

# Postoperative Morbidity by Procedure and Patient Factors Influencing Major Complications Within 30 Days Following Shoulder Surgery

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**Background:** Little data are available to prioritize quality improvement initiatives in shoulder surgery.

**Purpose:** To stratify the risk for 30-day postoperative morbidity in commonly performed surgical procedures about the shoulder completed in a hospital setting and to determine patient factors associated with major complications.

**Study Design:** Cohort study; Level of evidence, 3.

**Methods:** This retrospective study utilized the National Surgical Quality Improvement Program (NSQIP) database from the years 2005 to 2010. Using Current Procedural Terminology codes, the database was queried for shoulder cases that were divided into 7 groups: arthroscopy without repair; arthroscopy with repair; arthroplasty; clavicle/acromioclavicular joint (AC) open reduction and internal fixation (ORIF)/repair; ORIF of proximal humeral fracture; open tendon release/repair; and open shoulder stabilization. The primary end point was any major complication, with secondary end points of incisional infection, return to the operating room, and venothromboembolism (VTE), all within 30 days of surgery.

**Results:** Overall, 11,086 cases were analyzed. The overall major complication rate was 2.1% ( $n = 234$ ). Factors associated with major complications on multivariate analysis included: procedure performed ( $P < .001$ ), emergency case ( $P < .001$ ), pulmonary comorbidity ( $P < .001$ ), preoperative blood transfusion ( $P = .033$ ), transfer from an outside institution ( $P = .03$ ), American Society of Anesthesiologists (ASA) score ( $P = .006$ ), wound class ( $P < .001$ ), dependent functional status ( $P = .027$ ), and age older than 60 years ( $P = .01$ ). After risk adjustment, open shoulder stabilization was associated with the greatest risk of major complications relative to arthroscopy without repair (odds ratio [OR], 5.56;  $P = .001$ ), followed by ORIF of proximal humerus fracture (OR, 4.90;  $P < .001$ ) and arthroplasty (OR, 4.40;  $P < .001$ ). These 3 groups generated over 60% of all major complications. Open shoulder stabilization had the highest odds of reoperation (OR, 8.34;  $P < .001$ ), while ORIF of proximal humerus fracture had the highest risk for VTE (OR, 6.47;  $P = .001$ ) compared with the reference group of arthroscopy without repair.

**Conclusion:** Multivariable analysis of the NSQIP database suggests that open shoulder stabilization, ORIF for proximal humerus fractures, and shoulder arthroplasty are associated with the highest risk of major complications within 30 days after shoulder surgery in a hospital setting. Age, functional status, ASA score, pulmonary comorbidity, emergency case, preoperative blood transfusion, and transfer from an outside institution are patient variables that significantly influence complication risk.

**Keywords:** high-risk procedures; NSQIP; open shoulder stabilization; ORIF; arthroplasty; shoulder

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One of more of the authors has declared the following potential conflict of interest or source of funding: I.V. is a consultant for Zimmer, Acumed, Arthrosurface, Arthrocare, and Arthrex.

The Orthopaedic Journal of Sports Medicine, 2(10), 2325967114553164

DOI: 10.1177/2325967114553164

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Shoulder surgical procedures are commonly performed in the United States.<sup>9</sup> The number of shoulder replacements and rotator cuff repairs performed each year is increasing, and this upward trend is projected to continue.<sup>8,18</sup> The population of patients older than 65 years is rapidly increasing, and it is anticipated there will be 88.5 million people older than 65 years by 2050.<sup>4</sup> As the population ages, the number of athletically active elderly patients will likely increase, potentially resulting in more injuries and degenerative conditions requiring visits to an orthopaedic specialist.

The United States government is actively working to reduce health care costs through bundled payments, non-reimbursable “never events,” and decreasing payment for readmission after joint arthroplasty,<sup>3,19,20</sup> and it is likely that private insurers will eventually adopt similar measures.<sup>10</sup> Postoperative complications can significantly increase health care costs,<sup>2,12</sup> and the Patient Protection and Affordable Care Act (March 2010) contains provisions that reduce payments for hospital costs associated with joint arthroplasty readmissions occurring within 30 days of discharge, and it will likely include shoulder arthroplasty in the future.<sup>20</sup> Thus, quality improvement efforts during the 30-day postoperative period should be a major focus.

Understanding the complication rates for specific procedures will help focus quality improvement efforts. This study sought to stratify the risk for 30-day postoperative morbidity in commonly performed surgical procedures about the shoulder, and also to determine patient factors associated with major complications utilizing the National Surgical Quality Improvement Program (NSQIP) database.

## METHODS

### Data Source and Analytic Data Set

The study was based on a retrospective analysis of prospectively collected data as a part of the American College of Surgeons NSQIP database. The NSQIP database comprises cases sampled from participating national hospitals. Ambulatory surgery suites and outpatient surgery centers that are attached or within participating hospitals contribute cases, while stand-alone ambulatory surgical centers do not participate. Sampling strategy, data abstraction, and variable definition have been described previously.<sup>17</sup> In brief, dedicated nurse reviewers sample a proportion of cases performed and provide details on preoperative patient characteristics, intraoperative factors, and postoperative occurrences. Postoperative outcomes are recorded for up to 30 days following surgery.<sup>17</sup>

The 2005-2011 NSQIP data set was queried for shoulder procedures. Inclusion criteria were based on Current Procedural Terminology (CPT) codes for primary procedures. The procedures were categorized into the following groups: arthroscopy without repair (CPT codes 29819, 29820, 29821, 29822, 29823, 29824, 29825, 29826), arthroscopy with repair (29806, 29807, 29827, 29828), arthroplasty (23470, 23472, 23616), clavicle/acromioclavicular joint (AC) open reduction and internal fixation (ORIF)/repair (23480, 23485, 23490, 23515, 23530, 23550, 23552), ORIF of proximal humeral fracture (23615, 23630, 23660, 23670, 23680), open tendon release/repair (23410, 23412, 23415, 23420, 23430, 23440, 23405, 23406), and open shoulder stabilization (23450, 23455, 23466, 23465). Groups were based on anatomic region and by invasiveness in an attempt to aggregate procedures together that would be expected to have similar 30-day perioperative complications. Patients with missing age and sex data were excluded. The final data set included 11,086 patients who underwent primary shoulder procedure in NSQIP-participating hospitals between 2005 and 2011.

### Study End Points

The primary study end point was any major complication, as reported by NSQIP.<sup>13,15,25</sup> Major complications were considered life-threatening or debilitating conditions that developed within 30 days of the primary procedure, including organ/space infections not related to initial surgical site, sepsis, postoperative bleed requiring transfusion, dependence on ventilator (reintubation or failure to wean), cardiac event, neurologic event, pneumonia, venous thromboembolic event, return to the operating room (ROR), graft failure, or acute renal failure. ROR was recorded as any unplanned major surgical procedure within the 30-day postoperative period that is a result of an adverse outcome related to the principal procedure. A patient with any of the previous complications was deemed to have a major complication. Further analysis was then carried out to obtain secondary end points in an attempt to determine the risk factors predisposing patients to specific complications, which included ROR, venothromboembolism (VTE), and incisional complications (superficial surgical site or deep surgical site infections).

### Patient and Operative Characteristics

Preoperative comorbidities were grouped by organ system, as previously described.<sup>14</sup> Age was evaluated as a categorical variable with the reference group set as age 60 years or younger. American Society of Anesthesiologists (ASA) class was evaluated as a categorical variable, with ASA 1 or 2 set as the reference group compared with ASA class 3 or 4. Wound class was defined in accordance with the Centers for Disease Control and Prevention assessment of the degree of surgical wound contamination at the time of the operation and was defined as a categorical variable with the reference group set as wound class 1 or 2 compared with 3 or 4. Functional status was evaluated as a categorical variable with any functional dependency compared with no functional dependency (obtained by nurse reviewers). Other clinical variables included race (white, black, or other); admission from an outside facility; obesity (defined as body mass index [BMI]  $\geq 30$  kg/m<sup>2</sup>); smoking within the past year; alcohol use (>2 drinks daily); weight loss >10% in past 6 months; pulmonary hepatic, cardiac, renal, and neurological comorbidities; chemotherapy/radiotherapy/disseminated cancer; chronic steroid use; preoperative transfusion (representing greater than 4 units of blood transfused within 72 hours prior to the index procedure); bleeding disorder (defined as any condition putting the patient at risk for bleeding due to a deficiency of blood clotting elements, ie, vitamin K deficiency, hemophilia, thrombocytopenia, or use of chronic anticoagulants); hypoalbuminemia (<3.5 g/dL); anemia (hematocrit <35%); general anesthesia; and emergent surgery (classified by anesthesiologist and surgeon).

### Analytic Plan

Clinical characteristics were assessed for association with the primary and secondary end points. Analysis was performed using independent-sample Student *t* tests or

Pearson chi-square analysis as appropriate. Because this was an observational study and patients were not randomly assigned to treatment, we further used multivariable logistic regressions for each end point to control for factors other than treatment that could lead to observed differences in the primary and secondary end points. Factors from the bivariate analysis with  $P < .1$  were included in multivariable logistic regressions for each end point. Predictors for each end point in multivariable analysis were considered statistically significant if the 2-tailed  $P$  value was less than .05. All analyses were carried out using SPSS Statistics software, version 20 (IBM Corp). This study met institutional review board criteria for an exempt study.

## RESULTS

### Characteristics of the Study Cohort

Inclusion criteria were met in 11,086 patients. Major complications were experienced in 2.1% ( $n = 235$ ) of all cases. The mean age was  $54.9 \pm 16.4$  years; 56.8% ( $n = 6301$ ) were male and 90.1% were white ( $n = 8691$ ). In univariate analysis, patients more likely to experience a major complication were older ( $64 \pm 16.3$  years,  $P < .001$ ), female (2.5%,  $P = .008$ ), from another facility (18.4%,  $P < .001$ ), diabetics (3.4%,  $P < .001$ ), had dependent functional status (8.7%,  $P < .001$ ), drank alcohol daily (4.4%,  $P = .008$ ), had a pulmonary comorbidity (8.0%,  $P < .001$ ), had a cardiac comorbidity (3.8%,  $P < .001$ ), had a neurologic comorbidity (10.2%,  $P < .001$ ), had preoperative sepsis (18.1%,  $P < .001$ ), were hypoalbuminemic (1.9%,  $P = .017$ ), and more likely to be operated on under emergent conditions (17.5%,  $P < .001$ ). Wound class and ASA score also significantly correlated with major complications (Table 1).

### Bivariate Analysis

Major complication rates for the different procedures were as follows: shoulder arthroscopy without repair, 1% ( $n = 34$ ); arthroplasty, 5.8% ( $n = 104$ ); open clavicle/acromioclavicular joint repair, 4% ( $n = 11$ ); ORIF of the proximal humerus, 8.5% ( $n = 36$ ); arthroscopy with repair, 0.7% ( $n = 23$ ); open tendon release/repair, 1.4% ( $n = 21$ ); and shoulder stabilization, 4.3% ( $n = 5$ ). Shoulder arthroplasty represented the greatest proportion of all complications (44%, 104/235), followed by ORIF of the proximal humerus (15%, 36/235) (Table 2).

### Risk-Adjusted Analysis

Factors associated with major complications on multivariable analysis included: procedure ( $P < .001$ ), emergency case ( $P < .001$ ), pulmonary comorbidity ( $P < .001$ ), preoperative blood transfusion ( $P = .033$ ), transfer from an outside institution ( $P = .03$ ), ASA class ( $P = .006$ ), wound class ( $P < .001$ ), dependent functional status ( $P = .027$ ), and age over 60 years ( $P = .01$ ). Further analysis of procedure type, referencing arthroscopy without repair (odds

TABLE 1  
Patient Characteristics and Factors Associated With Major Complications on Univariate Analysis<sup>a</sup>

	Total	Major Complications	$P$ Value
Age, y, mean $\pm$ SD	54.9 $\pm$ 16.4	64.0 $\pm$ 16.3	<.001
Sex			.008
Male	6301 (56.8)	113 (1.8)	
Female	4785 (43.2)	121 (2.5)	
Race			.311
White	8691 (90.1)	202 (2.3)	
Black	668 (6.9)	11 (1.6)	
Other	291 (3.0)	4 (1.4)	
Transfer from facility	76 (0.7)	14 (18.4)	<.001
Obese (BMI $\geq$ 30 kg/m <sup>2</sup> )	4537 (40.9)	96 (2.1)	.993
Diabetes	1450 (13.1)	49 (3.4)	<.001
Dependent functional status	366 (3.3)	32 (8.7)	<.001
ASA class			<.001
1	1589 (14.3)	14 (0.9)	
2	6194 (55.9)	91 (1.5)	
3	3133 (28.3)	112 (3.6)	
4	167 (1.5)	18 (10.8)	
5	0	0	
Smoker	2080 (18.7)	44 (2.1)	.998
Alcohol use (>2 drinks/d)	274 (2.5)	12 (4.4)	.008
Weight loss >10% in past 6 mo	23 (0.2)	2 (8.7)	.084
Pulmonary comorbidity	327 (2.9)	26 (8.0)	<.001
Hepatic insufficiency	6 (0.1)	1 (16.7)	.120
Cardiac comorbidity	868 (7.8)	33 (3.8)	<.001
Renal insufficiency	28 (0.3)	2 (0.9)	.118
Neurological comorbidity	429 (3.9)	24 (10.2)	<.001
Chemotherapy/XRT/ disseminated cancer	41 (0.4)	6 (14.6)	<.001
Chronic steroid use	185 (1.7)	14 (7.6)	<.001
Preoperative transfusion	5 (0.0)	3 (60.0)	<.001
Bleeding disorder	187 (1.7)	7 (3.7)	.12
Preoperative sepsis	72 (0.6)	13 (18.1)	<.001
Hypoalbuminemia	8220 (74.0)	158 (1.9)	.017
Anemia (HCT $\leq$ 36%)	4987 (44.9)	116 (2.3)	.165
Wound class			<.001
1	10,883 (98.0)	220 (2.0)	
2	120 (1.1)	2 (1.7)	
3	52 (0.5)	4 (7.7)	
4	51 (0.5)	9 (17.6)	
General anesthesia	10,284 (92.6)	219 (2.1)	.733
Emergency surgery	126 (1.1)	22 (17.5)	<.001

<sup>a</sup>Values are reported as n (%) unless otherwise indicated. ASA, American Society of Anesthesiologists; BMI, body mass index; HCT, hematocrit; XRT, external radiation therapy.

ratio [OR], 1), revealed that patients undergoing open clavicle/acromioclavicular joint repair (OR, 3.0;  $P = .002$ ), arthroplasty (OR, 4.4;  $P < .001$ ), ORIF of proximal humerus (OR, 4.9;  $P < .001$ ), and open shoulder stabilization procedures (OR, 5.56;  $P < .001$ ) carried significantly higher risks of major complications relative to arthroscopy without repair (Table 3).

The odds of returning to the operating room, relative to arthroscopy without repair, were significantly higher for shoulder stabilization procedures (OR, 8.34;  $P < .001$ ),

TABLE 2  
Major Complications, ROR, VTE, and Incisional Complications by Procedure Type<sup>a</sup>

Procedure	Total	Major Complications	ROR	VTE	Incisional
Arthroscopy (without repair)	3357 (30.3)	34 (1.0)	16 (0.5)	6 (0.2)	7 (0.2)
Arthroplasty	1797 (16.2)	104 (5.8)	20 (1.1)	8 (0.4)	4 (0.2)
Open clavicle repair	462 (4.2)	11 (2.4)	7 (1.5)	2 (0.4)	4 (0.9)
ORIF of proximal humeral fracture	421 (3.8)	36 (8.5)	10 (2.4)	7 (1.7)	2 (0.5)
Arthroscopy (with repair)	3340 (30.2)	23 (0.7)	15 (0.4)	4 (0.1)	5 (0.1)
Open tendon release/repair	1532 (13.8)	21 (1.4)	7 (0.5)	5 (0.3)	9 (0.6)
Shoulder stabilization	114 (1.0)	5 (4.3)	4 (3.4)	0 (0.0)	3 (2.6)

<sup>a</sup>Values are reported as n (%). ORIF, open reduction and internal fixation; ROR, return to operating room; VTE, venothromboembolism.

TABLE 3  
Multivariable Analysis of Major Complications<sup>a</sup>

Covariate	Odds Ratio	95% CI	P Value
Procedure <sup>b</sup>	1	—	<.001
Arthroplasty	4.40	2.89-6.71	<.001
Open clavicle repair	3.00	1.48-6.07	.002
ORIF of proximal humeral fracture	4.90	2.89-8.31	<.001
Arthroscopy (with repair)	0.80	0.46-1.37	.412
Open tendon release/repair	1.33	0.76-2.32	.323
Shoulder stabilization	5.56	2.10-14.70	.001
Emergency	4.19	2.44-7.19	<.001
Pulmonary comorbidity	2.05	1.29-3.27	.002
Preoperative transfusion	8.96	1.19-67.81	.033
Transfer from other institution	2.19	1.07-4.50	.033
ASA class (3 or 4 vs 1 or 2)	1.52	1.12-2.05	.006
Wound class (3 or 4 vs 1 or 2)	4.67	2.42-9.01	<.001
Dependent functional status	1.65	1.06-2.58	.027
Age >60 y	1.52	1.11-2.10	.010

<sup>a</sup>ASA, American Society of Anesthesiologists; ORIF, open reduction and internal fixation.

<sup>b</sup>Reference procedure: arthroscopy without repair.

TABLE 4  
Multivariable Analysis of Return to the Operating Room by Procedure<sup>a</sup>

Covariate	Odds Ratio	95% CI	P Value
Procedure <sup>b</sup>	1	—	<.001
Arthroplasty	2.33	1.18-4.62	.016
Open clavicle repair	3.54	1.41-8.89	.007
ORIF of proximal humeral fracture	3.72	1.59-8.74	.003
Arthroscopy (with repair)	1.17	0.57-2.43	.669
Open tendon release/repair	1.09	0.44-2.70	.861
Shoulder stabilization	8.34	2.68-25.95	<.001
Pulmonary comorbidity	1.49	0.60-3.70	.388

<sup>a</sup>ORIF, open reduction and internal fixation.

<sup>b</sup>Reference procedure: arthroscopy without repair.

followed by ORIF of the proximal humerus (OR, 3.72; *P* = .003), open clavicle/acromioclavicular joint repair (OR, 3.54; *P* = .007), and lastly, shoulder arthroplasty (OR, 2.33; *P* = .016). The risk after arthroscopy with repair and

TABLE 5  
Multivariable Analysis for Venothromboembolism<sup>a</sup>

Covariate	Odds Ratio	95% CI	P Value
Procedure <sup>b</sup>	1	—	.022
Arthroplasty	2.08	0.71-6.11	.182
Open clavicle repair	2.64	0.523-13.299	.24
ORIF of proximal humeral fracture	6.47	2.058-20.321	.001
Arthroscopy (with repair)	0.72	0.202-2.558	.61
Open tendon release/repair	1.72	0.519-5.682	.376
Shoulder stabilization <sup>c</sup>	—	—	—

<sup>a</sup>ORIF, open reduction and internal fixation.

<sup>b</sup>Reference procedure: arthroscopy without repair.

<sup>c</sup>No events.

open tendon release/repair surgery did not differ from arthroscopy without repair (Table 4).

The risk of VTE after surgery, using arthroscopy without repair as the reference, was highest for ORIF of the proximal humerus (OR, 6.47; *P* = .001). Patients undergoing arthroplasty, open clavicle repair, arthroscopy with repair, open tendon release/repair surgery, and shoulder stabilization procedures did not result in higher risk of VTE compared with arthroscopy without repair (Table 5).

Patients undergoing shoulder stabilization surgery had the highest risk of incisional complications (OR, 8.89; *P* = .003), followed by open tendon release/repair surgery (OR, 3.065; *P* = .029). No other procedure differed significantly on multivariable analysis of incisional complications compared with arthroscopy without repair (Table 6).

## DISCUSSION

This is the first study using a large national database to compare complications between a large number of surgical procedures specific for the shoulder, and our results suggest that shoulder surgery in general is associated with low rates of major complication. However, patients undergoing open stabilization procedures, ORIF of proximal humerus fractures, shoulder arthroplasty, and clavicle ORIF/acromioclavicular joint reconstruction have significantly increased risk of major complications compared with arthroscopic procedures after adjusting for confounding variables. Furthermore, these 4 procedures also had

TABLE 6  
Multivariable Analysis of Incisional Complications  
by Procedure Type

	Odds Ratio	95% CI	P Value
Procedure <sup>b</sup>	1	—	.007
Arthroplasty	1.443	0.40-5.18	.574
Open clavicle repair	2.876	0.79-10.45	.109
ORIF of proximal humeral fracture	2.55	0.50-13.08	.261
Arthroscopy (with repair)	0.67	0.21-2.12	.495
Open tendon release/repair	3.065	1.12-8.36	.029
Shoulder stabilization	8.89	2.12-37.37	.003

<sup>a</sup>ORIF, open reduction and internal fixation.

<sup>b</sup>Reference procedure: arthroscopy without repair.

significantly higher rates of ROR. Patients who underwent proximal humerus ORIF or shoulder arthroplasty experienced 60% of all major complications within this large cohort. Proximal humerus fractures demonstrated a significantly higher risk of VTE compared with other shoulder procedures, and this risk was higher than that reported previously in the literature.<sup>7</sup>

There are plans for the Centers for Medicare and Medicaid Services (CMS) to reduce reimbursements to hospitals that demonstrate suboptimal 30-day readmission rates for total joint patients starting in 2015,<sup>6</sup> and additional orthopaedic procedures will likely fall under the same scrutiny. Because patients undergoing ORIF of the proximal humerus and shoulder arthroplasty tend to be elderly, this poses a significant threat for reduced reimbursement for these procedures.<sup>22</sup> Furthermore, our study demonstrates that these patients make up the majority of 30-day perioperative complications for shoulder surgery, and carry high risk for ROR, further increasing readmission rate.

To help control costs, orthopaedic total joint centers are already experimenting with bundled payment systems.<sup>3</sup> Bundled payment refers to a lump sum that is paid to the hospital or facility to cover all costs of care for a patient undergoing a procedure, including costs associated with postoperative rehabilitation and complications.<sup>3</sup> While bundled payment systems largely apply to the Medicare patient population, private insurance reimbursements often mirror CMS changes, especially reductions in payment.<sup>10</sup> These reductions are compounded by the implementation of “never events,” such as surgical site infections for shoulder surgery and deep venous thrombosis following total joint arthroplasty, and costs associated with these complications are not reimbursed.<sup>19</sup> Expansion of these measures to more orthopaedic surgical specialties and the participation of private insurance companies should be anticipated.

Preparation for these changes must begin with defining the highest-risk shoulder surgeries and identifying patient variables that increase complication rates. More and more patients remain active and participate in athletic activity as they get older. It is becoming very common for orthopaedic surgeons to take care of shoulder disorders in a “mature athlete.” Knowing which procedures carry the highest risks along with the frequency of common complications allows

for a more informed discussion with patients. The identification of patient factors increasing risk for major complications allows for modifiable risks to be optimized before undergoing surgery and theoretically lower complication rates. Finally, knowing which patient factors are associated with more complications allows for these factors to be studied more in depth for each individual procedure to better define high-risk patients undergoing each procedure.

Complications following shoulder arthroscopy, total shoulder arthroplasty, reverse total shoulder arthroplasty, open stabilization, and even biceps tenodesis have been described.<sup>5,11,21,23,24</sup> Attempting to compare complication rates between individual studies is difficult, as different studies focus on different complications and have variable lengths of follow-up. This study compares complication rates between the most common shoulder procedures using a national representative database, utilizing standardized patient comorbidities and defined complications. The NSQIP database is designed to generate a nationally representative case sample,<sup>1,26</sup> making these results more widely applicable for patients undergoing surgery in a hospital setting.

This study utilized multivariable analysis to control for a large number of patient factors when analyzing risks for complications (see Table 1). Only 1 other study using data from the NSQIP database<sup>21</sup> analyzed this number of patient factors, and the authors found that smoking, history of chronic obstructive pulmonary disease, longer operative time, and increasing ASA score all increased the risk of complications after shoulder arthroscopy. Our study identified 15 patient variables that increase the risk of complications. Notably, increasing ASA score, increasing wound class, presence of a pulmonary comorbidity, age over 60 years, and requirement for preoperative transfusion all elevated the risk of major complications. Other studies evaluating some of these patient characteristics have found similar results with regard to their association with complications. Increasing ASA and Charlson scores have been linked to higher 90-day mortality and increased surgical complications after shoulder arthroplasty.<sup>5,16,27</sup> Similarly, increasing Charlson scores, increasing age, and prior cardiac events have been linked to increased risk of postoperative cardiac events.<sup>28</sup>

Risk of VTE was significantly higher in the proximal humerus ORIF group compared with the other groups, with all other procedures having similar rates of VTE. Previous reports have also concluded that risk of VTE after shoulder surgery is greatest with the treatment of proximal humerus fractures.<sup>7</sup> Combined analysis of multiple studies suggests that although most common after fracture care, VTE after shoulder procedures still occurs in less than 1% of patients, regardless of the operation. Diabetes mellitus, rheumatoid arthritis, and ischemic heart disease have been identified as the major risk factors for VTE following shoulder and elbow surgery.<sup>7</sup> The fracture group in our study had a 1.7% rate of VTE, which is higher than previously reported.

Although open shoulder stabilization had a lower overall complication rate compared with proximal humeral ORIF and shoulder arthroplasty, the risk-adjusted odds

of experiencing a major complication was the highest of all procedures. The likely explanation is that patients undergoing ORIF and shoulder arthroplasty were older with more comorbidities, and the shoulder stabilization group had a higher number of complications than would be expected based on the population characteristics.

Strengths of this study include the use of a nationally validated database and a large sample size with robust clinical characteristics, allowing for risk-adjusted analysis. This type of analysis allows for identification-independent risk factors associated with complications. The limitations of this study are inherent to studies where data are derived from a registry. Specific details about the procedures and reoperations in each group were unavailable. A major weakness of this study is that we did not review patient factors increasing the risk of complications for each individual procedure. Results from the open shoulder stabilization group should be interpreted with caution, as this group represented a small percentage of all patients and we were unable to determine from the database whether these patients had previous surgery on the same shoulder. We were also unable to perform any radiographic analysis, and all follow-up data were limited to 30 days after surgery. However, 30-day complication rates and readmissions are what the federal government has elected to use as a measure of quality and thus reimbursement.

An additional weakness of this study is that these cases are collected from hospitals or attached outpatient surgical suites, while the majority of the shoulder procedures analyzed in this study are performed at stand-alone ambulatory surgery centers. We did not analyze whether patients were documented as “inpatient,” and information on whether ambulatory surgical centers were available to the surgeons is not documented. This does create a potential bias, in that patients with more comorbidities may have their procedures performed in a hospital setting versus an ambulatory surgery center for safety. This would potentially lead to higher complication rates overall than the actual national averages. However, multivariate analysis attempts to control for these factors, and this potential bias should have less of an effect on the odds ratios calculated.

## CONCLUSION

Major complication rates following shoulder surgery in a hospital setting are low, averaging 2.1%. Open shoulder stabilization, ORIF for proximal humerus fractures, and shoulder arthroplasty are the procedures associated with the highest risk of major complications, combined representing over 60% of all complications in this study. Increasing ASA score, higher wound class, presence of a pulmonary comorbidity, age over 60 years, designation as an emergency case, transfer from an outside institution, dependent functional status, and preoperative transfusion requirement all increased a patients risk for major complications following shoulder surgery in risk-adjusted analysis. Future initiatives for quality improvement in shoulder surgery should focus specifically on

these procedures to decrease the overall complication burden.

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