



Hypertension and postoperative complications following arthroscopic rotator cuff repair



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Background: The purpose of this study was to investigate the relationship between hypertension and postoperative complications following arthroscopic rotator cuff repair (aRCR).

Methods: The American College of Surgeons National Surgical Quality Improvement Program database was surveyed for all patients who underwent aRCR between 2015 and 2021. Patient demographics, comorbidities, and 30-day postoperative complication data were analyzed. Multivariate logistic regression identified postoperative complications associated with hypertension.

Results: Forty-six thousand five hundred and sixty-two patients were included in the analysis: 20,999 (45.1%) patients in the hypertensive cohort and 25,563 (54.9%) in the nonhypertensive cohort. Hypertension was associated with male gender ($P < .001$), age ≥ 65 years ($P < .001$), body mass index > 30 ($P < .001$), dependent functional status ($P < .001$), American Society of Anesthesiologists classification ≥ 3 ($P < .001$), current smoker ($P < .001$), diabetes ($P < .001$), chronic obstructive pulmonary disease ($P < .001$), and bleeding disorders ($P < .001$). Thirty-day postoperative complications significantly associated with hypertension included pneumonia ($P = .012$), reintubation ($P = .009$), urinary tract infection ($P = .002$), stroke ($P = .044$), myocardial infarction ($P = .004$), ventilator > 48 hours ($P = .017$), readmission ($P < .001$), non-home discharge ($P < .001$), and mortality ($P = .020$). After adjusting for patient demographics and comorbidities, readmission (odds ratio [OR] 1.41; 95% confidence interval [CI] 1.13–1.75; $P = .002$) was independently associated with hypertension.

Conclusion: Hypertension was identified as a risk factor for various postoperative complications following aRCR. Hypertension was found to be an independent predictor for readmission following aRCR.

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Arthroscopic rotator cuff repair (aRCR) is a common procedure to repair partial-thickness or full-thickness rotator cuff tears in patients experiencing pain or discomfort who have failed nonoperative treatment. Other studies have established that the average age of patients undergoing aRCR is between 55 and 60 years.¹⁰

Hypertension is a systemic illness with a recorded prevalence in 2010 of 31.1% in adults (1.39 billion) worldwide and has been established as the primary preventable risk factor for cardiovascular disease and mortality.¹ Hypertension is on the rise due to the aging population, in addition to unhealthy lifestyle choices such as diet and lack of physical activity.⁶ In orthopedic surgery, hypertension has been associated with severe postoperative

complications such as deep vein thrombosis.⁴ Hypertension is becoming more prevalent, particularly in the older population.

The association between hypertension and postoperative complications has been studied for hip and knee arthroplasty. Hypertension has been found to be a risk factor for 30-day readmission in both total knee and hip arthroplasty.⁸ In hip arthroplasty, hypertensive patients had a higher risk of prolonged wound discharge.¹ In knee arthroplasty, hypertension was a risk factor for unplanned reintubation, urinary tract infection, postoperative transfusion, myocardial infarction, and extended length of hospital stay.³ To our knowledge, hypertension as an independent risk factor for postoperative complications following aRCR has not been studied.

Given the association between hypertension and postoperative complications following other orthopedic surgical procedures, hypertension as a risk factor for postoperative complications specific to aRCR is prudent to elucidate. This may help surgeons with risk management and preoperative planning. The purpose of this study was to investigate the relationship between hypertension and

Institutional review board approval was not required for this study.

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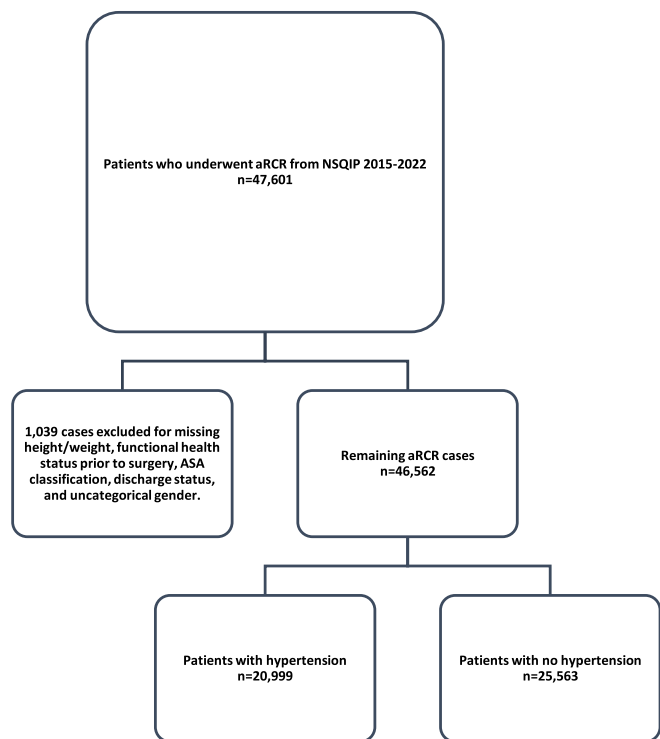


Figure 1 Strengthening the reporting of observational studies in epidemiology (STROBE) diagram with inclusion and exclusion criteria. aRCR, arthroscopic rotator cuff repair; NSQIP, National Surgical Quality Improvement Program.

postoperative complications following aRCR. We hypothesized that hypertension is associated with higher rates of myocardial infarction and readmission following aRCR.

Methods

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database was queried for all patients who underwent aRCR between 2015 and 2021. The NSQIP database is a validated tool to track outcomes in surgery and is fully deidentified.⁹ Therefore, this study was rendered exempt from approval by our university’s institutional review board. Data in the NSQIP database are obtained from over 600 hospitals in the United States and are collected by trained surgical clinical reviewers.

Current Procedural Terminology code 29827 was used to identify patients who underwent aRCR from 2015 to 2021. Exclusion criteria automatically included patients younger than 18 years of age. Cases were also excluded if missing any of the following variables: age, height, weight, gender, functional status, American Society of Anesthesiologists (ASA) classification, discharge destination, and hypertension.

Variables collected in this study included patient demographics, comorbidities, surgical characteristics, preoperative laboratory values, and 30-day postoperative complication data. Patient demographics included body mass index (BMI), age, gender, smoking status, functional status, American Society of Anesthesiologists (ASA) classification, and hypertension. Preoperative comorbidities included insulin-dependent and non-insulin-dependent diabetes, severe chronic obstructive pulmonary disease (COPD), bleeding disorder, and disseminated cancer. Complications that occurred within 30 days postoperatively were included in the analysis. Complications included cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, deep vein thrombosis

requiring therapy, cerebrovascular accident, stroke, unplanned intubation, pulmonary embolism, ventilator >48 hours, sepsis, septic shock, reoperation, readmission, mortality, deep incisional surgical site infection (SSI), organ/space SSI, progressive urinary tract infection, transfusions within 72 hours after surgery, pneumonia, and superficial incisional SSI.

The original pool of patients from NSQIP was divided into 2 cohorts: hypertensive and nonhypertensive patients. The hypertensive patient cohort consisted of patients who required medication for their hypertension. According to the NSQIP database, hypertension was defined as blood pressure greater than 140/90 bpm most of the time. The diagnosis of hypertension must have been documented in the patient’s medical record and the condition be classified as severe enough to be taking antihypertensive medication within 30 days before the operative procedure or at the time the patient was being considered for surgery. The patient must have been receiving long-term antihypertensive medication for greater than 2 weeks.

A total of 47,601 patients underwent primary aRCR in NSQIP from 2015 to 2021. Cases were excluded as follows: 413 for missing height/weight, 1 for uncategorical gender, 548 for missing functional health status before surgery, 68 for missing ASA classification, 9 for unknown discharge destination. There were 46,562 patients remaining after exclusion criteria: 20,999 (45.1%) patients were included in the hypertensive cohort and 25,563 (54.9%) patients were included in the non-hypertensive cohort (Fig. 1).

Statistical methods

All statistical analyses were completed using SPSS Software version 28.0 (IBM Corp., Armonk, NY, USA). Patient demographics and comorbidities were compared between hypertensive and nonhypertensive cohorts using bivariate logistic regression.

Multivariate logistic regression, adjusted for all significantly associated patient demographics and comorbidities, was used to determine significance between hypertension and postoperative complications. Odds ratios (ORs) were reported with 95% confidence intervals (CIs). The level of statistical significance was set at $P < .05$.

Results

Patient demographics and comorbidities that were significantly associated with hypertension were age ≥ 65 years ($P < .001$), BMI > 30 ($P < .001$), male gender ($P < .001$), dependent functional status ($P < .001$), ASA classification ≥ 3 ($P < .001$), smoking status ($P < .001$), diabetes status ($P < .001$), COPD ($P < .001$), and bleeding disorders ($P < .001$) (Table I).

Bivariate logistic regression was used to determine postoperative complications associated with hypertension (Table II). The postoperative complications that were significantly associated with hypertension included pneumonia ($P = .012$), reintubation ($P = .009$), urinary tract infection ($P = .002$), stroke ($P = .044$), myocardial infarction ($P = .004$), ventilator > 48 hours ($P = .017$), readmission ($P < .001$), non-home discharge ($P < .001$), and mortality within 30 days ($P = .020$).

After adjusting for the patient variables significantly associated with hypertension (as shown above), multivariate logistic regression identified readmission (OR 1.41; 95% CI 1.13-1.75; $P = .002$) to be the only postoperative complication independently associated with hypertension. The other postoperative complications with significance in bivariate analysis were no longer significant after adjustment (Table III). Overall, readmission was most commonly due to pulmonary (15%) and thromboembolic (13%) complications.

Table I
Patient demographics/comorbidities for patients with and without hypertension.

	Hypertension		No hypertension		P value
	Number	Percent	Number	Percent	
Total	20,999	100	25,563	100	
Age					<.001
18-39	247	1.2	2060	8.1	
40-64	12,354	58.8	18,048	70.6	
65-74	6695	31.9	4674	18.3	
≥75	1703	8.1	781	3.1	
BMI (kg/m ²)					<.001
<18.5	45	0.2	126	0.5	
18.5-29.9	8075	38.4	14,769	57.8	
30-34.9	6453	30.7	6558	25.7	
35-39.9	3680	17.5	2614	10.2	
≥40	2746	13.1	1496	5.9	
Gender					<.001
Female	8594	40.9	10,324	40.4	
Male	12,405	59.1	15,239	59.6	
Functional status before surgery					<.001
Independent	20,887	99.5	25,511	99.8	
Dependent	112	0.5	52	0.2	
ASA classification					<.001
1-2	9904	47.2	20,372	79.7	
≥3	11,095	52.8	5191	20.3	
Smoker					<.001
No	18,116	86.3	21,658	84.7	
Yes	2883	13.7	3905	15.3	
Diabetes mellitus					<.001
No diabetes	14,935	71.1	23,854	93.3	
Non-insulin dependent	4352	20.7	1322	5.2	
Insulin dependent	1712	8.1	387	1.5	
COPD					<.001
No	20,164	96.0	25,101	98.2	
Yes	835	4.0	462	1.8	
Bleeding disorders					<.001
No	20,562	80.4	25,401	99.4	
Yes	473	19.6	162	0.6	
Disseminated cancer					.151
No	20,981	99.9	25,550	99.9	
Yes	18	0.1	13	0.1	

ASA, American Society of Anesthesiologists; COPD, chronic obstructive pulmonary disease; BMI, body mass index.

Bold P values indicate statistical significance with $P < .05$.

Discussion

This study used a large national database to identify 30-day postoperative complications associated with hypertension in patients who underwent aRCR between 2015 and 2021. Our analysis included 46,562 patients, with 20,999 (45.1%) patients in the hypertensive cohort and 25,563 (54.9%) patients in the non-hypertensive cohort. Through bivariate analysis, hypertension was identified as a risk factor for pneumonia, reintubation, urinary tract infection, stroke, myocardial infarction, ventilator > 48 hours, readmission, non-home discharge, and mortality within 30 days. After controlling for significantly associated patient demographics and comorbidities, hypertension was classified as an independent predictor for readmission following aRCR.

As the demand for aRCR increases, significant complications and comorbidities can be analyzed in order to reduce adverse outcomes. Our study identified several comorbidities associated with hypertension including age ≥ 65 years, BMI > 30, male gender, dependent functional status, ASA classification ≥3, smoking status, diabetes, COPD, and bleeding disorders. Many of these risk factors (age, BMI, and diabetes) have been associated with the specific postoperative complication of re-tear.^{7,11}

The present study did not find hypertension to be a significant risk factor for prolonged wound discharge, urinary tract infection,

Table II
Bivariate analysis of 30-day postoperative complications in patients with and without hypertension.

	Hypertension		No hypertension		P value
	Number	Percent	Number	Percent	
Total	20,999	100	25,563	100	
Sepsis	14	0.07	11	0.04	.277
Septic shock	1	<0.01	3	0.01	.262
Pneumonia	38	0.18	24	0.09	.012
Reintubation	13	0.06	3	0.01	.009
Urinary tract infection	57	0.27	36	0.14	.002
Stroke	12	0.06	5	0.02	.044
Cardiac arrest	6	0.03	1	<0.01	.066
Myocardial infarction	23	0.11	9	0.04	.004
Bleeding transfusions	4	0.02	1	<0.01	.157
Deep vein thrombosis	0	0	0	0	.096
Pulmonary embolism	0	0	0	0	.113
Failure to wean off ventilator	10	0.05	1	<0.01	.017
Deep incisional SSI	0	0	0	0	.842
Superficial incisional SSI	0	0	0	0	.649
Organ/space SSI	12	0.06	8	0.03	.187
Wound dehiscence	0	0	0	0	.905
Readmission	285	1.36	165	0.65	<.001
Reoperation	68	0.32	56	0.22	.030
Non-home discharge	130	0.62	87	0.34	<.001
Mortality	10	0.05	2	0.01	.020

SSI, surgical site infection.

Table III
Multivariate analysis of 30-day postoperative complications in patients with hypertension, adjusted for significantly associated patient demographics/comorbidities.

Postoperative complication	Hypertension		
	Odds ratio	95% CI	P value
Pneumonia	1.12	0.62-2.03	.697
Reintubation	2.31	0.57-9.35	.240
Urinary tract infection	1.25	0.79-2.00	.345
Stroke	2.22	0.72-6.84	.166
Myocardial infarction	1.96	0.83-4.63	.124
Failure to wean off ventilator	2.30	0.27-19.41	.443
Readmission	1.41	1.13-1.75	.002
Non-home discharge	1.13	0.82-1.54	.464
Mortality	3.14	0.63-15.60	.162

CI, confidence interval.

Bold P values indicate statistical significance with $P < .05$.

postoperative transfusion, and extended length of hospital stay, as reported in those studies focusing on knee and hip arthroplasty.^{1,3} However, we did show an increased risk for readmission associated with hypertension, consistent with studies that reviewed hip and knee arthroplasty.⁸ We also showed support for hypertension as a risk factor of unplanned reintubation and myocardial infarction as found in knee arthroplasty.³

Other studies have supported the claim that multiple risk factors result in readmission after aRCR, but have not extensively reviewed hypertension independently. For example, hypertension in addition to age greater than 65 years, female sex, BMI > 35, ASA > 2, and open surgical technique were found to be significant predictors of unanticipated readmission.² Other studies established hypertension, among other characteristics, to be significant predictors of unanticipated readmission in aRCR. In our study, hypertension was classified as an independent predictor for readmission following aRCR. The most common causes overall of readmission were pulmonary and thromboembolic complications. Of note, readmission was significant in our multivariate analysis even after controlling for COPD and smoking status. Therefore, hypertensive patients with pre-existing pulmonary comorbidities may require further evaluation before surgery.

Readmission has previously been extensively studied as a significant postoperative complication due to the financial repercussions. Hospitals and staff are financially motivated to restrict the number of readmissions following surgical procedures. The Patient Protection and Affordable Care Act of 2010 prevents payment of hospital costs associated with readmission within 30 days of discharge after total joint arthroplasty is performed.⁵ If patients that have a greater risk of readmission can be identified, then the anticipated cost of care in outpatient rotator cuff repair can be modified. This was the basis of a previous study completed by Gil et al that reviewed several characteristics that place patients at risk for unanticipated inpatient admission after aRCR.² The present study identified hypertension to be an independent predictor for readmission following aRCR. We also showed that hypertension is an associated risk factor for other postoperative complications such as pneumonia, reintubation, urinary tract infection, stroke, myocardial infarction, failure to wean off of ventilator, non-home discharge, readmission, and mortality.

Because this study has identified hypertension as a risk factor for myocardial infarction, reintubation, stroke, pneumonia, and failure to wean off of a ventilator, patients with preexisting cardiopulmonary diseases may require more extensive preoperative screening and optimization. For example, the modified frailty index (mFI-5) has been established as a sensitive tool for predicting severe medical complications, hospital admission, increased length of stay, adverse discharge, and mortality following aRCR.¹⁰ The mFI-5 consists of a 5-factor score including diabetes, congestive heart failure, chronic obstructive pulmonary disease, functional status limiting independence, and hypertension. The findings of our present study support the use of the mFI-5 as a screening tool.

Major limitations of the study were inherent to the NSQIP database. There are restrictions on the operative variables, such as the complexity of the procedure, concomitant procedures, and postoperative rehabilitation, because our study was limited to the data available on the NSQIP database. Additionally, NSQIP restricts postoperative complications to a 30-day window following surgery. Therefore, we were unable to account for long-term (greater than 30 days) complications following aRCR, such as retear and shoulder stiffness. There were other potential risk factors of interest that we were not able to evaluate for, as the information was not available on the database. While the hypertension variable was defined as a patient receiving long-term antihypertensive medication for greater than 2 weeks, we could not account for whether the preoperative blood pressure was well controlled by medical treatment. We also could not account for whether the arthroscopic surgery was performed with the patient in beach chair position or in lateral decubitus. Given that we identified reintubation as a significant complication, it may be of interest to evaluate patient positioning, as causes for reintubation such as refractory hypotension and inability to protect the airway may be related to patient positioning. Despite these limitations, we used a large national database to investigate postoperative complications associated with hypertension in patients undergoing aRCR.

Conclusion

Hypertension was identified as a risk factor for pneumonia, reintubation, urinary tract infection, stroke, myocardial infarction, ventilator > 48 hours, readmission, non-home discharge, and mortality within 30 days following aRCR. After controlling for significantly associated patient demographics and comorbidities, hypertension was classified as an independent predictor for readmission following aRCR. This study emphasizes the importance of preoperative screening specifically addressing hypertension to help improve perioperative risk stratification and help to minimize adverse outcomes following aRCR.

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