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Risk factors for unexpected admission following arthroscopic and open treatment of shoulder instability: a national database study of 11,230 cases

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Background: Shoulder instability procedures have low morbidity; however, complications can arise that result in readmission to an inpatient healthcare facility. The purpose of this study is to identify the demographics and risk factors associated with unplanned 30-day readmission and reoperation following arthroscopic and open treatment for shoulder instability.
Methods: The American College of Surgeons National Surgical Quality Improvement Program database was queried to find patients who underwent shoulder instability surgery from 2015 to 2019. Independent sample Student t-tests, chi-square, and (where appropriate) Fisher's exact tests were used in univariate analyses to identify demographic, lifestyle, and perioperative variables related to 30-day readmission and reoperation following repair for shoulder instability. Multivariate logistic regression modeling was subsequently performed.
Results: Of the 11,230 cases included in our sample, only 0.54% were readmitted, and 0.23% underwent reoperation within the 30-day postoperative period. Multivariate logistic regression modeling confirmed that the following patient variables were associated with statistically significantly increased odds of readmission and reoperation: open repair, congestive heart failure (CHF), and hospital length of stay.
Conclusions: Unplanned 30-day readmission and reoperation after shoulder instability surgery is infrequent. Patients with American Society of Anesthesiologists class II, CHF, longer than average hospital length of stay, or an open procedure have higher odds of readmission than patients without those factors. Patients who have CHF, longer than average hospital length of stay, and open surgery have higher odds of reoperation than others. Arthroscopic procedures should be used to manage shoulder instability, if possible.
Level of evidence: III.

Keywords: Shoulder instability; Arthroscopy; Risk factors; Readmission; Reoperation

INTRODUCTION

Shoulder instability is a common condition, affecting roughly 2% of the general population [1]. Traditionally, first line management of shoulder instability is nonoperative; however surgical management can be indicated in cases of recurrent instability, bony pathology, or other patient-specific or injury-specific patterns [2-8]. For example, young patients have been shown to have high rates of recurrent shoulder instability [9].

Several documented operative techniques are used to stabilize an unstable shoulder, including both arthroscopic and open treatments. Various complications of shoulder stabilization sur-

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gery have been reported, including readmission, reoperation, infection, pneumonia, deep vein thrombosis (DVT), pulmonary embolism (PE), and bleeding requiring a transfusion, though recent studies have shown those complications of the early postoperative period to be rare [10].

Although these complications are uncommon, they can lead to unexpected readmission. A previous study showed that readmission rates within 30 days of surgery were higher following the Latarjet-Bristow procedure than arthroscopic Bankart repairs [10]. Readmission and reoperation carry a significant cost, and understanding the risk factors for those issues could decrease costs and improve outcomes. However, the risk factors that lead to unexpected admission following both arthroscopic and open treatment for shoulder instability are poorly understood, as are the patient factors associated with reoperation. Therefore, the purpose of this study is to identify the demographic and risk factors associated with unplanned 30-day readmission and reoperation following arthroscopic and open treatment for shoulder instability. We hypothesized that the readmission rate would be higher with open procedures than with arthroscopic ones and be associated with medical comorbidities. The data collected here will allow surgeons to give patients preoperative descriptions of the risk and benefits of surgery. They will also help to identify the factors that increase the risk of adverse outcomes.

METHODS

Database

This study used the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database. Trained clinical reviewers collected the following data from more than 700 participating hospitals: patient demographics, comorbidities, surgery type in the form of Current Procedural Terminology (CPT) codes, and 30-day postoperative surgical outcomes.

Patient Population

The ACS-NSQIP databased was queried to find patients who underwent shoulder instability surgery from 2015 to 2019 by using CPT codes 23455 "capsulorrhaphy, anterior; with labral repair (i.e., Bankart procedure)," 23460 "capsulorrhaphy, anterior, any type; with bone block," 23462 "capsulorrhaphy, anterior, any type; with coracoid process transfer," and 29806 "arthroscopy, shoulder, surgical; capsulorrhaphy," and it yielded 11,230 cases. CPT codes 23455, 23460, and 23462 are for open shoulder instability procedures, and 29806 is for an arthroscopic shoulder instability procedure. Patients who received the defined procedures and were included in the database were included in this study. No patients in the database who received any of the above procedures were excluded.

Variables Collected

Data on the following demographic, lifestyle, and comorbidity variables were recorded: sex, age, body mass index (BMI), hypertension requiring medication, current tobacco use, diabetes mellitus, bleeding disorders, steroid use for a chronic condition, chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), and American Society of Anesthesiologists (ASA) classification. The primary outcome of 30-day readmission was defined as unplanned hospital readmission likely related to the principal procedure. Secondary outcomes recorded were pneumonia, DVT/thrombophlebitis, PE, acute renal failure, urinary tract infection, CVA/stroke, myocardial infarction, bleeding requiring transfusion, systemic sepsis, wound complications (superficial surgical site infection, deep incisional surgical site infection, or wound disruption), total operative time, hospital length of stay (if patient remained in the hospital for at least 1 day after surgery), discharge destination (home or non-home), and reoperation, which was defined as a proxy for failure of the initial intervention.

Statistical Analyses

All data were analyzed using the SPSS ver. 23.0 (IBM Corp.). The criterion for statistical significance was set at $a = 0.05$. The univariate analyses used chi-square testing and, where appropriate, Fisher's exact test to compare the arthroscopic and open treatment cohorts with regard to categorical demographic, comorbidity, lifestyle, and 30-day outcome variables. Student's t-testing was used in a similar fashion for continuous outcome variables. Multiple logistic regression modeling was subsequently performed in a stepwise fashion to examine differences between the arthroscopic and open treatment cohorts while controlling for covariates.

RESULTS

In total, the search returned 11,230 patients treated with a shoulder instability procedure (arthroscopic cohort: 9,288; open treatment cohort: 1,942). Demographic, lifestyle, and comorbidity profiles, stratified by procedure type (arthroscopic or open), are presented in Table 1. In both cohorts, patients who underwent treatment for shoulder instability were significantly more likely to be male, χ^2 (1, 11,230) = 30.7, $P < 0.001$, or ages 18 to 24, χ^2 (4, 11,230) = 18.38, $P = 0.001$, than people in the general population.

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Table 1. Demographics and comorbidities between the arthroscopic and open cohorts

Variable	Arthroscopy cohort	Open cohort	P-value
Case	9,288 (82.7)	1,942 (17.3)	-
Sex			< 0.001
Male	7,212 (83.3)	1,618 (77.6)	
Female	2,076 (16.7)	324 (22.4)	
Age (yr)			0.001
< 18	12 (0.1)	1 (0.1)	
18–24	3,450 (37.1)	727 (37.4)	
25–34	2,960 (31.9)	690 (35.5)	
35–44	1,509 (16.2)	298 (15.3)	
≥ 45	1,357 (14.6)	226 (11.6)	
Body mass index (kg/m^2)			0.772
Underweight	60 (0.7)	13 (0.7)	
Normal weight	2,949 (32.1)	631 (32.8)	
Overweight	3,781 (41.2)	794 (41.3)	
Obese, Class I	1,578 (17.2)	333 (17.3)	
Obese, Class II	516 (5.6)	97 (5.0)	
Obese, Class III	300 (3.3)	53 (2.8)	
Comorbidity			
Hypertension	820 (8.8)	151 (7.8)	0.133
Current smoker	1,876 (20.2)	505 (26.0)	< 0.001
Diabetes	284 (3.1)	32 (1.6)	0.001
Bleeding disorder	13 (0.2)	2 (0.1)	0.772
Steroid use	61 (0.7)	10 (0.5)	0.473
Chronic obstructive pulmonary disease	46 (0.5)	8 (0.4)	0.629
Congestive heart failure	5 (0.1)	0	0.306
ASA classification			0.631
Class I	4,260 (45.9)	881 (45.4)	
Class II	4,400 (47.4)	919 (47.3)	
Class III	601 (6.5)	139 (7.2)	
Class IV	22 (0.2)	3 (0.2)	

Values are presented as number (%).
ASA: American Society of Anesthesiologists.

Patients who underwent arthroscopic management were significantly more likely to have diabetes mellitus (3.1% vs. 1.6%), χ^2 (1, 11,230) = 11.68, P = 0.01, than patients who underwent an open procedure. Patients who underwent an open procedure were significantly more likely to be current smokers (26.0% vs. 20.2%), χ^2 (1, 11,230) = 32.41, P < 0.001, than those who underwent arthroscopic treatment. The arthroscopic and open treatment cohorts did not differ significantly in BMI, hypertension, bleeding disorders, steroid use, COPD, CHF, or ASA classification.

The results of the univariate analysis comparing 30-day outcomes between the arthroscopic and open treatment cohorts are displayed in Table 2. Patients who underwent an open procedure were more likely than those in the arthroscopic cohort to require reoperation (0.8% vs. 0.1%), χ^2 (1, 10,324) = 34.44, P < 0.001. Additionally, patients who underwent open repair were more likely than others to develop a deep incisional surgical site infection (0.2% vs. < 0.01%), χ^2 (1, 11,230) = 13.75, P = 0.04, and be readmitted (1.3% vs. 0.4%), χ^2 (1, 8,188) = 18.94, P < 0.001. Open repairs were also associated with significantly longer mean operative time (112.06 ± 54.8 vs. 86.92 ± 44.7 minutes), t(11,218) = 21.62, P < 0.001, and hospital length of stay (0.34 ± 1.5 vs. 0.14 ± 1.6 days), t(11,227) = 5.02, P < 0.001. The open repair and arthroscopic cohorts did not differ significantly with regard to pneumonia, PE, acute renal failure, urinary tract infection, CVA/stroke, myocardial infarction, bleeding requiring transfusion, DVT/thrombophlebitis, sepsis, or discharge destination. No patients died within 30 days of surgery.

Of the 11,230 patients included in our sample, only 0.54% were readmitted within the 30-day postoperative period. The results of the univariate analyses reveal statistically significant relationships between readmission status and the following patient variables (Table 3): ASA classification, χ^2 (3, 8,187) = 15.4, P = 0.002; hyperten-

Table 2. Univariate analysis of 30-day outcomes between the arthroscopic and open cohorts

Outcome	Arthroscopy cohort	Open cohort	P-value
Reoperation	9 (0.1)	15 (0.8)	< 0.001
Pneumonia	7 (0.1)	4 (0.2)	0.106
Pulmonary embolism	4 (0.0)	1 (0.1)	> 0.999
Acute renal failure	1 (0.0)	1 (0.1)	0.316
Urinary tract infection	6 (0.1)	0	0.598
Cerebral vascular accident/stroke	1 (0.0)	0	> 0.999
Myocardial infarction	1 (0.0)	0	> 0.999
Bleeding requiring transfusions	2 (0.0)	1 (0.1)	0.434
Deep vein thromboses/thrombophlebitis	6 (0.1)	4 (0.2)	0.078
Sepsis	20 (0.2)	3 (0.2)	0.785
Wound complication	10 (0.1)	8 (0.4)	0.002
Superficial surgical site infections	7 (0.1)	4 (0.2)	0.106
Deep incisional surgical site infections	1 (0.0)	4 (0.2)	0.004
Wound disruption	2 (0.0)	0	> 0.999
Total operative time (min)	86.92 ± 44.7	112.06 ± 54.8	< 0.001
Hospital length of stay (day)	0.14 ± 1.6	0.34 ± 1.5	< 0.001
Discharge destination			0.784
Home	8,718 (99.5)	1,848 (99.6)	
Non-home	42 (0.5)	8 (0.4)	
Readmission	25 (0.4)	19 (1.3)	< 0.001

Values are presented as number (%) or mean ± standard deviation.

sion, χ^2 (1, 8,188) = 7.76, P = 0.12; current smoker, χ^2 (1, 8,188) = 6.51, P = 0.011; CHF, χ^2 (1, 8,188) = 44.81, P < 0.001; COPD, χ^2 (1, 8,188) = 17.63, P < 0.001; hospital length of stay (1.09 ± 2.9 vs. 0.16 ± 1.5 days), t(8,188) = 16.32, P < 0.001; and procedure type, χ^2 (1, 8,188) = 18.94, P < 0.001. Patient sex, age, BMI, steroid use, anesthesia type, total operative time, diabetes, and bleeding disorders were not significantly associated with readmission.

Multivariate logistic regression modeling confirmed that the following patient variables were associated with statistically significantly increased odds of readmission (Table 4): open repair (P < 0.001; odds ratio [OR], 3.64; 95% confidence interval [CI], 1.98–6.68), ASA class II (P = 0.001; OR, 4.45; 95% CI, 1.85–10.68), CHF (P = 0.004; OR, 37.73; 95% CI, 3.23–441.06), and hospital length of stay (P = 0.007; OR, 1.07; 95% CI, 1.02–1.12). The relationships between hypertension, current smokers, and COPD and readmission did not achieve statistical significance in the multivariate model.

Of the 11,230 patients included in our sample, only 0.23% underwent a reoperation within the 30-day postoperative period. The results of the univariate analyses reveal statistically significant relationships between reoperation and the following patient variables (Table 5): age, χ^2 (3, 10,324) = 8.73, P = 0.033; CHF, χ^2 (1, 10,324) = 105.84, P < 0.001; hospital length of stay t(10,324) = 12.38, P < 0.001; and procedure type, χ^2 (1, 10,324) = 18.94, P < 0.001. Patient sex, BMI, steroid use, current smoking, ASA classification, anesthesia type, total operative time, hypertension, diabetes mellitus, bleeding disorders, COPD, and CHF were not significantly associated with reoperation.

Multivariate logistic regression modeling confirmed that the following patient variables were associated with statistically significantly increased odds of reoperation (Table 6): open repair (P < 0.001; OR, 9.22; 95% CI, 3.88–21.91), CHF (P < 0.001; OR, 284.6; 95% CI, 25.74–3,147.12), and hospital length of stay (P < 0.05; OR, 1.08; 95% CI, 1.02–1.14). The relationship between age and reoperation did not achieve statistical significance in the multivariate model.

DISCUSSION

To our knowledge, this is the largest study to examine a matched-cohort comparison of arthroscopic and open treatment for shoulder instability. We determined that patients who underwent open treatment were significantly more likely than those who received arthroscopic treatment to require readmission, and they had longer operative times and hospital lengths of stay. Additionally, patients who had an open repair, CHF, longer hospital length of stay, or ASA class II were at significantly higher odds of readmission than others. Patients who underwent open treatment and had CHF or an increased hospital length of stay were significantly more likely than to require reoperation than those with

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Table 3. Univariate analysis of readmissions following arthroscopic and open repairs

Variable	Not admitted (n = 8,144)	Admitted (n = 44)	P-value
Sex			0.856
Male	6,386 (78.4)	35 (79.5)	
Female	1,758 (21.6)	9 (20.5)	
Age (yr)			0.133
< 18	0	0	
18–21	3,029 (37.2)	9 (20.5)	
25–34	2,670 (32.8)	17 (38.6)	
35–44	1,304 (16.0)	9 (20.5)	
≥ 45	1,141 (14.0)	9 (20.5)	
Body mass index (kg/m^2)			0.233
Underweight	43 (0.5)	1 (2.3)	
Normal weight	2,588 (32.1)	13 (29.5)	
Overweight	3,340 (41.5)	16 (36.4)	
Obese, Class I	1,341 (16.7)	12 (27.3)	
Obese, Class II	460 (5.7)	1 (2.3)	
Obese, Class III	279 (3.5)	1 (2.3)	
ASA classification			0.002
Class I	3,804 (46.7)	13 (29.5)	
Class II	3,781 (46.4)	22 (50.0)	
Class III	541 (6.6)	9 (20.5)	
Class IV	17 (0.2)	0	
Comorbidity			
Hypertension	701 (8.6)	9 (20.5)	0.012
Current smoker	33 (0.4)	2 (4.5)	0.011
Diabetes	239 (2.9)	0	0.640
Congestive heart failure	3 (0.0)	1 (2.3)	0.021
Bleeding disorders	11 (0.2)	0	> 0.999
Steroid use	51 (0.6)	0	> 0.999
Chronic obstructive pulmonary disease	33 (0.4)	2 (4.5)	0.015
Anesthesia type			0.646
General	7,869 (96.9)	44 (100.0)	
Regional	251 (3.1)	0	
Total operative time (min)	90.38 ± 45.7 (n = 8,136)	109.75 ± 50	0.404
Hospital length of stay (day)	0.16 ± 1.5 (n = 8,143)	1.09 ± 2.9	< 0.001
Procedure type			< 0.001
Arthroscopy	6,687 (82.1)	25 (56.8)	
Open	1,457 (17.9)	19 (43.2)	

Values are presented as number (%) or mean ± standard deviation.
ASA: American Society of Anesthesiologists.

Table 4. Multivariate analysis of outcomes for readmission

Outcome	OR	95% CI	P-value
Arthroscopic vs. open (reference = arthroscopic)	3.64	1.98–6.68	0.001
ASA (reference = Class IV)			0.011
Class I	1.68	0.84–3.36	0.139
Class II	4.45	1.85–10.68	0.001
Class III	< 0.001	-	> 0.999
Hypertension	0.58	0.24–1.38	0.216
Current smoker	0.58	0.30–1.11	0.098
Congestive heart failure	37.73	3.23–441.06	0.004
Chronic obstructive pulmonary disease	0.37	0.06–2.30	0.285
Hospital length of stay	1.07	1.02–1.12	0.007

OR: odds ratio, CI: confidence interval, ASA: American Society of Anesthesiologists.

Table 5. Univariate analysis of reoperation following arthroscopic and open repairs

Outcome	No reoperation	Reoperation	P-value
Case	10,300 (99.8)	24 (0.2)	-
Sex			0.606
Male	8,142 (79.0)	20 (83.3)	
Female	2,158 (21.0)	4 (16.7)	
Age (yr)			0.033
< 18	0	0	
18–24	3,825 (37.1)	5 (20.8)	
25–34	3,382 (32.8)	14 (58.3)	
35–44	1,668 (16.2)	1 (4.2)	
≥ 45	1,425 (13.8)	4 (16.7)	
Body mass index (kg/m^2)			0.093
Underweight	60 (0.6)	1 (4.2)	
Normal weight	3,201 (31.4)	6 (25.0)	
Overweight	4,259 (41.8)	10 (41.7)	
Obese, Class I	1,775 (17.4)	7 (29.2)	
Obese, Class II	566 (5.6)	0	
Obese, Class III	326 (3.2)	0	
Comorbidity			
Hypertension	887 (8.6)	4 (16.7)	0.148
Current smoker	2,142 (20.8)	5 (20.8)	> 0.999
Diabetes	291 (2.8)	0	> 0.999
Bleeding disorders	15 (0.2)	0	> 0.999
Steroid use	65 (0.6)	0	> 0.999
Chronic obstructive pulmonary disease	50 (0.5)	1 (4.2)	0.112
Congestive heart failure	3 (0.0)	1 (4.2)	0.009
ASA classification			0.962
Class I	4,734 (46.0)	10 (41.7)	
Class II	4,855 (47.1)	12 (50.0)	
Class III	686 (6.7)	2 (8.3)	
Class IV	22 (0.2)	0	
Anesthesia type			> 0.999
General	9,934 (96.7)	24 (100.0)	
Regional	338 (3.3)	0	
Total operative time (min)	91.44 ± 47.1	123.63 ± 54.4	0.227
Hospital length of stay (day)	0.17 ± 1.59	1.67 ± 3.5	< 0.001
Procedure type			< 0.001
Arthroscopic repair	8,532 (82.8)	9 (37.5)	
Open repair	1,768 (17.2)	15 (62.5)	

Values are presented as number (%) or mean ± standard deviation.
ASA: American Society of Anesthesiologists.

Table 6. Multivariate analysis of outcomes for reoperation

Outcome	OR	95% CI	P-value
Arthroscopic vs. open repair (reference = arthroscopic)	9.22	3.88–21.91	< 0.001
Congestive heart failure	284.60	25.74–3,147.12	< 0.001
Hospital length of stay	1.08	1.02–1.14	< 0.050
Age	1.08	0.73–1.59	0.714

OR: odds ratio, CI: confidence interval.

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CHF or a long hospitalization who received arthroscopic treatment. Furthermore, those same factors increased the odds of reoperation in the overall study population.

Previous studies have examined readmission and reoperation rates among arthroscopic and open shoulder stabilization procedures. Bokshan et al. [10] found that 30-day readmission rates tended to be higher in patients who underwent Latarjet-Bristow procedures than in those who received arthroscopic Bankart repairs; however, their results were not statistically significant. This coincides with another recent database study that determined that Latarjet-Bristow procedures had increased odds of readmission compared with arthroscopic Bankart repairs [11]. Overall, both studies noted that the rate of 30-day return to the operating room was significantly higher for the Latarjet-Bristow procedure than for arthroscopic Bankart repairs [10,11].

The literature indicates that patient risk factors can affect the risk for readmission or reoperation following shoulder surgery [12-14]. Shields et al. [15] analyzed adult patient risk factors and complications within 30 days after arthroscopic shoulder surgery and found greater odds of complications in patients who were older than 60 years, had COPD or disseminated cancer, or were current smokers. Shields et al. [15] also found that the presence of COPD was a significant predictor for reoperation within 30 days, concluding that pulmonary comorbidity increased the risk of 30-day reoperation. However, unlike our results, Shields et al. [15] did not find any cardiovascular comorbidities that increased the risk of reoperation. It is important to note that Shields et al. [15] examined patients undergoing arthroscopic surgery and not only patients undergoing shoulder instability procedures, which differs from our data and could explain the discrepancies in the results. Additionally, 90% of their cohort was older than 30 years, whereas in our study only 30% of the patients were older than 35 years, and only 63% were older than 25 years. This age variation could also explain the statistical difference.

As expected, the open procedure cohort in our analysis had significantly greater surgical times than the arthroscopic cohort. Similarly, previous work by Bokshan et al. [10] compared arthroscopic Bankart, open Bankart, and Latarjet-Bristow procedures, and found that the Latarjet-Bristow procedure took significantly longer than the arthroscopic Bankart repair. Increased operative time has been shown to increase the risk of short-term postoperative complications [16,17]. Shields et al. [15] determined that patients with a surgical time greater than 1.5 hours and patients with inpatient status had greater odds of complications following shoulder arthroscopy than those with shorter surgical times or outpatient status. Surgeons choosing between arthroscopic and open procedures for shoulder stabilization treatment should be mindful of these data.

This study is not without limitations. Some limitations are inherent to using the ACS-NSQIP database. For example, identifying patients in the ACS-NSQIP database requires the use of CPT codes in the query. Therefore, miscoding could lead to incomplete patient capture. The database is reported by participating hospitals and thus might not be generalizable to all patient populations. In addition, postoperative data are collected for only 30 days. Complications often occur outside that 30-day period, including DVT, PE, infections, reoperation, and readmission. The indications for the studied procedures also differ, which is a limitation when comparing arthroscopic and open procedures. Additionally, the database does not include freestanding surgery centers. Despite those limitations, however, the ACS-NSQIP database has been used to report on many other orthopaedic procedures [10,11,15,18-21].

Unplanned 30-day readmission and reoperation after shoulder instability surgery is infrequent. Patients who have ASA class II, CHF, longer than average hospital length of stay, or an open procedure have higher odds of readmission than others. Patients who have CHF, longer than average hospital length of stay, and open surgery have higher odds of reoperation than others. Arthroscopic procedures should be used to manage shoulder instability, if possible. Surgeons should explain the risks and benefits of intervention taking individual patient risk factors into account because comorbidities can also increase the risk of adverse outcomes.

NOTES

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Conflict of interest

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Data availability
Contact the corresponding author for data availability.

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