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Predictors of Early Complications of Total Shoulder Arthroplasty

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ABSTRACT

The authors hypothesized that age, body mass index (BMI), and medical comorbidities (graded with the Charleson Comorbidiy index [CCI]) could be used to predict early complications after TSA. The authors performed a retrospective review of primary TSAs with a minimum of 90-day follow-up. One hundred twenty-seven patients met the inclusion criteria. Complications occurred in 12 (9.4%) of patients. Major complications occurred in 1 patient (0.8%), medical in 8 (6.3%), and surgical in 4 (3.1%). CCI significantly correlated with complication rates and multivariate regression analysis demonstrated CCI to be the only significant determinant of overall complication rates ($P = 0.005$) and medical complication rates ($P = 0.015$). While BMI subgroup did not affect complication rates, transfusion rates, intra-operative blood loss, or operative time, our study may have been underpowered for this variable.

Total shoulder arthroplasty (TSA) offers significant pain relief and functional improvement in patients with degenerative joint disease of the glenohumeral joint with a functional rotator cuff [1–3]. Complications, however, occur in roughly 10% [4,5]. These complications range widely in severity and can include seroma formation, acute blood-loss anemia requiring transfusion [5–7], neurologic injury [8], dislocation [9], infection [10], cardiopulmonary complications [11], and even death [12]. Given that these procedures are performed on an elective basis, orthopaedic surgeons must develop a full understanding of the risk factors for the development of a complication so that patients can be accurately counseled pre-operatively.

Within the hip and knee arthroplasty literature, the risk factors that can contribute to post-operative complications include medical comorbidities and body mass index (BMI) [13,14]. Similar studies have been performed examining total shoulder arthroplasty complications in the intra-operative, peri-operative, and post-operative period [4–7,10–12,15–21]. However, the results of these studies have conflicted with one another and thus it remains unclear which factors are the most important determinants of post-operative complication rates. While some have identified medical comorbidities as significant determinants of cardiopulmonary complications [11] and mortality [12], others have found no correlation between medical comorbidities in rates of infection, revision surgery, or overall complication rates [10,16,19,20,22]. Similarly, BMI has been identified as a predictor of complications and need for revision in some studies [11,18,20,23], while others have either shown higher BMI to be protective or to have no effect [5,6,10,19,22]. Still other studies have examined complication rates without analyzing the effect of medical comorbidities or BMI [4,5,7,15]. Unfortunately, these studies have also combined primary TSA, revision TSA, reverse TSA, and/or humeral hemiarthroplasty [11,12]. These procedures have widely divergent complication rates. Complication rates after reverse TSA are 25-50% [24,25] while those after TSA are 10% [4,5]. In addition, some studies have included patients with proximal humeral fractures in their cohort, which significantly alters the patient population and circumstances of the risk/benefit discussion [16]. Given these difficulties with the previous literature little evidence exists to guide the surgeon as the complication rates and predictors after primary anatomic TSA.

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Our primary questions with this study were: 1) What is the incidence and type of early complications after primary TSA by a single-surgeon in a consecutive series of patients? 2) Do medical cormorbidities predict these complications? 3) Does BMI predict these complications? 4) If both of these variables predict complications, which is a more important predictor? We hypothesized that 1) the incidence of complications would be similar to that published in the literature and that these would be primarily minor medical complications, 2) medical comorbidities would serve as primary determinant of rates of acute post-operative complications after TSA, 3) BMI would serve as a primary determinant of rates of acute post-operative complications after TSA, and 4) BMI would be more predictive of complication rates than medical comorbidities.

Materials and Methods

Our institutional review board approved this study. All patients who underwent TSA by the senior author with a minimum of 90-days of post-operative follow-up were included in this study. Exclusion criteria included a history of prior ipsilateral shoulder arthroplasty, or incomplete peri- or post-operative records. Indications for TSA included glenohumeral osteoarthritis, glenohumeral post-traumatic arthritis, and glenohumeral instability arthropathy.

The operative reports, peri-operative inpatient records, and post-operative outpatient records for each patient were reviewed and the following data was recorded: age, gender, BMI, laterality of the dominant extremity, laterality of the TSA, indication for TSA, medical comorbidities, length of the procedure in minutes (min), estimated intraoperative blood loss in milliliters (mL), specific implants, concomitant procedures, and the need for intra-operative or post-operative transfusion. All noted complications were recorded.

Medical comorbidities were quantified with the Charlson Comorbidity Index (CCI), an instrument validated for use in surgical patients [26–28]. This tool has been shown to be predictive of long-term mortality in patients based upon a score assigned to their medical conditions, such as renal dysfunction, oncologic history, and diabetes, assigning scores from 1–6 to each condition based upon their contribution to the risk of death [26–28]. CCI was calculated for each patient included in our study.

Complication Classification

Any event that deviated from the normal post-operative course was considered as a complication. Complications were then subdivided into "minor" and "major" as well as "medical" and "surgical" (Table 1). Complications that occurred locally at the operative site or that stemmed from the surgical site, such as instability, fracture, incisional breakdown, or transfusion due to operative blood loss were considered "surgical" while systemic complications such as renal insufficiency, myocardial infarction, and thromboembolic complications were considered "medical".

Statistical Analysis

All analyses were performed in SPSS 18 (IBM Inc., Armonk, NY). Descriptive statistics were calculated. An *a priori* decision was made to divide patients into three groups: Group 1 – normal BMI (BMI less than 25), Group 2 – BMI classified as overweight or "mildly obese" or class I obesity (BMI 25–35), and Group 3 – BMI classified as moderately/severely obese or class II or greater obesity (BMI >35) [30]. These group divisions were made based upon our anecdotal clinical experience, the mean and standard deviation of BMI of the average patient undergoing TSA and reverse TSA (RTSA) in the senior authors' practice (~30 ± 5), as well as evidence from the hip and knee arthroplasty literature suggesting that complication rates may not be increased until obesity is severe [14]. CCI was divided *a priori* into those patients with medical complications (CCI > 0) and those without (CCI = 0).

Table 1
Classification of Complications – Major and Minor, Medical and Surgical (Based Off of the Classification Scheme Described by Dindo et al [29].

Complication type	Definition	Example
Minor	Any deviation from the normal post-operative course that requires pharmacologic treatment	Medical: ileus, acute renal failure responding to fluids, urinary retention, blood sugar derangement, altered mental status, acute blood loss anemia requiring transfusion Surgical: cellulitis responding to oral antibiotics alone, lymphedema, shoulder stiffness, fracture not requiring additional fixation or change in postoperative protocol
Major	Potentially life-threatening complication requiring prolonged pharmacologic treatment or requiring surgical intervention	Medical: Death, Stroke, Myocardial infarction, Deep Vein Thrombosis, Pulmonary Emboli, Pneumonia Surgical: Dislocation, Deep infection, Any return to operating room, Fracture requiring change to post-operative protocol or requiring additional fixation

Komolgorov–Smirnov analysis was performed on continuous variables and all variables significantly differed from the normal distribution ($P < 0.05$). Thus Kruskal–Wallis test was performed to compare continuous variables between BMI groups and CCI groups. Statistical comparison of categorical variables involved the chi-square test.

Given concern that multiple variables may predict complication rates, multivariate logistic regression was planned to determine which variables served as the primary determinants of complication rates.

Results

One hundred and thirty-two consecutive patients underwent anatomic TSA. Five patients were excluded as they were revision cases, leaving 127 patients that met the inclusion criteria. These patients were 58% female with an average age of 66.3. The vast majority of patients underwent TSA for a diagnosis of osteoarthritis (120/127 patients) with a minority undergoing TSA for post-traumatic arthritis (4/127 patients) or instability-related arthropathy (3/127). Complications were infrequent, occurring in 9.4% of patients. The majority were classified as minor, with only a single major complication occurring (post-operative dislocation requiring revision surgery). An additional dislocation occurred, which was successfully treated with closed reduction and thus classified as minor. Medical complications occurred in eight patients and included urinary retention requiring catheterization (four patients), hypotension and tachycardia requiring transfer to our critical care unit for more intensive monitoring (two patients), severe nausea and vomiting limiting rehabilitation (one patient), and hyponatremia requiring free-water restriction (one patient). Surgical complications occurred in four patients and included two dislocations and three transfusions for acute blood loss anemia. No thromboembolic complications, infections, or mortalities occurred.

The mean CCI for the cohort was 0.3 (Table 3). BMI correlated with CCI ($P < 0.001$, Table 3). Mean age, operative indications, operative time, estimated blood loss, and percentage of patients requiring a transfusion did not differ between patients in CCI subgroups ($P > 0.244$ in all cases). Overall complication rates were significantly more frequent in the group with a CCI > 0 ($P = 0.024$). Significantly higher CCI scores were seen in those with a complication (0.75) as compared to those without (0.24, $P = 0.01$, Table 4). In addition,