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## ORIGINAL ARTICLE

# The impact of insulin dependence on short-term postoperative complications in diabetic patients undergoing total shoulder arthroplasty

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**Background:** The number of total shoulder arthroplasty (TSA) procedures performed is steadily increasing, and it is important to characterize predictors of postoperative complications for risk assessment models. Whereas diabetes has been associated with increased morbidity after TSA, the impact of insulin dependence on the risk profile of diabetic patients has not been described.

**Methods:** The National Surgical Quality Improvement Program database from 2011-2014 was used to identify 5918 TSA cases. Patients were categorized as non-diabetes mellitus (non-DM), non-insulin-dependent diabetes mellitus (NIDDM), or insulin-dependent diabetes mellitus (IDDM). Thirty-day postoperative complication rates, length of stay (LOS), and readmission rates were compared across the diabetes groups. Multivariable logistic regression adjusting for demographics and comorbidity burden was performed to determine the independent association between insulin dependence and postoperative outcomes.

**Results:** In bivariate analysis, NIDDM and IDDM were associated with multiple postoperative complications, including stroke, sepsis, wound complications, blood transfusion, and extended LOS. With multivariable logistic regression, however, NIDDM patients did not have significantly greater odds of any study end point relative to non-DM patients. IDDM patients had significantly greater odds for having any postoperative complication (odds ratio [OR], 1.53), stroke (OR, 13.63), blood transfusion (OR, 1.67), and extended LOS (OR, 1.38).

**Conclusions:** After adjustment for demographics and comorbidity burden, NIDDM patients had risk profiles similar to those of non-DM patients. IDDM was an independent predictor of multiple postoperative complications. Insulin dependence should be considered in the preoperative risk assessment of diabetic patients undergoing TSA.

**Level of evidence:** Level III; Retrospective Cohort Design with Large Database; Treatment Study

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**Keywords:** Total shoulder arthroplasty; complications; diabetes; insulin; insulin dependence; outcomes

Institutional Review Board approval is not required for this database retrospective study.

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The number of total shoulder arthroplasty (TSA) procedures performed in the United States has been steadily increasing in recent years, with growth rates comparable to or greater than those for total hip and knee procedures.<sup>10,25</sup> In addition, after its approval by the US Food and Drug Administration in 2003, reverse TSA has been increasingly

performed for an expanding number of indications.<sup>14,38</sup> Both anatomic and reverse TSA has been proven to reliably improve pain, function, and quality of life with medium- to long-term follow-up.<sup>11,12,38,39</sup>

Concurrently, diabetes mellitus continues to be an important public health problem, with >29 million Americans having diabetes and a further 86 million with prediabetes.<sup>6</sup> Overall, approximately 40% of adults older than 20 years are estimated to have hyperglycemic conditions,<sup>9</sup> and between 2010 and 2030, the prevalence of diabetes among adults is projected to increase 69% in developing countries and 20% in developed countries.<sup>35</sup> In addition, there is clinical and animal model evidence to suggest that diabetes may enhance the development and severity of osteoarthritis.<sup>26</sup> Therefore, the number of TSA procedures performed in diabetic patients is likely to rise.

The association between diabetes mellitus and increased postoperative morbidity risk has been established for lower extremity arthroplasty<sup>13,23,24,28,29,36</sup> as well as for shoulder arthroplasty.<sup>23,31</sup> In a recent study by Garcia et al on the effect of metabolic syndrome (defined as the confluence of obesity, diabetes, and hypertension) on short-term outcomes after TSA, diabetes was shown to be a stronger risk factor than obesity or hypertension.<sup>18</sup> Diabetic patients, however, can be further stratified by whether they are dependent on insulin to achieve glycemic control. Whereas insulin dependence has been shown to have a significant impact on postoperative outcomes in the spine literature,<sup>20,32,33</sup> with important ramifications for accurate risk characterization among diabetic patients, this level of stratification has not been reported for TSA patients. Using a large multicenter patient registry, the goal of this study was to examine the differences between non-insulin-dependent and insulin-dependent diabetic patients in terms of 30-day complication rates after TSA.

## Materials and methods

A retrospective cohort study was performed using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) registry from years 2011-2014. The NSQIP is a registry of surgical patients from >600 hospitals across the United States, with specialized clinical data reviewers prospectively collecting perioperative information on site.<sup>2</sup> Clinical information is gathered through inpatient provider notes, outpatient clinic visits, and direct interviews with surgical providers up to postoperative day 30. Data elements are subject to frequent testing to ensure data quality, with an overall interobserver discrepancy rate reported to be approximately 2%.<sup>2</sup>

Patients who underwent TSA were identified by *Current Procedural Terminology* code 23472, which includes both anatomic and reverse TSA. An initial cohort of 6039 TSA cases was identified. Patients with incomplete data including gender, age, height, and weight were excluded, as were patients who underwent emergency surgery or had preoperative contaminated wound classifications. After these cases were excluded, 5918 patients were included in the study.

From the history of diabetes variable in the registry, patients were categorized into 3 groups: (1) no history of diabetes mellitus (non-

DM), (2) a positive history of non-insulin-dependent diabetes mellitus (NIDDM), or (3) a positive history of insulin-dependent diabetes mellitus (IDDM). Body mass index was determined from the patient's height and weight, and patients were classified on the basis of body mass index according to the World Health Organization classification as nonobese (<30 kg/m<sup>2</sup>), obese I (30-34.9 kg/m<sup>2</sup>), obese II (35-39.9 kg/m<sup>2</sup>), and obese III (≥40 kg/m<sup>2</sup>). This classification system has been used extensively in clinical outcomes research with the NSQIP data set.<sup>5,15,17,18</sup> From medical comorbidity information available from the NSQIP, an age-adjusted modified Charlson Comorbidity Index (CCI) was determined as a measure for overall comorbidity burden.<sup>7</sup> The use of this modified CCI has been well established in previous large database studies in orthopedics and has demonstrated comparable effectiveness to the original CCI.<sup>3,15,16,37</sup> In this study, the following comorbidities were included in the calculation of the modified CCI: congestive heart failure (1 point), peripheral vascular disease (1 point), myocardial infarction (1 point), stroke or transient ischemic attack (1 point), chronic obstructive pulmonary disease (COPD, 1 point), diabetes (1 point), end-stage renal disease (2 points), hemiplegia (2 points), ascites or esophageal varices (3 points), and cancer (6 points). An additional point was also added for each decade older than 40 years.

Baseline demographics, obesity classification, modified CCI, relevant individual medical comorbidities, and preoperative functional status were compared across the diabetes groups in bivariate analyses using Pearson  $\chi^2$  tests. Positive cardiac history was defined as having a history of congestive heart failure, myocardial infarction, angina, and cardiac surgery. Complication end points as captured by the NSQIP included cardiac arrest or myocardial infarction, pulmonary complications (unplanned intubation, ventilator requirement, or pneumonia), renal insufficiency, stroke or cerebrovascular accident (CVA), deep venous thrombosis or pulmonary embolism, sepsis, return to the operating room, death, wound complications (wound dehiscence, deep incisional site infection, or superficial incisional site infection), urinary tract infection, blood transfusion, and readmission within 30 days. Extended postoperative length of stay (LOS) was defined as >75th percentile, which corresponded to ≥3 days.

Complication rates were compared across the diabetes groups first in bivariate fashion, with Pearson  $\chi^2$  analysis. Multivariate logistic regressions were then performed to determine the risk-adjusted predictive strengths of NIDDM and IDDM relative to non-DM for all study outcomes. Regressions were adjusted for the patient's gender, age, obesity classification, modified CCI, hypertension, cardiac history, COPD, current smoking history within 1 year, and preoperative functional status. Results were reported as odds ratios (ORs) relative to the non-DM cohort, with 95% confidence intervals. Statistical significance was defined as  $P < .05$ . SPSS 21 (IBM Corp., Armonk, NY, USA) was used for statistical analyses.

## Results

A total of 5918 TSA cases were included in the study, of which 4932 (83.3%) were non-DM, 691 (11.7%) were NIDDM, and 295 (5.0%) were IDDM (Table I). Relative to non-DM patients, the NIDDM patients were less likely to be younger than 65 years and more likely to be obese; they were more likely to have hypertension, cardiac history, and COPD and to be a current smoker within 1 year; they had greater modified

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