RESEARCH ARTICLE

Hypoalbuminemia and the Higher Risk of Perioperative Sentinel Adverse Events in Patients Undergoing Total Shoulder Arthroplasty: A Propensity Score Matched Analysis

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Abstract

Background: The purpose of this study is to examine the effect of hypoalbuminemia (HA) on sentinel adverse events after total shoulder arthroplasty (TSA).

Methods: Patients who underwent primary TSA from 2015-2018 were collected from the National Surgical Quality Improvement Program (NSQIP) database. Patients with HA (serum albumin < 3.5 g/dL) were compared to patients with normal serum albumin. A probit regression model was used to estimate a propensity score. Logistic regression was performed to evaluate the effect of HA on sentinel adverse events after surgery.

Results: A total of 4,337 patients were included, 8.2% of patients had HA. Patients with HA had higher rates of sentinel adverse events (14.0% vs 5.5%, *P<0.01*) compared with patients who had normal serum albumin. Reoperation (4.5% vs 1.5%, *P<0.01*), readmission (11.2% vs 3.9%, *P<0.01*), urinary tract infection (0.8% vs 0.03%, *P<0.01*) and pulmonary embolism (1.1% vs 0.2%, *P=0.01*) were higher in patients with HA. The odds ratio for a sentinel event for patients with HA was 2.6 (95% CI: 1.54, 4.44, *P<0.01*) when compared to a propensity score-matched control group.

Conclusion: Patients with HA are at increased risk of sentinel adverse events following TSA compared to patients with normal serum albumin levels.

Level of evidence: II

Keywords: Adverse events, Albumin, Hypoalbuminemia, Shoulder arthroplasty

Introduction

Serum albumin is a common marker used to assess levels of nutrition or malnutrition.[1] Hypoalbuminemia (serum albumin < 3.5 g/dL) has been shown to be a risk factor for poor outcomes following a variety of surgical procedures and is present in up to 6% of patients undergoing total hip and knee arthroplasty.[2] Bohl et al. showed that compared to patients with normal serum albumin, patients with serum albumin concentrations of less than 3.5 g/dL had a higher risk for infection, pneumonia, prolonged length of stay, and readmission after total hip and knee arthroplasty.[2] Additionally, Black et al. studied over 4,000 patients undergoing total hip and knee arthroplasty and showed that albumin < 3.5 g/dL was associated with more frequent discharge to skilled nursing facilities/rehab, increased 90-day readmission rate, and increased risk of 90-day emergency room visits compared with patients who had normal serum albumin.[3]

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Although HA has been associated with worse outcomes after total hip and knee arthroplasty, less is known about its impact on patients undergoing total shoulder arthroplasty (TSA). The purpose of this study is to determine the presence of HA in patients undergoing TSA and to determine the effect of HA on sentinel adverse events following TSA. We hypothesize that patients with HA undergoing TSA will have a higher risk of postoperative sentinel adverse events compared with patients without HA.

Materials and Methods

This study utilizes de-identified patient information and does not require institutional review board approval.

Data Sources

Data from the National Surgical Quality Improvement Program (NSQIP) database was used for this study. The NSQIP databases collect information including preoperative diagnoses, procedure codes, patient demographics, 30-day medical complications, mortality as well as unplanned readmissions, and reoperations. Data at each of the participating sites are entered by trained specialists. The NSQIP databases frequently undergo quality checks and the inter-rater agreement and data capturing rates are reportedly higher than 95%.

Total Shoulder Arthroplasty

Patients admitted between the years 2015 and 2018 were included. We identified patients undergoing TSA using the Current Procedural Terminology code 23472 which represents "Arthroplasty, glenohumeral joint, total shoulder (glenoid and proximal humeral replacement)". Patients who underwent additional or concurrent procedures were excluded from the analysis.

Outcomes

Our outcome of interest was the occurrence of a sentinel event (SE). We defined a SE as any occurrence associated with patient harm or requiring further treatment. It includes mortality, surgical site infection, wound dehiscence, pneumonia, deep vein thrombosis, pulmonary embolism, reintubation, requiring >48 hours of ventilation, acute renal failure, urinary tract infection, cerebrovascular accident, cardiac arrest, myocardial infarction, reoperation, and readmission.

Data Points

We analyzed preoperative patient characteristics likely to be associated with the risk of SE occurrence. Continuous variables such as age and body mass index (BMI) were categorized into groups with arbitrary cutoffs for ease of interpretation. Furthermore, analyzed was the presence of anemia, which was defined as a preoperative hematocrit level of less than 36% in women and less than 39% in men. Dependence on the performance of activities of daily living (ADLs) was also analyzed using the functional status variable in the database. Patients designated as independent are those who can perform all ADLs without assistance (including patients who function independently with a prosthetic or device). The presence of pulmonary disease was defined as either having a diagnosis of chronic obstructive pulmonary disease or the presence of dyspnea on moderate exertion. A preoperative diagnosis of fracture was identified by using the International Classification of Diseases 10th revision, code S42.

Statistical Analysis

Sample characteristics were reported as mean and standard deviation or proportion and frequencies. An albumin level of less than 3.5 g/dL was defined as having HA. Patients with and without HA were compared with respect to a battery of covariates using Fischer's exact test. Those that were significantly different were marked as potential confounders. A probit regression model including potential confounders was used to estimate a propensity score. Patients with HA were then matched to the nearest neighbor on a 1:1 basis without replacement or caliper determination. The student's t-test was then utilized to compare the propensity score means between the HA patients and matched controls. Logistic regression was then used to estimate the odds ratio for having a SE in patients with HA using matched controls as reference. Robust estimates of the standard error were used in the final logistic regression. All statistical analyses were performed using Stata, version 14.0, software (StataCorp LP, College Station, TX). Statistical significance was set at $P < 0.05$.

Results

Patient Sample

We identified 16,972 patients who underwent TSA between 2015 and 2018. After excluding patients who underwent concomitant procedures and had missing data, a total of 4,337 patients remained in the final sample. [Figure 1]. The mean age was 69.6 (SD: 9.7) years and 57% (N=2451) were women. The mean albumin level was 4.0 g/dL (SD: 0.4). A total of 357 patients (8.2%) had HA at the 3.5 g/dL thresholds. Pulmonary disease was the most common preoperative comorbidity at 13.4% (N=582). [Table 1].

Comparison of Patient Characteristics

The proportion of patients older than 80 years old was significantly higher in the HA group (24.1 vs 13.9, *P<0.01*). The proportion of women was also higher in the HA group (74.8 vs 54.9, *P<0.01*). Significant differences also existed in the distribution of other covariates including BMI group, congestive heart failure, pulmonary disease, need for dialysis, anemia, preoperative diagnosis of fracture, as well as dependence (*P<0.05*). [Table 2].

Comparison of Sentinel Events

Patients with HA had significantly higher rates of sentinel events (14.0% vs 5.5%, *P<0.01*). When looking at isolated adverse events, the rates of reoperation (4.5% vs 1.5%, *P<0.01*), readmission (11.2% vs 3.9%, *P<0.01*), urinary tract infections (0.8% vs 0.03%, *P<0.01*), and pulmonary embolism (1.1% vs 0.2%, *P=0.01*) were significantly higher in the HA group. [Table 3].

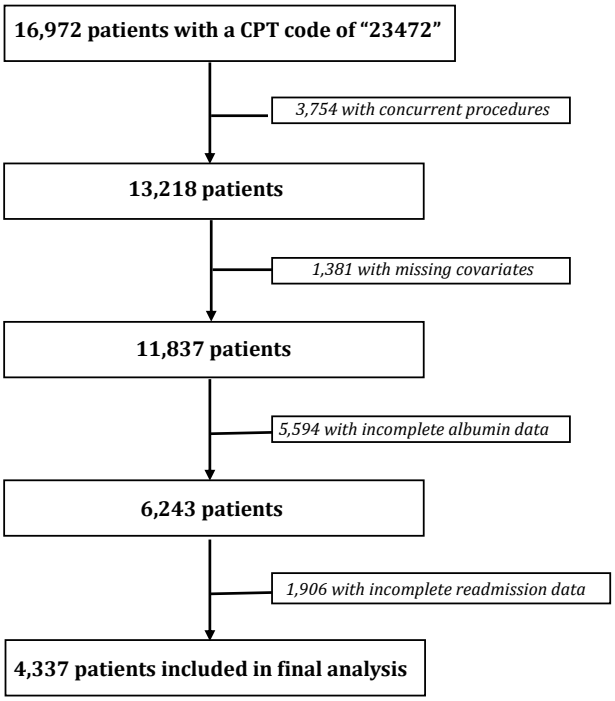

Figure 1. Flowchart showing number of study subjects and derivation of final sample.

Table 1. Preoperative Characteristics of Study Population

Preoperative Characteristic	N	%[a]
Total Population[b]	4337	100
Gender		
Female	2451	56.51
BMI Group		
<25	759	17.5
25-35	2490	57.41
>35	1088	25.09
Comorbidity[c]		
CHF	37	0.85
Pulmonary	582	13.42
ESRD	21	0.48
Anemia	340	7.84
Fracture	279	6.43
Dependence	107	2.47
Low Albumin	357	8.23

a Percent of the study population that satisfies the criteria for each preoperative characteristic.
b Age (mean +/- standard deviation) = 69.58 +/- 9.659 years
c Where CHF = congestive heart failure; Pulmonary = pulmonary disease, defined as COPD or dyspnea on exertion; ESRD = end-stage renal disease; anemia = hematocrit <36% in female, <39% in male; Fracture = preoperative fracture; Dependence = not independent for all activities of daily living; and Low Albumin = albumin < 3.5 g/dL.

Propensity score matching

A probit regression model was used to predict a propensity score accounting for age, gender, BMI, congestive heart failure, pulmonary disease, dialysis, anemia, preoperative diagnosis of fracture, as well as dependence. Nearest-neighbor matching matched 357 patients with HA to 357 controls. Propensity score means were similar between the HA and control groups (0.15 vs 0.15, *P=0.95*).

Final Outcome

The odds ratio for an SE postoperatively in patients with HA undergoing TSA was 2.6 (95% CI: 1.54, 4.44, *P<0.01*) when compared to a propensity score matched control group.

Table 2. Comparison of Preoperative Characteristics vs Albumin Levels across Study Population

Preoperative Characteristic	Albumin >3.5 g/dL		Albumin <3.5 g/dL		*P-value*[c]
	N	%[a]	N	%[b]	
Age Group[d]					0.000
<65	1129	28.37	67	18.77	
65-80	2299	57.76	204	57.14	
>80	552	13.87	86	24.09	
Gender					0.000
Female	2184	54.87	267	74.79	
BMI Group					0.010
<25	2312	58.09	178	49.86	
25-35	687	17.26	72	20.17	
>35	981	24.65	107	29.97	
Comorbidity[e]					
CHF	26	0.65	11	3.08	0.000
Pulmonary	494	12.41	88	24.65	0.000
ESRD	16	0.4	5	1.4	0.025
Anemia	291	7.31	49	13.73	0.000
Fracture	203	5.1	76	21.29	0.000
Dependent	77	1.93	30	8.4	0.000

a Percent of patients with albumin >3.5 g/dL that satisfies the criteria for each preoperative characteristic.
b Percent of patients with albumin <3.5 g/dL that satisfies the criteria for each preoperative characteristic.
c Using Fisher's exact test to compare patients across albumin levels
d Age (mean +/- standard deviation) = 69.58 +/- 9.659 years
e Where CHF = congestive heart failure; Pulmonary = pulmonary disease, defined as COPD or dyspnea on exertion; ESRD = end-stage renal disease; anemia = hematocrit <36% in female, <39% in male; Fracture = preoperative fracture; Dependence = not independent for all activities of daily living; and Low Albumin = albumin < 3.5 g/dL.

Table 3. Comparison of Sentinel Events vs Albumin Level across Study Population

Sentinel Event [a]	Experienced Sentinel Event				*P-value* [d]
	Albumin >3.5 g/dL		Albumin <3.5 g/dL		
	N	% [b]	N	% [c]	
Death	10	0.25	3	0.84	0.085
SSI	11	0.28	0	0	0.388
Dehisce	2	0.05	0	0	0.842
Pneumonia	27	0.68	5	1.4	0.118
DVT	13	0.33	1	0.28	0.678
PE	8	0.2	4	1.12	0.013
Reintubate	15	0.38	2	0.56	0.414
Fail to Wean	7	0.18	1	0.28	0.497
Renal Failure	2	0.05	0	0	0.842
UTI	1	0.03	3	0.84	0.002
CVA	4	0.1	1	0.28	0.349
Cardiac Arrest	11	0.28	3	0.84	0.102
MI	5	0.13	0	0	0.651
Reoperation	59	1.48	16	4.48	0.000
Readmit	157	3.94	40	11.2	0.000
Adverse Event	218	5.48	50	14.01	0.000

a Where Death = patient perioperative mortality; SSI = surgical site infection; Dehisce = surgical wound dehiscence; Pneumonia = postoperative pneumonia; DVT = deep venous thrombosis; PE = pulmonary embolism; Reintubate = reintubation postoperatively; Fail to wean = failed to be weaned from ventilator within 48 hours; Renal Failure = postoperative renal failure; UTI = urinary tract infection; CVA = cerebrovascular accident; Cardiac arrest = cardiac arrest; MI = myocardial infarction; Reoperation = reoperation related to procedure; Readmit = readmission related to procedure; and Adverse Event = Summative sentinel events.

b Percent of patients with albumin >3.5 g/dL that satisfies the criteria for each sentinel event.

c Percent of patients with albumin <3.5 g/dL that satisfies the criteria for each sentinel event.

d Using Fisher's exact test to compare patients across albumin levels

Discussion

In this study of over 4,000 patients, we showed that HA was associated with an increased risk of perioperative sentinel adverse events in patients undergoing TSA. Specifically, we showed that compared to patients with normal albumin, those with HA were at increased risk for reoperation, readmission, and developing medical complications, such as pulmonary embolism and urinary tract infection, within 30 days of TSA. These findings are important as HA may be an important factor in determining expected rates of complications which can be used by during preoperative risk stratification as well as for ratings and quality measures for hospitals and surgeons.

In this study, the rate of reoperation within 30 days of TSA was three times higher in patients with HA compared to patients with normal albumin. HA has been shown to be an increased risk factor for reoperation in lower extremity trauma patients as well. Wilson et al. evaluated over five thousand patients undergoing surgical treatment for lower extremity fractures (including acetabulum and pelvis fractures).[4] They found that the reoperation rate was 5.5% in patients with serum albumin of less than 3.5 g/dL which is similar to our finding of a 4.5% reoperation rate.[4] Sloan et al. evaluated albumin levels in over one hundred thousand patients undergoing total hip and knee arthroplasty and found a 2% rate of reoperation in patients with HA.[5] One reason for the lower reoperation rate found in their study is that the researchers did not perform a propensity score matching analysis, which helps to isolate the effect of HA in our study.

Readmission is an important factor in health care costs, bundled payments, and physician or hospital statistical ratings.[6-9] Here we showed that patients with HA had a readmission rate of 11.2% compared with 3.9% for patients with normal albumin levels. This readmission rate is higher than previous reports for other surgical procedures. Bohl et al. utilized the NSQIP database to study HA in patients undergoing total hip and knee arthroplasty.[2] The researchers found a readmission rate of 6.3% in patients with HA compared with 3.5% in patients with normal serum albumin.[2] Our readmission rate of 11% is substantial and to our knowledge, has not been reported before in the literature for TSA. The widespread success and increasing incidence of total hip and knee arthroplasty have led to the development of preoperative protocols for medical optimization, as well as strict preoperative criteria and patient qualifications for Medicare reimbursement. Although preoperative albumin is not currently used as a standard assessment for patients undergoing total hip and knee arthroplasty, strict preoperative medical optimization and risk stratification may help reduce the number of malnourished patients undergoing total hip and knee arthroplasty when compared with TSA. In their study, Bohl et al. demonstrated a prevalence of HA of 4% which is lower than 8.2% in our study.[2] The higher prevalence in our study may have contributed to the higher rate of readmission demonstrated in TSA patients.

In our study, HA was associated with an increased risk of medical complications including urinary tract infection and pulmonary embolism. Prior studies have shown an association between HA and infectious complications after total joint arthroplasty.[2, 10] A possible reason for this association is due to the decrease in the immune system's ability to fight infection in patients with malnutrition which may provide reason for the higher risk for urinary tract infection seen in our study. Kishawi et al. also reported an increased risk of urinary tract infection using the NSQIP database to evaluate over 130,000 patients who underwent total hip, knee, shoulder, wrist,

or ankle arthroplasty.[11] To our knowledge, the increased risk of pulmonary embolism seen in patients with HA in our study; has not been previously reported in the TSA literature and may warrant further study.

This study has several limitations. Although the NSQIP database has been widely utilized in studying outcomes and complications following TSA, missing data in the database may influence the statistical analysis. [12, 13] However, our propensity-matching analysis should help to account for statistical limitations that arise with missing data. Additionally, the database is subject to a coding error. Finally, the NSQIP database is limited to outcomes and events that occur within 30 days of surgery and does not provide data for longitudinal follow-up of patients. Our study is strengthened by the large patient sample that allows for easier assessment of rare complications and events.

Patients with HA are at increased risk of sentinel adverse events following TSA when compared with patients who have normal serum albumin levels. Specifically, HA is associated with increased rate of reoperation, increased risk of readmission, and higher risk of medical complications such as urinary tract infection and pulmonary embolism after TSA. More studies are needed to determine whether normalization of serum albumin prior to surgery can improve outcomes in these patients.

Disclosure: The researchers report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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