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A retrospective study evaluating the association between hypoalbuminemia and postoperative outcomes for patients receiving open rotator cuff repair

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ABSTRACT

Purpose: Malnutrition has historically been shown to influence surgical outcomes. Although the diagnosis of malnutrition can be multifactorial, serum albumin levels serve as a useful indicator of malnutrition in patients undergoing orthopaedic surgery. The purpose of this study is to examine the prevalence of post-operative complications in patients with malnutrition (hypoalbuminemia) who underwent open rotator cuff repair. We hypothesized that patients with low preoperative albumin levels will have an increased risk for postoperative complications, readmission, reoperation, and prolonged hospital stay.

Methods: The National Surgical Quality Improvement Program database was queried for patients undergoing open rotator cuff repair from 2006 to 2019. Two patient cohorts were defined: patients with hypoalbuminemia (<3.5 g/dL) and patients with normal preoperative serum albumin (≥3.5 g/dL), with the former being an indicator for malnutrition. In this analysis, demographics, comorbidities, and postoperative complications were compared between the two cohorts using bivariate analyses. Confounding factors found in the control group included sex, race, age, body mass index, smoking status, chronic obstructive pulmonary disease, hypertension, dialysis, diabetes, and dyspnea. To eliminate potential biases, multivariable logistic regression was used to adjust for these confounding factors.

Results: Of 3,052 patients undergoing open rotator cuff repair with serum albumin levels recorded within 90 days before the surgery, 2,914 patients (95.5%), with an age range of 21–90 years, had normal albumin levels and 138 patients (4.5%), with an age range of 24–87 years, were hypoalbuminemic. Following adjustment on multivariate analyses, compared to patients with normal preoperative serum albumin, those with hypoalbuminemia had an increased risk of extended length of hospital stay (OR 7.47; $p < 0.001$) and hospital readmission (OR 4.16; $p = 0.002$).

Conclusion: Hypoalbuminemia is associated with extended length of stay and readmission after receiving open rotator cuff repair surgery.

1. Introduction

Rotator cuff tears are one of the most common causes of shoulder pain and disability, resulting in more than 45 million clinic visits and 40,000 surgeries per year.[1,2] Bigliani et al. found that 39% of individuals older than 60 years had full-thickness rotator cuff tears.[3] The cause of a degenerative rotator cuff tear is multifactorial including gradual tendon degeneration with age, which can predispose the rotator cuff to tears or chronic impingement and overload, which are more commonly seen with athletes.[4–6] While most rotator cuff tears can be successfully treated with non-operative management, those that fail conservative management can be treated surgically. Surgical repair of a rotator cuff tear is done either arthroscopically or through an open procedure. Despite recent increase in popularity for the arthroscopic method, open rotator cuff repair is a viable option, particularly in larger tears as well as in cases where the surgeon feels more familiar with open techniques

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compared with arthroscopic techniques.[7] For example, surgical times may be increased and the overall repair construct weaker in the hands of less experienced surgeons compared to those who perform arthroscopic rotator cuff repairs more regularly.[7] Longer operative times can result in longer anesthetic times, which can increase the risk of complications from anesthesia. However, open rotator cuff repair is not without its own complications, including higher infections rates, glenohumeral joint stiffness, deltoid detachment, and increased post-operative pain due to the larger incision and tissue invasiveness.[8]

Malnutrition has shown to influence postoperative complications in orthopedics. The effect of malnutrition on post-operative outcomes has been studied in orthopaedic trauma as well as elective spine surgery and joint arthroplasty.[9–12] Studies have demonstrated an increase in complications, including infection, increased length of stay, and impaired wound healing.[13] The influence of malnutrition on shoulder complications has also been studied. Analyzing the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, Garcia et al. found the prevalence of malnutrition in patients undergoing total shoulder arthroplasty to be 7.6%, with increased risk of extended hospital recovery, blood transfusion, and death within 30 days after surgery.[12] Similarly, in arthroscopic rotator cuff repair, the prevalence of malnutrition was 3.7% and postoperative complications included hospital admission immediately after the surgery following an outpatient procedure and increased length of stay.[13]

To our understanding, no study has assessed the prevalence of malnutrition among patients undergoing open rotator cuff repair or investigated the associated postoperative complications. Open surgical repair of a torn rotator cuff will lead to larger soft tissue trauma which can potentially further increase the risk of postoperative complications in patients with malnutrition. The purpose of this study is to identify the prevalence of malnutrition in patients undergoing open rotator cuff repair and determine what, if any, postoperative complications exist in this vulnerable patient population.

2. Methods

This was a retrospective study utilizing the ACS-NSQIP database from the years 2006–2019. This national database has been described extensively in prior studies.[14–18] The NSQIP database undergoes regular auditing and the clinical reviewers enter data into this database with high inter-rater reliability, as demonstrated by a disagreement rate of less than 1.8%.[16] Current procedural terminology (CPT) codes 23410 (open treatment of an acute rotator cuff tear) and 23412 (open treatment of a chronic rotator cuff tear) were used to identify all patients undergoing open rotator cuff repair. The exclusion criteria were as follows: patients with missing demographics data [race, gender or American Society of Anesthesiologists (ASA) classification], patients with disseminated cancer, sepsis, and wound infection on admission. Only patients whose serum albumin was recorded 90 days prior to the surgery were included in our dataset. The reason for the measurement of albumin levels was not provided in the database. Patients were categorized by preoperative serum albumin concentration as normal albumin ($\geq$3.5 g/dL) or hypoalbuminemic ($<$3.5 g/dL), with the hypoalbuminemic group being the indicator for malnutrition in this study. This methodology is consistent with previous studies.[12,13]

Patients' demographics and comorbidities recorded are shown in Tables 1 and 2. The various thirty-day postoperative complications assessed and compared between the two cohorts are shown in Table 3. Other outcomes included postoperative hospital admission, extended length of hospital stay (defined as $>$ 3 days, or one standard deviation above the mean length of stay for the patients in this study), readmission, and reoperation. Based on previous literature, postoperative admission was defined as at least one overnight stay in the hospital immediately after the surgery.[13,19]

Using IBM SPSS Version 26, bivariate analyses were used to compare patient demographics, comorbidities, and postoperative complications

Table 1
Demographics and clinical characteristics among patients undergoing open rotator cuff repair.

Demographics	Normal Albumin ($\geq$3.5 g/dL)	Hypoalbuminemic ($<$3.5 g/dL)	p-value
Total patients, n	2,914	138	
Sex, n (%)			**< 0.001**¶
Female	1,340 (46.0)	86 (62.3)	
Male	1,574 (54.0)	52 (37.7)	
Ethnicity, n (%)			0.157¶
Caucasian	2,199 (75.5)	116 (84.1)	
Black or African American	227 (7.8)	8 (5.8)	
Hispanic	352 (12.1)	13 (9.4)	
American Indian or Alaska Native	26 (0.9)	1 (0.7)	
Asian	87 (3.0)	0 (0.0)	
Native Hawaiian or Pacific Islander	23 (0.8)	0 (0.0)	
ASA, n (%)			**< 0.001**¶
I or II	1,561 (53.6)	38 (27.5)	
III or IV	1,353 (46.4)	100 (72.5)	
Smoker, n (%)	540 (18.5)	32 (23.2)	0.171¶
Dependent Functional Status, n (%)	22 (0.7)	3 (2.2)	0.295¶
Mean age, yrs (SD)	60.93 (10.44)	62.74 (11.63)	**0.049****
Mean BMI (SD)	31.55 (6.81)	34.77 (9.10)	**< 0.001****

¶Pearson's chi-squared test.
**Analysis of variance.
Bolding equals significance $p < 0.05$.
ASA, American Society of Anesthesiologists; SD, standard deviation; BMI, body mass index.

Table 2
Medical comorbidities and intraoperative variables among patients undergoing open rotator cuff repair.

Comorbidities	Normal Albumin ($\geq$3.5 g/dL)	Hypoalbuminemic ($<$3.5 g/dL)	p-value ¶
Total patients, n	2,914	138	
CHF, n (%)	5 (0.2)	1 (0.7)	0.152
COPD, n (%)	172 (5.9)	20 (14.5)	**< 0.001**
Hypertension, n (%)	1,712 (58.8)	98 (71.0)	**0.004**
Dialysis, n (%)	9 (0.3)	2 (1.4)	**0.029**
Renal failure, n (%)	3 (0.1)	0 (0.0)	0.706
Chronic steroid use, n (%)	87 (3.0)	6 (4.3)	0.363
Bleeding disorder, n (%)	69 (2.4)	9 (6.5)	**0.003**
Preoperative transfusion, n (%)	0 (0.0)	2 (1.4)	**< 0.001**
DM status, n (%)			**0.001**
No DM	2,253 (77.3)	97 (70.3)	
Noninsulin-dependent DM	472 (16.2)	21 (15.2)	
Insulin-dependent DM	189 (6.5)	20 (14.5)	
Dyspnea, n (%)			**< 0.001**
No dyspnea	2,734 (93.8)	114 (82.6)	
Moderate exertion	165 (5.7)	23 (16.7)	
At rest	15 (0.5)	1 (0.7)	
Anesthesia type, n (%)			0.339
General	2,810 (96.6)	130 (94.2)	
Neuraxial	4 (0.1)	0 (0.0)	
Regional	79 (2.7)	6 (4.3)	
MAC	13 (0.4)	1 (0.7)	

¶Pearson's chi-squared test.
Bolding equals significance $p < 0.05$.
CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; MAC, monitored anesthetic care.

Table 3
Bivariate analysis of postoperative complications of patients following open rotator cuff repair.

Complications	Normal Albumin (≥3.5 g/dL)	Hypoalbuminemic (<3.5 g/dL)	p-value¶
Total patients, n	2,914	138	
Superficial Surgical Site Infection, n (%)	4 (0.1)	0 (0.0)	0.663
Deep Surgical Site Infection, n (%)	7 (0.2)	0 (0.0)	0.564
Pneumonia, n (%)	6 (0.2)	0 (0.0)	0.594
Pulmonary Embolism, n (%)	4 (0.1)	0 (0.0)	0.663
Urinary Tract Infection, n (%)	10 (0.3)	0 (0.0)	0.491
Transfusion Requirement, n (%)	4 (0.1)	2 (1.4)	**0.001**
Deep Vein Thrombosis, n (%)	7 (0.2)	0 (0.0)	0.564
Myocardial Infarction, n (%)	1 (0.0)	1 (0.7)	**0.002**
Postoperative Admission, n (%)	716 (24.6)	38 (27.5)	0.430
Extended Length of Stay, n (%)	35 (1.2)	15 (10.9)	**< 0.001**
Readmission, n (%)	37 (1.7)	8 (8.5)	**< 0.001**
Reoperation, n (%)	24 (0.8)	1 (0.7)	0.900

¶Pearson's chi-squared test.
Bolding equals significance $p < 0.05$.

data between the two cohorts. Demographic and comorbidity variables were also included in the multivariate logistic regression models as covariates for p-values < 0.20 to identify the independent risk factors for postoperative outcomes.[20,21] Statistical significance was set at a p-value < 0.05.

3. Results

3.1. Demographics

In total, 8,608 patients underwent open rotator cuff repair, of which 3,052 patients had their serum albumin levels measured within 90 days before the surgery and were included in the analysis. Of these patients, 2,914 patients (95.5%) had normal albumin levels whereas 138 patients (4.5%) were hypoalbuminemic. The mean number of days from preoperative albumin measurement to surgery was 20 days. Compared to patients with normal albumin, patients with hypoalbuminemia were more likely to be female (62.3% vs 46.0%; $p < 0.001$), have a higher body mass index (BMI) (34.8 vs 31.6 kg/m^2; $p < 0.001$), and have an ASA classification of III or IV (72.5% vs 46.4%; $p < 0.001$) (Table 1). There were no differences in operation time between the two cohorts.

3.2. Comorbidities

Relative to patients with normal preoperative albumin, hypoalbuminemic patients were more likely to have medical comorbidities, including chronic obstructive pulmonary disease (COPD) (14.5% vs 5.9%; $p < 0.001$), hypertension (71.0% vs 58.8%; $p = 0.004$), dialysis requirement (1.4% vs 0.3%; $p = 0.029$), bleeding disorder (6.5% vs 2.4%; $p = 0.003$), preoperative transfusion (1.4% vs 0.0%; $p < 0.001$), diabetes mellitus (29.7% vs 22.7%; $p = 0.001$), and dyspnea on moderate exertion (16.7% vs 5.7%; $p < 0.001$) (Table 2).

3.3. Complications

Following open rotator cuff repair, relative to patients with normal albumin, those with hypoalbuminemia were more likely to experience bleeding requiring transfusion (1.4% vs 0.1%; $p = 0.001$), have a myocardial infarction within 30 days (0.7% vs 0.0%; $p = 0.002$), have an extended length of hospital stay (10.9% vs 1.2%; $p < 0.001$), and be readmitted to the hospital (8.5% vs 1.7%; $p < 0.001$) (Table 3). Bleeding requiring transfusion was defined as at least one unit of packed or whole red blood cells given from surgical start time and up to 72 h postoperatively. Although the reason for readmission for many patients are not recorded in the database, for the few patients whose readmission-related reason was recorded, it was seen that organ/space surgical site infections were the most common cause. Following adjustment on multivariate models to control for patients' demographics and comorbidities, compared to patients with normal preoperative albumin, those with hypoalbuminemia had an increased risk of extended length of hospital stay (OR 7.47; 95% CI 3.51 to 15.87; $p < 0.001$) and hospital readmission (OR 4.16; 95% CI 1.66 to 10.38; $p = 0.002$) (Table 4).

4. Discussion

Malnutrition in surgical patients has been well documented, as well as its effect on surgical outcomes.[12,13,22–24] This retrospective study investigated the association between malnutrition (defined by a serum albumin <3.5 g/dL) and postoperative complications in patients who underwent open rotator cuff repair. The definition of malnutrition is variable and the identification of a best measure for diagnosis continues to be debated. Albumin is a common biomarker used to assess malnutrition, offering a quick and reliable method to screen and diagnose patients preoperatively. For this study, data gathered from the NSQIP database from the years 2006–2019, showed that 4.5% of patients who underwent open rotator cuff repair had hypoalbuminemia going into surgery. This finding is comparable to the 7.6% and 3.7% prevalence in similar conducted studies looking at total shoulder arthroplasty and arthroscopic rotator cuff repair, respectively.[12,13] In contrast, the prevalence of malnutrition in geriatric hip fracture patients was significantly higher at 45%.[9] This difference is likely due to the age of the patient group studied, with older patients having a higher risk of hypoalbuminemia as a result of the loss of muscle mass and a poorer nutritional status, and also the higher comorbidity burden in hip fracture patients. Taken together, these results show that the causes of hypoalbuminemia can be multifactorial including age or poor nutritional status. Causes for hypoalbuminemia in our patient cohort were not investigated.

This study found that patients with hypoalbuminemia preoperatively were more likely to be female, of older age, have a higher BMI, and have an ASA classification of III or IV. This data is similar to findings for other surgical procedures.[16–18] It is important to highlight the fact that malnutrition can result not only from shortage of nutrients but also from excess intake. For example, obesity is a risk factor for intraoperative and postoperative complications. Therefore, it may be helpful to screen obese patients for malnutrition prior to surgery.[25] Furthermore, ASA is often used as marker for well-being. Ryan et al. compared albumin to ASA classification to identify patients who are most likely to develop postoperative complications following total hip arthroplasty (THA) and total knee arthroplasty (TKA).[26] The authors' results showed that checking albumin preoperatively can provide insight into possible

Table 4
Multivariate analysis of postoperative complications of patients following open rotator cuff repair.

Hypoalbuminemic (versus Normal Albumin)	Odds Ratio	95% CI		P-Value
Transfusion Requirement	2.377	0.081	70.083	0.616
Myocardial Infarction	12.138	0.254	579.666	0.206
Extended Length of Stay	7.467	3.513	15.868	**< 0.001**
Readmission	4.156	1.664	10.383	**0.002**

Bolding equals significance $p < 0.05$.
CI, confidence interval.

postoperative complications and outperformed the prognostic potential of ASA in several complications including periprosthetic joint infections.[26] Furthermore, patients with hypoalbuminemia were found to have more medical comorbidities which included COPD, hypertension, dialysis requirement, bleeding disorder, preoperative transfusion requirement, diabetes mellitus, and dyspnea on moderate exertion. Lastly, findings from this study suggest that hypoalbuminemia is associated with extended length of stay and readmission after receiving open rotator cuff repair surgery. These two postoperative complications continued to show significant difference even after adjusting for demographics and comorbidities.

Although arthroscopic rotator cuff repair has become more popular and prevalent in the past decade, open rotator cuff repair is still indicated to treat larger tears and when the surgeon is more familiar with using open techniques. In the end, it is important to ensure that the patient has a good operation and outcome, therefore open or arthroscopic techniques can be used depending on the surgeon's skill with each procedure. Also, both procedures result in similar long-term clinical and radiographic outcomes.[8]

This study has multiple limitations and highlights areas for further study. One limitation is that hypoalbuminemia was the sole marker for malnutrition. However, we were unable to assess the true nutritional status of the patient from a dietician or nutritional standpoint. Additionally, more studies and clinical guidelines are recommending the use of various measures to assess for malnutrition. However, given the limitation of a retrospective analysis, additional anthropometric measurements or a detailed nutritional history might be difficult to obtain, leaving albumin, which is a simple and frequently obtained lab value, as a useful tool to obtain some level of nutritional status in patients prior to surgery. It has been shown that prealbumin may be preferred over albumin as a marker for malnutrition due to its shorter half-life. Utilizing prealbumin levels would allow clinicians to understand more rapid changes of the patient's nutritional state. However, the NSQIP database does not record patients' prealbumin levels, therefore, future studies should evaluate the impact of prealbumin levels on patients undergoing open rotator cuff repair. It is important to note that diagnosing malnutrition should be based on the patient's history and a nutrition-focused physical exam. Laboratory values, such as albumin, should complement but not replace a thorough physical examination. In addition to serum protein levels like albumin and a focused history and physical exam, additional measures of malnutrition can include: appearance, human body measurements, biochemical markers (vitamins, iron, iodine), as well as demographics and environmental factors.[27] In 2012, The Academy of Nutrition and Dietetics (Academy) and the American Society for Parenteral and Enteral Nutrition (A.S·P.E.N.) released a set of clinical guidelines to help reach a consensus on diagnosing malnutrition.[28] The use of these guidelines in the field of surgery is still not common practice. Future studies that have adequate nutritional assessment could provide better information regarding this. Another limitation is that we are unable to investigate why these patients had hypoalbuminemia, which may be caused by multiple comorbidities. While adjusting for these comorbidities, we were unable to determine why these patients had hypalbuminemia initially. Common causes of hypoalbuminemia apart from malnutrition include hepatic insufficiency and protein-depleting enteropathy.[29] Additionally, albumin levels have been shown to also be highly influenced by inflammation of the body.[30] The morbidity and mortality attributed to hypoalbuminemia could potentially be a result of the underlying clinical characteristics rather than malnutrition alone in the patient population studied. Nonetheless, hypoalbuminemia may potentially be used as another marker for overall health and wellness assessment in patients with multiple comorbidities. A further limitation to the study is that the reasons for a longer hospital stay and readmission in the hypoalbuminemic group is not completely recorded in the database. Despite this, it is still important for clinicians to realize that patients with low albumin levels are at risk for prolonged hospital stay and readmission and to ensure appropriate pre- and postoperative management.

Another limitation is that NSQIP does not collect data outside of 30 days postoperatively, and therefore, we could not explore if patients had other complications outside of this window. Given that hypoalbuminemia can be chronic and systemic, these patients could have experienced additional complications that we did not capture within our 30-day postsurgical period. NSQIP is also limited in that it does not provide information on other important parameters with regards to open rotator cuff repairs. These include the type of tear, grading, amount of retraction, number of tendons involved, and the expertise of the surgeon. Future studies should consider these other parameters as they all play a significant role in the treatment of rotator cuff repairs. Additionally, NSQIP is also limited in that it does not provide information on functional outcomes, such as pain, disability, and mobility, following surgery. Future studies should evaluate the impact of malnutrition on functional outcomes following rotator cuff repair to add greater information on this topic. Also, since NSQIP is a national registry and includes patients from different hospitals, the postoperative protocol of treatment and rehabilitation may vary across institutions which can impact the results and conclusions drawn from this study.

This study supports previous studies looking at the prevalence of malnutrition in orthopedic surgeries and demonstrating the increased risk of postoperative complications. Given the following results, clinical practice in the field of orthopedics and surgery should place more emphasis on preoperative nutritional status and medical optimization of patients. Despite the limitation of albumin as a marker for malnutrition, it serves as a valuable and quick tool to identify patients with malnutrition who may benefit from a nutritional consultation. If further workup confirms malnutrition, then it may be prudent to consider postponing the elective surgical procedure until nutritional status is improved, as this could potentially reduce the risk of perioperative complications which we have reported in this study. Alternatively, if the procedure is performed, early postoperative enteral nutrition and close follow-up may be beneficial. Future investigations should focus on attempting to find a potential benefit of rectifying malnutrition preoperatively in order to improve postoperative outcomes such as return to hospital and extended length of stay in open rotator cuff surgery and other surgeries. Also, a prospective study should be conducted in the future to address the multiple limitations discussed in the present study to provide additional information on this topic and complement the current study.

5. Conclusion

Hypoalbuminemia is associated with increased length of stay and readmission for patients receiving open rotator cuff repairs. We recommend that patients with low albumin should receive appropriate medical care before, during and after their surgery in order to maximize their successful recovery.

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Ethics approval

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