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Diabetes increases risk for readmission and infection after shoulder arthroplasty: A national readmissions study of 113,713 patients

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ABSTRACT

Background: The recent increasing popularity of shoulder arthroplasty has been paralleled by a rise in prevalence of diabetes in the United States. We aimed to evaluate the impact of diabetes status on readmission and short-term complications among patients undergoing shoulder arthroplasty.

Methods: We analyzed the Healthcare Cost and Utilization Project National Readmissions Database (NRD) between the years 2016–2018. Patients were included in the study if they underwent anatomic total shoulder arthroplasty (aTSA) or reverse total shoulder arthroplasty (rTSA) according to ICD-10 procedure codes. Postoperative complications including surgical site/joint infection, dislocation, prosthetic complications, hardware-related complications, non-infectious wound complications, 30-day, and 90-day readmission were collected.

Results: A total of 113,713 shoulder arthroplasty patients were included. 23,749 (20.9%) had a diagnosis of diabetes and 89,964 (79.1%) did not. On multivariate analysis, a diagnosis of diabetes led to an increased risk of 30-day (OR: 1.24; 95% CI: [1.14, 1.34]; $p < 0.001$) and 90-day (OR: 1.18; 95% CI: [1.12, 1.25]; $p < 0.001$) readmission, surgical site/joint infection (OR: 1.21; 95% CI: [1.06, 1.38]; $p = 0.005$), respiratory complication (OR: 1.34; 95% CI: [1.09, 1.64]; $p = 0.005$), postoperative infection (OR: 1.22; 95% CI [1.07, 1.39]; $p = 0.003$), and deep vein thrombosis (OR: 1.38; 95% CI: [1.09, 1.74]; $p = 0.007$).

Conclusions: Our findings suggest that patients with diabetes may be at an increased risk of readmission, infection, respiratory complication, and deep vein thrombosis following shoulder arthroplasty. Shoulder surgeons should consider these potential adverse events when planning postoperative care for patients with diabetes.

1.1. Introduction

Over the past decade, the diabetes mellitus incidence has continued to rise and a 20% increase in prevalence among developed countries is expected by 2030.[1] Diabetes involves inadequate blood glucose control due to impaired insulin production or insulin resistance and has been associated with increased osteoarthritis rates,[2] which is the leading indication for total shoulder arthroplasty (TSA).[3] Furthermore, patients with diabetes may have reduced joint mobility due to non-enzymatic glycosylation and stiffening of collagen tissue.[4] As a result, diabetes has been associated with poorer range of motion (ROM) and patient-reported outcomes (PROs), as well as greater rates of post-operative complications following common orthopedic procedures.[5–7]

Along with the recent rise in diabetes prevalence, the demand for TSA procedures has steadily grown over the past several years, even in patient populations with greater rates of comorbidities at baseline.[3,8] Currently, there is some disagreement within current literature about the effect of diabetes status on TSA complications and outcomes.[9–11] Some studies have report diabetes as a risk factor for revision,[12] with insulin-dependent patients having an even greater risk of postoperative complications and extended hospital stay.[13] Further, several studies have reported that patients with diabetes are more likely to be readmitted to the hospital following TSA.[14,15] However, other studies have found no differences in follow-up outcomes among patients with non-insulin dependent diabetes compared to patients without diabetes.[11,13]

Despite the growing popularity of TSA and an increasing diabetic patient population, it remains unclear how diabetes mellitus may affect TSA outcomes. The goal of our study was to understand how diabetes status impacts short-term postoperative complications and readmissions following shoulder arthroplasty. Based on the systemic pathophysiology of diabetes, our hypothesis was that complication and readmission rates

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would be higher in patients with diabetes.

1.2. Methods

As we used a publicly available dataset for this study, institutional review board approval was not necessary. We analyzed the Healthcare Cost and Utilization Project National Readmissions Database (HCUP-NRD) between 2016 and 2018.[16] Patients with an ICD-10 procedure code for anatomic total shoulder arthroplasty (aTSA: 0RRJ0JZ and 0RRK0JZ) or reverse total shoulder arthroplasty (rTSA: 0RRJ00Z and 0RRK00Z) were included in the study. Patients who were <18 years old, underwent non-elective surgery, or died during their initial admission were excluded.

Patients were further stratified into those with and without a diagnosis of diabetes. Patients with diabetes were identified using the comorbidity package in R,[17] which defines Charlson comorbidities for each patient. The comorbidities differentiate between diabetes with and without complications, and patients with either diagnosis were included as part of the diabetes group.[18,19] Patients with complicated and uncomplicated diabetes were also analyzed separately, and the results are presented in supplemental tables.

The HCUP-NRD includes unique patient linkage identifiers which allows tracking of patients throughout each year of the dataset. Patients with a discharge date between October–December were excluded to account for the lack of continuity between years when calculating 30- and 90-day readmission rates. Joint-specific complications and general surgical complications were identified using ICD-10 diagnosis codes (Supplemental Tables 1 and 2). Furthermore, reasons for readmission were identified using the primary ICD-10 diagnosis code listed for each readmission.

1.2.1. Statistical analysis

Python version 3.8.8 was used to perform all statistical analyses. Chi-square tests were used to compare categorical variables and t-tests were used to compare continuous variables. The alpha level was set at 0.05 for all statistical testing. Multivariate logistic regression models were created using complications as the outcome variables. Diabetes status was the primary predictor, while the regression models also controlled for age, sex, and all statistically significant Charlson comorbidities from chi-square testing. Odds ratios and 95% confidence intervals are provided.

1.3. Results

There were 113,713 patients that met the inclusion criteria. Of these, 23,749 (20.9%) had a diagnosis of diabetes. Patients with diabetes were slightly older (70.1 years vs. 69.6 years, $p < 0.001$) and more likely to be male (45.1% vs. 42.4%; $p < 0.001$) (Table 1). The majority of the patients in the study were covered by either Medicare or private insurance. Patients with diabetes were more likely to have Medicare insurance (76.1% vs. 71.7%; $p < 0.001$) and less likely to have private insurance (16.0% vs. 20.3%; $p < 0.001$). Patients with diabetes generally had more comorbidities according to the Charlson index ($p < 0.001$). A routine discharge was more common in patients without diabetes (70.3% vs. 65.1%; $p < 0.001$), whereas patients with diabetes were more likely to be transferred (11.8% vs. 7.9%; $p < 0.001$) or discharged to home health care (22.9% vs. 21.7%; $p < 0.001$).

The most common comorbidities among patients with diabetes were chronic pulmonary disease (23.5%), congestive heart failure (7.8%), myocardial infarction (6.7%), and renal disease (14.7%). Patients with diabetes had a lower prevalence of rheumatoid disease and a higher prevalence of myocardial infarction, congestive heart failure, peripheral vascular disease, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, mild liver disease, renal disease, and moderate/severe liver disease compared to patients without diabetes (Supplemental Table 3).

Table 1
Demographics of patients undergoing shoulder arthroplasty with and without diabetes.

	No Diabetes (n = 89,964)	Diabetes (n = 23,749)	P-value
Mean Age (SD)	69.6 (9.3)	70.1 (8.2)	<0.001
Male Sex	38,143 (42.4%)	10,713 (45.1%)	<0.001
Insurance Status			
Medicare	64,474 (71.7%)	18,073 (76.1%)	<0.001
Private	18,297 (20.3%)	3796 (16.0%)	<0.001
Medicaid	2669 (3.0%)	668 (2.8%)	0.219
Self-Pay	272 (0.3%)	44 (0.2%)	0.003
No Charge	31 (0.0%)	15 (0.1%)	0.076
Other	4136 (4.6%)	1129 (4.8%)	0.316
Charlson Comorbidity Index			
0	62,538 (69.5%)	11,959 (50.4%)	<0.001
1-2	24,350 (27.1%)	9270 (39.0%)	<0.001
3-4	2715 (3.0%)	2068 (8.7%)	<0.001
≥5	358 (0.4%)	452 (1.9%)	<0.001
Discharge Status			
Routine	63,221 (70.3%)	15,461 (65.1%)	<0.001
Home Health Care	19,504 (21.7%)	5431 (22.9%)	<0.001
Transfer - Other	7106 (7.9%)	2810 (11.8%)	<0.001
Transfer to Short-Term Hospital	73 (0.1%)	32 (0.1%)	0.022
Against Medical Advice	60 (0.1%)	15 (0.1%)	0.963

The most common complications among patients with diabetes were hardware-related complications (5.15%), prosthetic complications (2.91%), dislocation (2.15%), postoperative infection (1.77%), surgical site/joint infection (1.49%), intraoperative complications (1.26%), and respiratory complications (0.66%). Compared to patients without diabetes, patients with diabetes had higher rates of surgical site/joint infection (1.49% vs. 1.15%; $p < 0.001$), dislocation (2.15% vs. 1.86%, $p = 0.004$), peripheral vascular complications (0.17% vs. 0.11%; $p = 0.037$), respiratory complications (0.66% vs. 0.44%; $p < 0.001$), genitourinary complications (0.30% vs. 0.19%; $p < 0.001$), postoperative infection (1.77% vs. 1.18%; $p < 0.001$), and deep vein thrombosis (0.48% vs. 0.35%, $p = 0.003$). Patients with diabetes also had higher rates of readmission within 30 days (4.66% vs. 3.15%, $p < 0.001$) and 90 days (9.71% vs. 7.21%, $p < 0.001$) after surgery (Table 2). Complication and readmission rates for patients with uncomplicated diabetes and patients without diabetes are compared in Supplemental Table 4. Complication and readmission rates for patients with complicated and uncomplicated diabetes are compared in Supplemental Table 5. An analysis of the reasons for 30-day and 90-day readmission did not show any significant differences between patients with and without diabetes among the complications included in this study (Supplemental Tables 6 and 7).

In the logistic regression analysis, patients with diabetes remained at a higher risk for surgical site/joint infection (OR: 1.21; 95% CI: [1.06, 1.38]; $p = 0.005$), respiratory complications (OR: 1.34; 95% CI: [1.09, 1.64]; $p = 0.005$), postoperative infection (OR: 1.22; 95% CI: [1.07, 1.39]; $p = 0.003$), and deep vein thrombosis (OR: 1.38; 95% CI: [1.09, 1.74]; $p = 0.007$). Similarly, diabetes status was significantly associated with both 30-day (OR: 1.24; 95% CI: [1.14, 1.34]; $p < 0.001$) and 90-day readmission (OR: 1.18; [1.12, 1.25]; $p < 0.001$) (Table 3).

1.4. Discussion

It is estimated that roughly 20% of the global population will have some form of diabetes within the next decade.[1] Thus, it is inevitable that the prevalence of diabetes among individuals indicated for shoulder arthroplasty will also increase. The purpose of this study was to understand how diabetes status affects short-term TSA complications and readmissions. Diabetes has previously been associated with an increased risk for surgical site infections, perioperative complications, extended

Table 2
Postoperative complications of patients undergoing shoulder arthroplasty with and without diabetes.

Complication	No Diabetes (n = 89,964)	Diabetes (n = 23,749)	P-value
Readmission			
30-Day Readmission	2830 (3.15%)	1106 (4.66%)	<0.001
90-Day Readmission	6485 (7.21%)	2306 (9.71%)	<0.001
Joint-Specific Complications			
Prosthetic Complication	2607 (2.90%)	691 (2.91%)	0.941
Dislocation	1672 (1.86%)	511 (2.15%)	0.004
Surgical Site/Joint Infection	1039 (1.15%)	355 (1.49%)	<0.001
Noninfectious Wound Complication	205 (0.23%)	68 (0.29%)	0.118
General Surgical Complications			
Hardware-Related Complications	4425 (4.92%)	1223 (5.15%)	0.150
Postoperative Infection	1058 (1.18%)	420 (1.77%)	<0.001
Intraoperative Complications	1011 (1.12%)	300 (1.26%)	0.079
Respiratory Complications	394 (0.44%)	157 (0.66%)	<0.001
Pulmonary Embolism	383 (0.43%)	104 (0.44%)	0.842
Deep Vein Thrombosis	313 (0.35%)	115 (0.48%)	0.003
Gastrointestinal Complications	192 (0.21%)	63 (0.27%)	0.154
Genitourinary Complications	167 (0.19%)	72 (0.30%)	<0.001
Wound Dehiscence	161 (0.18%)	52 (0.22%)	0.237
Peripheral Vascular Complications	101 (0.11%)	40 (0.17%)	0.037
Foreign Body Reaction	105 (0.12%)	29 (0.12%)	0.913
Neurologic Complications	72 (0.08%)	24 (0.10%)	0.386
Postoperative Shock	32 (0.04%)	14 (0.06%)	0.158

Table 3
Multivariate logistic regression results with odds ratios and 95% confidence intervals.

Outcome	OR	95% CI	P-Value
Readmission			
30-Day Readmission	1.24	[1.14, 1.34]	<0.001
90-Day Readmission	1.18	[1.12, 1.25]	<0.001
Joint-Specific Complications			
Prosthetic Complication	1.01	[0.92, 1.11]	0.870
Dislocation	1.09	[0.97, 1.21]	0.141
Surgical Site/Joint Infection	1.21	[1.06, 1.38]	0.005
Noninfectious Wound Complication	1.33	[0.99, 1.78]	0.056
General Surgical Complications			
Hardware-Related Complication	1.01	[0.94, 1.09]	0.696
Postoperative Infection	1.22	[1.07, 1.39]	0.003
Intraoperative Complication	1.03	[0.89, 1.19]	0.662
Respiratory Complication	1.34	[1.09, 1.64]	0.005
Pulmonary Embolism	1.07	[0.85, 1.35]	0.565
Deep Vein Thrombosis	1.38	[1.09, 1.74]	0.007
Gastrointestinal Complication	1.16	[0.85, 1.59]	0.355
Genitourinary Complication	1.28	[0.93, 1.75]	0.127
Wound Dehiscence	1.28	[0.92, 1.79]	0.146
Peripheral Vascular Complication	1.23	[0.82, 1.86]	0.318
Foreign Body Reaction	1.07	[0.69, 1.67]	0.766
Neurologic Complication	1.45	[0.90, 2.35]	0.127
Postoperative Shock	1.35	[0.66, 2.73]	0.410

length of stay, and revision procedures.[9,12,13] In our analysis of 113,713 patients who underwent TSA between 2016 and 2018, we found that diabetes was associated with increased 30-day and 90-day readmission, surgical site/joint infection, respiratory complications, postoperative infection, and deep vein thrombosis but not dislocation or prosthetic related complications.

Although 30-day readmission after total shoulder arthroplasty has been reported as less than 3% by many studies, readmission is undeniably associated with increased costs and patient morbidity.[20–22] Using data from the National Surgical Quality Improvement Program (NSQIP), Lung et al. showed that 30-day readmission was more common among TSA patients with diabetes.[23] Likewise, Scott et al. analyzed data from the 2014 NRD and found that diabetes was associated with an increased risk of 90-day readmission following reverse TSA.[24]

We found that 30-day and 90-day readmission rates were about 5% and 10% for patients with diabetes, which is higher than the current literature suggests. In agreement with the current literature, we found that a diabetes diagnosis was associated with higher 30-day and 90-day readmission rates. Interestingly, an analysis of the primary diagnosis at readmission did not show significant differences between patients with and without diabetes. This is likely due to the diverse reasons for readmission among the patients in our study but suggests that the increased readmission rate among patients with diabetes is due to reasons unrelated to the surgery or otherwise not captured by the ICD-10 codes included in our study.

Infections are a primary concern for patients undergoing shoulder arthroplasty as they are a common cause of readmission and revision surgery following TSA and can be difficult to treat.[12,25–27] Prior knee and hip arthroplasty studies report that diabetes is associated with an increased postoperative infection risk.[6,7,28] In a recent study by Bitzer et al., the authors found diabetes to be independently associated with risk for infection following non-arthroplasty shoulder surgery using NSQIP data from 2011 to 2018.[29] Conversely, Lung et al. did not find a statistical difference when comparing surgical site infections between shoulder arthroplasty patients with diabetes to patients without diabetes using NSQIP data from 2015 to 2016.[23] McElvany et al. analyzed data from a Kaiser Permanente database to show that deep infection risk was not associated with diabetes status.[30] Therefore, further investigation is necessary. In our study, we found that infections occurred in less than 2% of patients within 90 days. However, our multivariate results suggest that a diagnosis of diabetes significantly increases odds of infection following shoulder arthroplasty.

The literature reports a medical complication rate of roughly 7% following TSA, with respiratory complications being one of the most commonly cited issues.[31] Murgai et al. and others have demonstrated that patients respiratory complications following spine surgery are more common among patients with diabetes.[32,33] A study from 2014 looking into the relationship between peripheral nerve blocks and respiratory complications such as pneumonia found that regional anesthesia was not associated with an increased complication risk after TSA.[34] Furthermore, vascular complications are a risk factor for increased length of stay among patients undergoing TSA.[31] Although shoulder surgeons put focus on preventing complications directly affecting shoulder healing, other medical complications can lead to significant patient morbidity. Our analysis found that diabetes status was associated with a higher risk for both respiratory complications and deep vein thrombosis following shoulder arthroplasty after adjusting for demographics and comorbidities. This result is likely explained by the systemic nature of diabetes pathophysiology.

Hemoblogin A1c (HbA1c) levels are a widely used indicator of diabetes severity and control. In prior studies, perioperative HbA1c has been indicated as a mediator of infection risk in patients undergoing shoulder arthroplasty.[35,36] Conversely, other studies have found no relationship between diabetes disease severity and infection risk.[30] Our study found higher infection rates in patients with diabetes but did not evaluate diabetes severity or HbA1c levels as the NRD did not have this information available. Ultimately, further research should study how HbA1c levels moderate infection risk in shoulder arthroplasty. Additionally, future studies should include measures of fructosamine and glycosylated albumin as they have recently been shown to be predictors of outcomes following orthopedic surgery.[37–40] The results from this study suggest that shoulder surgeons should anticipate that patients with diabetes undergoing shoulder arthroplasty may have higher infection and other complication rates leading to hospital readmission. Moving forward, surgeons can be cognizant of the increased risk that diabetic patients may face following surgery and counsel patients

appropriately regarding adequate preoperative and postoperative management of their diabetes.

1.4.1. Limitations

Although the authors believe that this study is an important addition to the literature, there are several limitations that warrant consideration. First, while a national database allowed us to achieve a large sample size, we were limited in our ability to analyze information relating to HbA1c levels or other markers of diabetes severity. Furthermore, the use of an annual database limited our follow-up to 90 days which would not capture longer-term complications, particularly low-grade infections such as C. acnes. While we attempted to control for various variables including demographics and comorbidities in our multivariate analysis, other factors outside the scope of our study may influence complications and readmission following shoulder arthroplasty. Nevertheless, we present an analysis of a large sample of patients with diabetes undergoing shoulder arthroplasty using recent data from a national readmissions database.

1.4.2. Conclusions

In our analysis, we showed that patients with diabetes had higher readmission and complication rates including postoperative infections following shoulder arthroplasty. Further research into disease history and severity may elucidate preventative strategies to reduce these adverse events in patients with diabetes undergoing shoulder arthroplasty.

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Informed consent

Informed consent was not required as we analyzed a publicly available and anonymized dataset.

Institutional ethical committee approval

Ethics committee approval was not required as we analyzed a publicly available and anonymized dataset.

Authors contribution

Akiro H. Duey: Conceptualization, Formal analysis, Methodology, Writing – original draft; Christopher A. White:Conceptualization, Methodology, Writing – original draft; Kenneth H. Levy: Writing – original draft; Troy Li:Conceptualization, Writing – original draft; Justin E. Tang: Formal analysis; Akshar V. Patel: Conceptualization, Writing – review & editing; Jun S. Kim: Supervision, Writing – review & editing; Samuel K. Cho: Supervision, Writing – review & editing; Paul J. Cagle: Supervision, Writing – review & editing

Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jor.2023.03.003.

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