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Sex differences in complications and readmission rates following shoulder arthroplasty in the United States

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Introduction: Shoulder arthroplasty (SA) procedures are increasingly performed in the United States. However, there is a lack of data evaluating how patient sex may affect perioperative complications. The purpose of this study was to evaluate sex-based differences in 30-day postoperative complication and readmission rates after SA.

Methods: Total SA and reverse SA cases between 2012-2016 were identified from the American College of Surgeons National Surgical Quality Improvement Program database. The 30-day complication rate, readmission rate, operation time, length of stay, and mortality were compared between women and men. Multivariable logistic regression analysis was performed to identify independent perioperative complications associated with patient sex.

Results: Of 12,530 SA cases, 6949 (55.4%) were female and 5499 (44.5%) were male. Compared with women, on average men were significantly younger, had lower body mass index, and were less likely to be functionally dependent, and less likely to have an American Society of Anesthesiologists score of 3+ ($P < .001$). Although overall complications and readmission rates between women and men were similar (3.4% vs. 3.7%, $P = .489$; 3.0% vs. 2.8%, $P = .497$), men were significantly less likely to develop urinary tract infections (UTIs; odds ratio [OR] 0.58, $P = .032$) and require transfusions (OR 0.49, $P < .001$) and had shorter lengths of stay ($P < .001$). However, men were significantly more likely to have a superficial surgical site infection (OR 2.63, $P = .035$) and 6.8 minute longer operating time ($P < .001$) compared with women.

Conclusion: Though the overall complication risk is similar between the sexes, their risk profiles are distinct. Men had decreased risk of UTI, blood transfusions, and shorter length of stay but increased risk of surgical site and longer operating time compared with women. This disparity should be discussed when counseling and risk-stratifying patients for SA.

Shoulder arthroplasty (SA) is a successful treatment for patients with various glenohumeral pathologies. The use of SA has increased by 12% annually in the United States, and this increase in utilization is expected to continue as the aging population continues to grow.[10,23,29] Complications for SA range between 10%-16%, and these complications can contribute significantly to patient morbidity and mortality and also prolonged length of stay, which will contribute to increased health care cost.[2,30] In a landscape where there is a greater emphasis on value-based payment programs, it is important to properly identify and prevent perioperative complications that arise after high-demand procedures, such as SA.

Patient sex has been established as an independent risk factor for perioperative complications after hip and knee arthroplasty, with more women likely to develop urinary tract infections (UTIs), require transfusion, and be discharged to a facility.[20] In contrast, the significance of patient sex as a risk factor for perioperative complications after SA has not been evaluated. The purpose of this study was to use population-representative data from a national database to identify 30-day perioperative complications and readmission rates between men and women undergoing SA.

Institutional Review Board approval was not required for this retrospective study.

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Methods and materials

This is a retrospective cohort study using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) information for 2012-2016. The ACS-NSQIP is a centralized database that contains a collection of patient-based variables and surgical outcomes over a 30-day postoperative period.[9] Past studies have validated NSQIP as a reliable source for surgical outcomes.[24]

The NSQIP database was queried for patients who underwent total shoulder arthroplasty (TSA) or reverse total shoulder arthroplasty (rTSA) using the Current Procedural Terminology code 23472. Patient demographics and medical information were collected, including patient sex, age, medical comorbidities (using the Elixhauser comorbidity index), medical history, body mass index, and insurance status. Primary outcome measures were any perioperative complication within 30 days of the index surgery. Secondary outcome measures included operation time, length of stay, and mortality.

Perioperative complications within the 30-day period were divided into major complications (deep infection, sepsis, septic shock wound infection, etc), minor complications (UTIs, superficial surgical site infection, renal insufficiency, etc), need for transfusion, and unplanned readmissions. Operating time and lengths of stay (LOSs) were also included. Patient characteristics were stratified on the basis of sex (men vs. women), and within-group differences were compared using Pearson χ^2 test. Multivariable logistic regression analysis was used to compare perioperative complications between men and women.

Results

We identified 12,530 patients who underwent TSA and rTSA during the period of interest with an overall mean age of 69.1 years and a body mass index of 31.2. There were 6949 women (55.4%) and 5499 men (44.5%) (Table I). Men were found to be significantly younger (67.4 vs. 70.4 years, $P < .001$, respectively) and have a lower body mass index than women (30.9 vs. 31.4, $P < .001$, respectively). Men were also less likely to have a dependent functional status (1.5% vs. 3.4%, respectively; $P < .001$) and an American Society of Anesthesiologists score of 3 or higher compared with women (51.9% vs. 55.9%, $P < .001$). When evaluating comorbidities, men are less likely to have a history of chronic obstructive pulmonary disease (5.5% vs. 7.5%, respectively; $P < .001$), a history of dyspnea (4.8% vs. 7.6%, $P < .001$), and have a greater use of steroids (3.5% vs. 6.1%, $P = .036$). Men were significantly more likely to be smokers (12% vs. 9.9%, respectively; $P < .001$), be on dialysis (0.6% vs. 0.3%), have a bleeding disorder (3.2% vs. 2.2%, $P < .001$), and have diabetes (18.3% vs. 16.9%, $P < 1.000$) compared with women.

The overall complication rate for all patients was low (440, 3.5%). There was no significant difference in the overall complication rate between men and women (3.7% vs. 3.4%; $P = .489$; Table II). Similarly, there were no significant differences between men and women when these complications were categorized as major complications (2.5% vs. 2.2%, $P = .195$) and minor complications (1.5% vs. 1.7%, $P = .366$).

Multivariable logistic regression revealed complications that were independently associated with patient sex (Table II). Compared with women, men were less likely to develop UTIs (odds ratio [OR] 0.58, 95% confidence interval 0.35-0.95; $P = .032$) but were more prone to develop superficial surgical site infection (OR 2.63, $P = .035$). Postoperatively, compared with women, men were significantly less likely to require transfusions (OR 0.49, $P < .001$) and had a third of a day shorter length of stay ($P < .001$) but a 6.75 minutes longer operating time (OT; $P < .001$).

Table I
Characteristics of total shoulder replacement by sex, 2012-2016

	Total, n (%) (N = 12,530)	Female, n (%) (n = 6946)	Male, n (%) (n = 5499)	*P* value
Age group, y				<.001
18-49	356 (2.9)	130 (1.9)	226 (4.1)	
50-59	1543 (12.4)	665 (9.6)	878 (16)	
60-69	4309 (34.6)	2305 (33.2)	2004 (36.4)	
≥70	6237 (50.1)	3846 (55.4)	2391 (43.5)	
BMI group				<.001
<18.5 (underweight)	81 (0.7)	66 (1)	15 (0.3)	
18.5-24	1920 (15.5)	1271 (18.4)	649 (11.8)	
25-29	4001 (32.3)	1964 (28.4)	2037 (37.1)	
30-34	3290 (26.5)	1654 (23.9)	1636 (29.8)	
≥35	3108 (25.1)	1961 (28.4)	1147 (20.9)	
Functional status				<.001
Independent	12,049 (97.5)	6671 (96.6)	5378 (98.5)	
Dependent	313 (2.5)	232 (3.4)	81 (1.5)	
ASA score				<.001
1-2	5702 (45.9)	3060 (44.1)	2642 (48.1)	
≥3	6729 (54.1)	3881 (55.9)	2848 (51.9)	
Hypertension	8299 (66.7)	4669 (67.2)	3630 (66)	.162
Diabetes	2179 (17.5)	1174 (16.9)	1005 (18.3)	.048
Smoker	1348 (10.8)	689 (9.9)	659 (12)	<.001
History of COPD	828 (6.7)	524 (7.5)	304 (5.5)	<.001
History of Dyspnea	793 (6.4)	528 (7.6)	265 (4.8)	<.001
History of CHF	61 (0.5)	35 (0.5)	26 (0.5)	.907
Dialysis	54 (0.4)	22 (0.3)	32 (0.6)	.036
Steroid use	619 (5)	424 (6.1)	195 (3.5)	<.001
Bleeding disorder	334 (2.7)	156 (2.2)	178 (3.2)	<.001

BMI, body mass index; *ASA*, American Society of Anesthesiologists; *COPD*, chronic obstructive pulmonary disease; *CHF*, congestive heart failure.

Discussion

Summary of findings

In this large nationwide database study evaluating 30-day perioperative complications after shoulder arthroplasty, we found that distinct risk profiles exist between male and female patients after controlling for demographic and comorbidity differences. Although the overall complication rate was similar, men were less likely to develop UTI and require postoperative transfusion than women but were more likely to develop superficial surgical site infection. Additionally, men had on average a significantly longer OT compared with women.

Transfusion risk

Previous studies have reported mixed findings of women undergoing SA having a higher risk of transfusion.[7,15,27] Our results support previous reports that women have a higher risk of postoperative blood transfusion following SA. Several factors may have contributed to these findings, such as the overall advanced age (55.4% of women vs. 43.5% of men were aged ≥70 years) and increased medical complexity (55.9% of women vs. 51.9% of men had an American Society of Anesthesiologists score of 3+) of the female patients undergoing SA compared with the male patients in the NSQIP database. Age and American Society of Anesthesiologists score are known to be independent risk factors for postoperative blood transfusions.[1,7,28] Gruson et al[7] identified that transfusion risk increased by 32%, for every 5-year increase in age; they also discovered that patients aged ≥65 years are 3-fold more likely to receive a transfusion. Additionally, Gruson et al[7] reported that lower preoperative hemoglobin levels (men <13 g/dL and women <12 g/dL) were a risk factor for blood transfusion along with implanting reverse arthroplasty compared with a total or hemiarthroplasty. It is also known that women undergoing SA tend to be

Table II
Association of sex with 30-day adverse events and readmission after TSA

	Female (n = 6946)*	Male (n = 5499)*	*P*	Multivariable logistic regression: female vs. male	
				Adjusted OR (95% CI)	*P* value
Any complication	238 (3.4)	202 (3.7)	.489	1.14 (0.93, 1.38)	.201
Major complications	150 (2.2)	139 (2.5)	.195	1.25 (0.98, 1.58)	.068
Deep infection	13 (0.2)	20 (0.4)	.084	1.68 (0.83, 3.43)	.152
Sepsis	11 (0.2)	11 (0.2)	.738	1.27 (0.54, 2.98)	.585
Septic shock	7 (0.1)	1 (0)	.147	0.26 (0.03, 2.19)	.217
Wound dehiscence	2 (0)	5 (0.1)	.284	2.84 (0.53, 15.16)	.222
Pulmonary embolism	29 (0.4)	15 (0.3)	.231	0.78 (0.41, 1.48)	.447
Ventilator >48 h	10 (0.1)	3 (0.1)	.21	0.59 (0.16, 2.23)	.44
Unplanned intubation	14 (0.2)	8 (0.1)	.6	0.91 (0.37, 2.21)	.835
Acute renal failure	2 (0)	4 (0.1)	.485	5.14 (0.81, 32.58)	.083
Cardiac arrest requiring CPR	5 (0.1)	3 (0.1)	.98	1.12 (0.26, 4.88)	.876
Myocardial infarction	14 (0.2)	13 (0.2)	.825	1.36 (0.63, 2.94)	.432
Cerebrovascular accident	5 (0.1)	6 (0.1)	.698	1.76 (0.53, 5.84)	.353
Return to operating room	77 (1.1)	80 (1.5)	.101	1.27 (0.92, 1.75)	.143
Mortality	12 (0.2)	9 (0.2)	1	1.13 (0.47, 2.72)	.79
Minor complications	119 (1.7)	82 (1.5)	.366	0.93 (0.7, 1.24)	.62
Superficial SSI	7 (0.1)	17 (0.3)	.015	2.63 (1.07, 6.43)	.035
Pneumonia	34 (0.5)	23 (0.4)	.652	0.9968 (0.5761, 1.7246)	.991
Urinary tract infection	56 (0.8)	23 (0.4)	.01	0.58 (0.35, 0.95)	.032
DVT or thrombophlebitis	24 (0.3)	18 (0.3)	.986	0.98 (0.52, 1.81)	.937
Renal insufficiency	8 (0.1)	5 (0.1)	.891	0.91 (0.29, 2.88)	.876
Transfusion	297 (4.3)	111 (2)	<.001	0.49 (0.39, 0.61)	<.001
Unplanned readmission	208 (3)	153 (2.8)	.003	1.07 (0.88, 1.32)	.497
				Multivariable linear regression Adjusted coefficient (95% CI)	*P* value
Operating time, mean (SD)	108.1 (45.5)	116.4 (47.9)	<.001	6.75 (5.08, 8.41)	<.001
Length of stay, mean (SD)	2.1 (2)	1.8 (2.5)	<.001	−0.31 (−0.38, −0.23)	<.001

TSA, total shoulder arthroplasty; *CPR*, cardiopulmonary resuscitation; *SSI*, surgical site infection; *DVT*, deep vein thrombosis; *SD*, standard deviation; *OR*, odds ratio; *CI*, confidence interval.
* Percentage of patients with presence of complication shown in parentheses.

older and more likely to be on Medicare insurance.[11] Hence, it is appropriate to question whether it is the age or medical complexity differences that account for the elevated transfusion rate in women; however, the transfusion rate discrepancy remained significant in our study when accounting for these differences with a multivariable logistic regression. Thus, it is important to counsel older female patients undergoing reverse shoulder arthroplasty of the potential need for blood transfusion during the perioperative time period.

Comparison of complications

Overall, 30-day complication rates following SA were found to be similar in both male and female patients. Additionally, patient sex did not have a significant association when these complications were stratified into major and minor complications. This contradicts the finding by Saltzman et al,[21] which reported that men are at a significantly higher odds to develop myocardial infarction, sepsis, or even death; the variation of results could be attributed to a different study time frame, a constantly improving prosthetic design, and the difference in the database from which the study cohort is extracted between their study and ours. Nonetheless, in our study, there were individual minor complications identified that were significantly associated with patient sex. Women were found to be more likely to develop UTI, whereas men were at a greater risk to develop superficial surgical site infection. This is consistent with previous studies that reported women undergoing SA are more prone for readmissions because of UTI, compared with their male counterparts.[31]

The overall rate of unplanned readmissions was significantly higher in women compared with men. This difference can be attributed to the age and comorbidity discrepancies between the female and male populations. In fact, when corrected for these variables with multivariable logistic regression, both male and female populations had similar unplanned readmission rates. Regardless, it is important to recognize that women may pose a higher risk for readmission because of differences in age and medial comorbidities.

Length of stay comparison

Women undergoing SA were more likely to have a longer LOS compared with men (2.1 days compared with 1.8 days), even when accounting for age and comorbidity disparities (OR −0.31). Saltzman et al[21] reported similar findings that women have a greater length of stay, with a mean of 2.8 days for all SA procedures. Additionally, Dunn et al[4] also reported that women were more likely to stay ≥4 days compared with male counterparts. LOS is an important surgical benchmark because it has been established that patients with a longer LOS are more likely to develop hospital-acquired infections, such as UTI.[14,18] Accordingly, the observed elevated UTI rate for women in our analysis may be influenced by their longer LOS. In addition to possible nosocomial infections, LOS can directly impact the cost incurred on the hospital. As SA volume rises and an increasingly cost-conscious health care system, controlling LOS, can curtail spending; the average per-day hospital cost after SA is $29,707.[19] Therefore, shortening LOS is a crucial component to decrease hospital-acquired infections and control health care spending.

Operating room time

Men were found to have a significantly longer OT compared with their counterpart. This may be attributed to the anatomic

variation that exists between both sexes—where men have a greater amount of soft tissue and muscle mass, which requires a longer OT to expose the glenohumeral joint to implant the components.[17] Perioperative complications associated with OT has been reported in total hip arthroplasty, where patients with a prolonged OT are more likely to develop infections.[26] This may be explained by the correlation between OT and surgical tray contamination as well as increased surgical site infection in men compared with women. Dalstrom et al[3] reported that in the first hour they identified 15% contamination, by the 2 hours 22%, and by 3 hours 26%. In addition to infection, increased OT may lead to other surgical complications. During SA, the surgeon must position the arm in an external rotation to expose the glenoid, thus increasing the risk of nerve damage with prolonged OT, especially in larger and muscular male patients.[12]

It is also important to consider the costs associated with OT. Singh et al[25] observed that the OT difference between high- and low-volume surgeons is 50 minutes for TSA and 30 minutes for rTSA and HA, respectively. Consequently, Hammond et al[8] found that the cost of SA (TSA or HA) is $1000 less when performed by high-volume surgeons. It is reported that the average OT ranges from $15 to $20, per minute, for basic surgical procedures.[13] Therefore, improving OT time will not just decrease perioperative complications but also decrease health care expenditures.

Strength and limitations

The strengths of this study include the large sample size provided by the ACS-NSQIP database. This database encompasses a multicenter data sample, including 462 hospitals in the United States and 34 hospitals in foreign nations, as reported in 2015. This affords a diverse patient population from which detailed perioperative complications and patient demographics can be evaluated.[16]

Limitations of this study include those inherent to a retrospective cohort study including the reliance on proper data collection and documentation in the NSQIP database. However, previous studies have confirmed the reliability of NSQIP for evaluating complications and readmissions in multiple surgical subspecialties.[5,6,22,24] Because NSQIP collects data from a variety of surgical procedures in several institutions, the variables collected are broad in nature and do not contain all data pertaining to surgical outcomes, such as amount of blood loss, hemoglobin levels, specific time from the moment of skin incision to closure, and preoperative complications. Because NSQIP data are gathered from hospital-based systems, there may be underreporting of complications that are documented at outpatient clinic charts. This may explain why the complication rate in our study was lower compared with other studies. Further, this database does not delineate the surgical sites from which the data are collected, nor does it include the surgeon's surgical experience, technique, prosthetic design, hospital case-volume, and perioperative protocols. No preoperative imaging is available to determine the severity of preoperative pathology that may certainly also influence outcomes.

Another important limitation inherent to the NSQIP database is the complication surveillance period of 30 days postsurgery, which excludes mid- to late-term complications that occur after this time frame. Although the inclusion of all complications would broaden the scope of our findings, an understanding of short-term complication differences with regard to patient sex provides important insight to appropriately optimize surgical outcomes.

Another shortcoming is that Current Procedural Terminology codes lack specificity in differentiating between TSA and rTSA along with the indications for surgery. Although these codes will likely be updated soon, for the purposes of this study the authors could not stratify by procedure to evaluate complications specific to each surgical procedure.

Conclusion

In this analysis of 12,530 shoulder arthroplasty cases, we found that women have a greater 30-day perioperative risk of developing UTI, increased risk of blood transfusions, and have a greater LOS compared with men who have a greater risk of superficial surgical site infection and have a longer OT. It is important to consider these risk factors for perioperative complications to appropriately counsel and optimize patients for shoulder arthroplasty surgery.

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Xinning Li reports that he holds equity in the *Journal of Medical Insight* and is on the editorial board.

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