	OR (95% CI)	*P* value	OR (95% CI)	*P* value	OR (95% CI)	*P* value
Female sex	1.24 (0.78-1.99)	.368	0.58 (0.23-1.49)	.257	3.19 (1.33-7.61)	.009
BMI						
Non-obese (<30 kg/m^2)	Reference	—	Reference	—	Reference	—
Obese I (30-34.9 kg/m^2)	1.20 (0.69-2.10)	.524	4.60 (1.53-13.85)	.007	0.67 (0.24-1.83)	.433
Obese II (35-39.9 kg/m^2)	1.36 (0.64-2.89)	.425	4.89 (1.24-19.38)	.024	0.31 (0.04-2.40)	.264
Obese III (≥40 kg/m^2)	1.68 (0.68-4.18)	.265	2.38 (0.26-21.67)	.442	1.81 (0.50-6.59)	.366
Comorbidities						
Diabetes mellitus	1.05 (0.59-1.89)	.866	1.22 (0.44-3.43)	.703	0.64 (0.21-1.97)	.438
Current smoker	0.96 (0.38-2.42)	.925	1.87 (0.52-6.76)	.339	1.27 (0.30-5.48)	.745
COPD	1.92 (0.87-4.23)	.104	3.49 (1.04-11.72)	.043	0.58 (0.08-4.45)	.599
Hypertension	1.23 (0.72-2.18)	.451	0.84 (0.30-2.34)	.735	1.83 (0.75-4.50)	.186
Preoperative corticosteroid use	1.21 (0.29-5.02)	.794	—	—	1.79 (0.24-13.53)	.571
Dependent functional status	8.98 (3.30-24.44)	<.001*	6.11 (0.69-54.24)	.104	11.50 (2.50-52.74)	.002*
ASA class						
I	Reference	—	Reference	—	Reference	—
II	0.99 (0.59-1.66)	.976	1.07 (0.39-2.90)	.897	0.91 (0.40-2.09)	.828
III or IV	0.94 (0.20-4.43)	.938	1.51 (0.14-16.10)	.734	—	—

OR, odds ratio; *CI*, confidence interval; *BMI*, body mass index; *COPD*, chronic obstructive pulmonary disease; *ASA*, American Society of Anesthesiologists.
* Statistically significant, defined as $P < .0042$ after Bonferroni correction.

surgery. Readmission rates have also previously been found to be increased in older patients, as underscored by 1 study examining complications and readmissions in patients undergoing transforaminal lumbar interbody fusion surgery.[14] Some studies have attributed increased readmission rates for those patients older than 65 years to factors including the quantity and complexity of discharge medication regimens, as well as socioeconomic status.[25,28] Thus, the current literature is corroborated by our study's conclusions that increased age correlates with a higher rate of postoperative complications.

This study has several limitations. The ACS-NSQIP registry only collects outcome data for the first 30 days following surgery. Therefore, longer-term results were unable to be assessed. In addition, shoulder-specific outcome measures are not included in the ACS-NSQIP registry. The ACS-NSQIP registry also does not provide psychiatric diagnoses, socioeconomic status, frequency of emergency department presentation, or discharge medications. Another limitation of this study is that the causes of overnight admissions were not recorded, preventing us from further analyzing these unplanned admissions. Although the ACS-NSQIP registry includes over 600 centers, freestanding ambulatory surgery centers not associated with larger medical centers are excluded; therefore, the representative population may differ from the general population as a whole. Cases performed at ambulatory surgery centers that are associated with a member institution are included in our study. Despite these limitations, this investigation of approximately 24,000 rotator cuff repairs represents the largest study to date assessing short-term outcomes after ARCR as a function of patient age.

Conclusion

As quality metrics increasingly impact orthopedic practice, the importance of risk stratifying patients to minimize complications has become paramount. This study demonstrates that older patients (ie, aged > 65 years) undergoing ARCR, especially those with dependent functional status, are at increased risk of perioperative complications. Furthermore, prospective research assessing pulmonary and urinary function via specialist preoperative clearance and optimization in select patients may be able to decrease overall complications and improve outcomes.

Disclaimer

Christopher S. Ahmad receives royalties from and is a paid consultant for Arthrex. He receives research support from Major League Baseball and Stryker. This is not directly related to the subject of this work.

Charles M. Jobin is a paid consultant for Zimmer Biomet, Acumed, Tornier, and DePuy. This is not directly related to the subject of this work.

William N. Levine is an unpaid consultant for Zimmer Biomet and receives research support from Smith & Nephew. This is not directly related to the subject of this work.

The other authors, their immediate families, and any research foundations 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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