



Malnutrition in elective shoulder arthroplasty: a multi-institutional retrospective study of preoperative albumin and adverse outcomes

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Background: Malnutrition is associated with poor postoperative outcomes after knee, hip, and spine surgery. However, whether albumin labs should be part of the routine preoperative workup for shoulder arthroplasty remains understudied. This study investigated the role of preoperative albumin levels in predicting common postoperative adverse outcomes in patients undergoing shoulder arthroplasty.

Methods: All shoulder arthroplasty cases performed at 2 tertiary referral centers between July 2013 and May 2019 (institution 1) and between June 2007 and Feb 2020 (institution 2) were reviewed. A total of 421 primary and 71 revision elective shoulder arthroplasty cases had preoperative albumin levels recorded. Common demographic variables and relevant Elixhauser comorbidities were pulled. Outcomes gathered included extended (>3 days) postoperative inpatient length of stay (eLOS), 90-day readmission, and discharge to rehab or skilled nursing facility (SNF).

Results: The prevalence of malnutrition (albumin <3.5 g/dL) was higher in the revision group compared with the primary group (36.6% vs. 19.5%, $P = .001$). Reverse shoulder arthroplasty ($P = .013$) and increasing American Society of Anesthesiologists score ($P = .016$) were identified as independent risk factors for malnutrition in the primary group. In the revision group, liver disease was associated with malnutrition ($P = .046$). Malnourished primary shoulder arthroplasty patients had an increased incidence of eLOS (26.8% vs. 13.6%, $P = .003$) and discharge to rehab/SNF (18.3% vs. 10.3%, $P = .045$). On univariable analysis, low albumin had an odds ratio (OR) of 2.34 for eLOS ($P = .004$), which retained significance in a multivariable model including age, American Society of Anesthesiologists score, sex, and body mass index (OR 2.11, $P = .03$). On univariable analysis, low albumin had an OR of 1.94 for discharge to SNF/rehab ($P = .048$), but this did not reach significance in the multivariable model. Among revisions, malnourished patients had an increased incidence of eLOS (30.8% vs. 6.7%, $P = .014$) and discharge to rehab/SNF (26.9% vs. 4.4%, $P = .010$). In both the primary and revision groups, there was no difference in 90-day readmission rate between patients with low or normal albumin.

Conclusion: Malnutrition is more prevalent among revision shoulder arthroplasty patients compared with those undergoing a primary procedure. Primary shoulder arthroplasty patients with low preoperative albumin levels have an increased risk of eLOS

This study was approved by the Duke University Health System institutional review board for clinical investigations (Protocol ID: Pro00102733) and the institutional review board at Rush University Medical Center (19061306-IRB01).

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and may have an increased need for postacute care. Low albumin was not associated with a risk of 90-day readmissions. Albumin level merits further investigation in large, prospective cohorts to clearly define its role in preoperative risk stratification.

Level of evidence: Level III; Retrospective Case-Control Design; Prognostic Study

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Malnutrition is a common medical comorbidity that has been previously associated with poor postoperative outcomes across other surgical fields, including general surgery, vascular surgery, and transplant surgery.^{5,10,17,21} In orthopedics, it has been associated with poor outcomes after knee, spine, and hip surgery, including major postoperative medical complications, delayed postoperative recovery, poor wound healing, increased hospital length of stay (LOS), infection, and wound drainage.^{1,3,13,32,37}

Few studies have evaluated the consequences of nutritional status in shoulder arthroplasty. One study using the National Surgical Quality Improvement Program (NSQIP) database found malnutrition to be a marker for an increased risk of blood transfusion, longer hospital LOS, and death within 30 days of shoulder surgery.¹⁴ Serum albumin can be used as a measure of nutritional status,^{9,40} but it remains unclear whether albumin labs should be part of the routine preoperative workup for shoulder arthroplasty. To our knowledge, there have been no studies to date analyzing the effects of malnutrition on primary or revision shoulder arthroplasty outcomes at an institutional level.

The purposes of this study were to (1) identify and compare the overall prevalence of malnutrition, here defined as a serum albumin <3.5 g/dL, among primary and revision shoulder arthroplasty patients at 2 large tertiary referral centers; (2) identify independent risk factors for hypoalbuminemia in shoulder arthroplasty; and (3) investigate the role of low preoperative albumin levels in predicting common postoperative adverse outcomes in patients undergoing shoulder arthroplasty.

Materials and methods

This is a retrospective cohort study of the effect of low preoperative albumin level on adverse shoulder arthroplasty outcomes. After approval from both institutional review boards and the execution of a data use agreement between 2 tertiary academic health institutions, the electronic medical records (EMRs) at both institutions were used to retrospectively collect the study cohort. The EMRs were queried using the Current Procedure Terminology codes for shoulder arthroplasty (23472) and revision shoulder arthroplasty (23473 or 23474), which include both anatomic total shoulder arthroplasty (TSA) and reverse TSA (rTSA). All shoulder arthroplasty cases performed between July 2013 and May 2019 (institution 1) and between June 2007 and Feb 2020 (institution 2) were screened for documented albumin levels within 60 days before surgery. These start dates reflect EMR

availability at each institution, and end dates were determined by institutional review board study protocols and institutional resources. During the designated time periods, a total of 4939 primary and 471 revision shoulder arthroplasty cases were performed, of which 460 primary and 75 revision cases had preoperative albumin levels available. Surgeries performed for fracture were excluded (primary: $n = 39$ and revision: $n = 4$). The remaining 421 primary and 71 revision shoulder arthroplasty cases were then stratified by preoperative albumin using a cutoff of 3.5 g/dL as a proxy for malnutrition.

Common patient-specific variables were then pulled for these cohorts, including age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score, smoking history, marital/partner status, and 7 relevant Elixhauser comorbidities. Secondary outcome variables were also collected, including 90-day readmissions, postoperative inpatient LOS, and discharge to rehab or skilled nursing facility (SNF). Extended LOS (eLOS) was defined as LOS exceeding 3 days, as defined in previous literature.^{2,14}

χ^2 and Fisher's exact tests were used to compare binary variables across categorical groups, and the Kruskal-Wallis test was used to compare continuous variables. Univariable logistic regression models were generated to examine the effect of low albumin on the outcome variables. Multivariable logistic regression models were also used to control for the possible confounding effects of age, BMI, sex, and ASA score. Categorical data were reported as percentages and continuous data as medians and means. P values of <.05 were considered to be statistically significant. Statistical analyses were performed using R version 3.5.3 (R Foundation, Vienna, Austria).

Results

The study cohort comprised 421 primary and 71 revision shoulder arthroplasty cases with preoperative albumin and outcome data recorded in the EMR. The overall prevalence of malnutrition (albumin <3.5 g/dL) among these 492 primary or revision patients was 22.0%. In the comparison between the revision and primary groups, there was a higher prevalence of malnutrition among revision patients (36.6% vs. 19.5%, $P = .001$). Patient characteristics were evaluated as potential risk factors for malnutrition. Reverse shoulder arthroplasty ($P = .013$) and increasing ASA score ($P = .016$) were identified as independent risk factors for malnutrition in the primary shoulder arthroplasty cohort, and renal failure approached significance ($P = .068$) (Table 1). Patient age, sex, BMI, and other Elixhauser comorbidities notably did not reach significance as

Table I Risk factors for preoperative albumin level below 3.5 g/dL among primary shoulder arthroplasty patients

Patient factors	Albumin <3.5 (N = 82)	Albumin ≥3.5 (N = 339)	P value
Average age (yr)	65.7	66.8	.689
Male sex, n (%)	34 (42.5)	168 (49.6)	.188
Average BMI	31.3 (32.2)	30.4 (30.7)	.120
ASA (1 vs. 2 vs. 3 vs. 4)	0:28:51:3	14:154:163:8	.016
Marital/partner status (current partner), n (%)	38 (46.3)	171 (50.4)	.505
Smoking history	37 (45.1)	157 (46.3)	.846
rTSA, n (%)	49 (59.8)	151 (44.5)	.013
CHF, n (%)	9 (11.0)	29 (8.6)	.492
Chronic pulmonary disease, n (%)	20 (24.4)	65 (19.2)	.291
Diabetes, n (%)	14 (17.0)	51 (15.0)	.648
Complicated diabetes, n (%)	9 (11.0)	30 (8.8)	.121
Renal failure, n (%)	15 (18.3)	37 (10.9)	.068
Liver disease, n (%)	3 (3.7)	11 (3.2)	.741

BMI, body mass index; ASA, American Society of Anesthesiologists score; rTSA, reverse total shoulder arthroplasty; CHF, congestive heart failure.

independent risk factors for malnutrition. In contrast, reverse shoulder arthroplasty ($P = .002$) and smoking history ($P = .010$) were associated with normal albumin levels (≥ 3.5 g/dL) in the revision shoulder arthroplasty group, and liver disease ($P = .046$) was identified as a risk factor for malnutrition. No other factors reached significance among revision patients.

Outcome variables were then compared between the 2 albumin groups (Tables II and III). Primary shoulder arthroplasty patients with low albumin had a significantly increased incidence of eLOS (26.8% vs. 13.6%, $P = .003$) and discharge to rehab/SNF (18.3% vs. 10.3%, $P = .045$). There was no difference in the rate of 90-day readmission (4.9% vs. 5.3%, $P = 1.000$) (Table II). Likewise, in the revision shoulder arthroplasty group, malnourished patients had an increased incidence of eLOS (30.8% vs. 6.7%, $P = .014$) and discharge to rehab/SNF (26.9% vs. 4.4%, $P = .010$). There was no difference in 90-day readmission rate between the low and normal albumin groups (3.8% vs. 2.2%, $P = 1.000$) (Table III).

The results of the univariable and multivariable logistic regressions for the primary shoulder arthroplasty cohort are reported in Table IV. On univariable regression treating albumin level as a categorical variable (<3.5 vs. ≥ 3.5 g/dL), patients with preoperative malnutrition had an odds ratio (OR) of 2.34 for experiencing an eLOS ($P = .004$);

this retained significance in a multivariable model including confounders such as age, ASA physical status score, sex, and BMI (OR 2.11, $P = .03$). The malnourished cohort had an OR of 1.94 for discharge to postacute care ($P = .048$), though this did not remain significant in the multivariable model (OR 1.68, $P = .18$), suggesting the presence of confounding effects. Ninety-day readmission was not statistically significant on univariable or multivariable analysis for low albumin (Table IV). In the revision group, eLOS, discharge to SNF/rehab, and 90-day readmission did not reach statistical significance on univariable or multivariable regression for low albumin.

Discussion

Malnutrition is associated with substantial clinical and socioeconomic impact, increasing both complications in hospitalized patients and the cost of health care.²⁵ Although there have been multiple reports on the effects of malnutrition on knee, spine, and hip surgery outcomes,^{1,3,13,32,37} research on malnutrition in shoulder arthroplasty remains sparse. Many studies in total joint arthroplasty have used data from the American College of Surgeons NSQIP database. Although the NSQIP database offers a large number of cases for analysis, the data come from many

Table II Descriptive statistics for 3 outcome variables comparing primary shoulder arthroplasty patients with and without preoperative albumin levels below 3.5 g/dL

Primary shoulder arthroplasty	Albumin <3.5 (N = 82)	Albumin ≥3.5 (N = 339)	P value
90-d readmission	4 (4.9)	18 (5.3)	1.000
Extended LOS (>3 d)	22 (26.8)	46 (13.6)	.003
Discharge to SNF/rehab	15 (18.3)	35 (10.3)	.045

LOS, length of stay; SNF, skilled nursing facility.

Data are presented as n (%).

Table III Descriptive statistics for 3 outcome variables comparing revision shoulder arthroplasty patients with and without preoperative albumin levels below 3.5 g/dL

Revision shoulder arthroplasty	Albumin <3.5 (N = 26)	Albumin ≥3.5 (N = 45)	P value
90-d readmission	1 (3.8)	1 (2.2)	1.000
Extended LOS (>3 d)	8 (30.8)	3 (6.7)	.014
Discharge to SNF/rehab	7 (26.9)	2 (4.4)	.010

LOS, length of stay; SNF, skilled nursing facility.

Data are presented as n (%).

different institutions where there may be heterogeneity in surgical indications, risk stratification protocols, patient characteristics, clinician preferences, and outcome measures. Furthermore, the database is dependent on coding accuracy, and outcome measures are limited to 30 days after the operation. To our knowledge, the only research to date on malnutrition and shoulder arthroplasty is by Garcia et al,¹⁴ a retrospective cohort study using data from the NSQIP database. Our present study investigates this topic using more granular data collected from 2 large tertiary referral centers, while still harnessing the advantages of large numbers through a 2-institution database.

Low albumin level has long been used as a good indicator of malnutrition in patients who are not acutely ill.^{7,26,27} In orthopedic surgery, an albumin level of less than 3.5 g/dL has widely been considered as suggestive of malnutrition and has also been shown to be associated with poor outcomes after hip, knee, shoulder, and distal radius fracture surgery, including wound infection, readmission, emergency department visits, eLOS, transfusion risk, other complications, and mortality.^{3,4,14,33,34,38,39} In keeping with previous orthopedic literature on this topic, malnutrition was defined as an albumin level <3.5 g/dL in the present study. The prevalence of malnutrition in our primary shoulder arthroplasty study cohort was 19.5%, which is considerably higher than the 7.6% reported by Garcia et al.¹⁴ This may be due to the fact that tertiary care

hospitals such as the ones in this study serve high-risk patients who are more susceptible to malnutrition. The higher 36.6% prevalence of malnutrition in the revision shoulder arthroplasty cohort notably reflects similar findings in total joint arthroplasty²³ and suggests an association between malnutrition and all-cause revision surgery. Our study found that increasing ASA physical status classification score was a risk factor for hypoalbuminemia, which was a shared finding in Garcia et al.¹⁴ Although this may seem to be an unsurprising result, some previous research has suggested that ASA score would not be a good predictor of nutritional status.⁸ Moreover, ASA classification score and low albumin levels have both been previously linked to worse outcomes in total hip and total knee arthroplasty.³⁵ We further found that rTSA was more common among primary shoulder arthroplasty patients with low albumin than normal albumin. As a multi-institutional study, our work was able to detect this finding, whereas NSQIP-based studies such as Garcia et al¹⁴ are unable to differentiate rTSA from TSA because of limitations in the coding. Renal failure approached significance as an independent risk factor for malnutrition, which is unsurprising given the known association between hypoalbuminemia and end-stage renal disease.²² In the revision shoulder arthroplasty group, rTSA and smoking history were unexpectedly associated with normoalbuminemia. Given the size of the revision cohort, it is possible

Table IV Preoperative albumin examined in primary shoulder arthroplasty patients as a predictive variable for discharge to SNF/rehab, 90-day readmission, and extended length of stay, with odds ratios (OR) and P values

Method of analysis	Outcome	Continuous		Binary*	
		OR	P value	OR	P value
Univariable regression: albumin only	Discharge to SNF/rehab	1.28	.187	1.94	.048
	90-d readmission	1.16	.657	1.09	.875
	Extended LOS	1.09	.627	2.34	.004
Multivariable regression: albumin + covariates†	Discharge to SNF/rehab	1.37	.199	1.68	.180
	90-d readmission	1.32	.467	1.29	.659
	Extended LOS	1.00	.996	2.11	.030

SNF, skilled nursing facility; LOS, length of stay; BMI, body mass index; ASA, American Society of Anesthesiologists.

Continuous and binary regressions were used to generate univariable models with only albumin and multivariable models containing albumin and 4 other covariates to control for confounding effects.

* Binary: albumin <3.5 vs. ≥3.5 g/dL.

† Covariates: age, BMI, sex, ASA.

that these are merely chance findings that could lose significance after Bonferroni correction for multiple measurements.

Prolonged inpatient hospital stay is known to be a costly adverse outcome in shoulder arthroplasty,^{30,36} with an inpatient day in the United States costing on average \$2,517 in 2018.²⁵ We found that a greater proportion of primary shoulder arthroplasty patients in the hypoalbuminemia group had an eLOS (>3 days) (26.8% vs. 13.6%), which aligns with previous findings by Garcia et al¹⁴ that 20.3% of hypoalbuminemic patients experienced eLOS compared with 9.0% in the normoalbuminemic group. Our findings also agree with prior data demonstrating increased LOS in total joint arthroplasty patients with low albumin.^{3,15,24} Notably, eLOS was significant on both univariable logistic regression and multivariable logistic regression controlling for confounders, but only when albumin level was treated as a categorical variable. This suggests that the state of being malnourished preoperatively (albumin <3.5 g/dL) is more important for predicting eLOS than the exact preoperative serum albumin level. This multivariable regression model demonstrates that a low preoperative albumin directly predicts eLOS after accounting for known confounding patient factors such as preoperative BMI and age, which have been linked to both increased LOS after surgery and lower albumin levels.^{16,19,20,23,31} Although we found that a greater proportion of revision shoulder arthroplasty patients in the hypoalbuminemia group experienced eLOS (30.8% vs. 6.7%), this finding did not reach significance on regression analysis, likely due to the limited size of the revision group.

Skilled nursing and rehabilitation facilities have previously been demonstrated to be one of the primary cost drivers during the episode of care after total joint arthroplasty.^{11,12,29} According to the Medicare Payment Advisory Commission, the median Medicare payment in 2017 for a stay at an SNF or inpatient rehab facility was \$18,121 and \$20,322, respectively.²⁸ Our study found a correlation between hypoalbuminemia and more frequent discharge to an SNF or rehab facility, which was also significant on univariable logistic regression. However, discharge to postacute care did not reach significance on multivariable logistic regression. This result suggests that although a low preoperative albumin may not directly predict increased need for postacute care, it may instead serve as a proxy for other confounding risk factors that also predict discharge to postacute care. It is likewise possible that a multivariable regression analysis on a larger sample size would attain significance. As with eLOS, we found that revision shoulder arthroplasty patients with malnutrition were more likely to require discharge to SNF/rehab (26.9% vs. 4.4%), though this finding did not reach significance on logistic regression.

A previous study using single-institutional data found that malnutrition conferred an increased risk of 90-day readmission in patients who had undergone total hip or total

knee replacement.³ Although our study did not find a difference in 90-day readmission between the normal and low albumin groups in either the primary or revision groups, this may be due to beta error.

Studies on malnutrition in shoulder arthroplasty to date have faced 2 challenges: (1) preoperative albumin is not drawn on every patient undergoing shoulder arthroplasty, limiting the sample sizes for analysis, and (2) there are no standardized indications for obtaining a preoperative albumin, which introduces a selection bias. Our findings suggest that hypoalbuminemia is more prevalent in primary and revision shoulder arthroplasty cohorts than previously expected and that hypoalbuminemia has a negative effect on outcomes after shoulder arthroplasty. Thus, whether routine risk stratification with preoperative serum albumin is indicated for all patients merits further investigation with large, prospective cohorts.

The question remains whether correction of preoperative hypoalbuminemia improves postoperative outcomes. Indeed, systematic reviews and meta-analyses representing several nonorthopedic surgical fields have found that nutritional repletion preoperatively reduces postoperative complications.^{6,18,41} Further investigation of the effects of correcting preoperative malnutrition on outcomes such as LOS, 90-day readmission, and discharge to postacute care could pave the way for improving patient care and reducing financial and resource burden on the health system.

This retrospective study is subject to several limitations. As serum albumin is not currently part of routine preoperative lab testing, only the primary and revision shoulder arthroplasty cases that had preoperative albumin levels could be analyzed, creating a possible source of selection bias. Surgeries that were indicated for fracture were also excluded, so these results cannot be applied to such cases. Finally, although the 2 tertiary referral institutions involved in this study are diverse—geographically, and with regard to population density—this study may not broadly generalize to other populations and other centers.

Conclusions

The prevalence of malnutrition in this study cohort was 19.5% in primary shoulder arthroplasty patients. Malnutrition was more prevalent in revision patients, with 36.6% being malnourished. Primary shoulder arthroplasty patients with low preoperative albumin levels have an increased risk of eLOS and may have an increased need for postacute care. Malnourished revision shoulder arthroplasty patients had an increased incidence of eLOS and discharge to postacute care compared with those who were not malnourished. No disproportionate risk of readmission within 90 days after shoulder arthroplasty was identified in malnourished primary or revision patients. Albumin level may serve as

a proxy for other risk factors predicting adverse outcomes and merits further investigation in large, prospective cohorts to clearly define its role in preoperative risk stratification.

Disclaimer

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