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The effects of hypoalbuminemia in obese patients undergoing total joint arthroplasty

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Abstract

Introduction Total joint arthroplasty (TJA) is a highly effective surgery. However, poor nutritional status has been associated with worse outcomes. In orthopedics, nutrition status is commonly evaluated using serum albumin. When albumin levels fall below 3.0 g/dL, wound healing ability becomes impaired. Typically, malnutrition is associated with low BMI, but malnourished patients can also be obese. The goals of this study were to investigate the relationship between malnourishment represented through albumin levels of obese patients and likelihood of postoperative complications.

Methods A retrospective review of patients undergoing primary TJA from 2016 to 2020 in the American College of Surgeons National Surgical Quality Improvement Program national database was performed. Patients with an albumin of < 3.5 g/dL were considered to have hypoalbuminemia and those with ≥ 3.5 g/dL were considered normal albumin. Univariate analysis was used to determine demographic and comorbidity differences between those with and without hypoalbuminemia. Outcomes of interest included length of stay, resource utilization, discharge disposition, and unplanned readmissions. Multivariate logistic regression examined albumin as a predictor of increased resource utilization and complications after controlling for possible confounding variables.

Results Of the 79,784 patients, 4.96% of patients had low albumin. Those with hypoalbuminemia were nearly 1.5 years older than those with normal albumin, were more likely to be black, female, and had an overall increased comorbidity burden as shown by percent of patients with ASA > 3 (all $p < 0.001$). After risk adjustment, those with hypoalbuminemia and a BMI of 35 + had greater risk of complications and increased resource utilization.

Conclusion Our results demonstrated the prevalence of malnutrition increases as a patient's BMI increases. Further, hypoalbuminemia was associated with increased resource utilization and increased complication rates in all obese patients. We suggest screening albumin levels in obese patients preoperatively to give surgeons the best opportunity to optimize patient nutrition before undergoing surgery.

Keywords Albumin · Preoperative screening · Nutrition · Obesity · Total joint arthroplasty

Introduction

Total joint arthroplasty (TJA) is a highly effective and successful surgery. However, poor nutritional status has been associated with worse surgical outcomes and implant failure [1]. A well-balanced, healthy diet consists of a combination of carbohydrates, proteins, fruits, vegetables, and dairy products. These foods provide necessary nutrients, vitamins, and minerals and malnutrition occurs when there is an imbalance between these nutritional requirements and intake [2]. When malnutrition is present, micronutrients essential to various stages of wound healing can be absent, impairing a patient's ability to heal wounds [2]. In orthopedics, nutrition status is typically evaluated using transferrin, total lymphocyte count (TLC), and serum albumin [3]. As the most abundant protein in human plasma, albumin plays an important regulatory role in fluid distribution, acid–base physiology, and substrate transportation [4]. Malnutrition and inflammation both affect serum visceral protein synthesis and as such, low serum albumin and prealbumin are used as markers for undernourishment and determination of physiologic status

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[5]. When albumin levels fall below 3.0 g/dL, tissue edema occurs which decreases oxygen tension leading to impaired wound healing. This leads to a reduction in angiogenesis and fibroblast proliferation resulting in impaired collagen synthesis and remodeling [6]. Recent studies have identified albumin levels as a potential predictor of complications and poor outcomes after TJA suggesting preoperative albumin levels may be useful labs to obtain in high-risk patients [7]. However, other studies have suggested that routine preoperative nutritional screening has little utility [3]. Currently, there are no widely accepted thresholds for preoperative albumin values necessary to minimize risk of complications.

Traditionally, malnutrition is associated with a low body mass index (BMI) and low muscle mass, while obesity is associated with nutrient excess; however, it has been reported that at least 15–20% of obese patients are nutritionally deficient in at least one micronutrient [8]. Furthermore, Ozkalkanli et al. demonstrated that 23–33% of patients undergoing orthopedic surgery were malnourished or at risk for malnutrition [9]. Obesity is another known risk factor for poor outcomes after TJA, increasing risk of prolonged surgical stay, postoperative complications, and revision. Many institutions utilize a BMI threshold to determine surgical eligibility, requiring patients to lose significant amounts of weight in a short period of time [10, 11]. These patients may have low albumin levels, as many obese patients are actually malnourished which may be amplified in a patients' attempt to lose weight for surgery [12].

The goals of this study were to investigate the relationship between the malnourishment represented through albumin levels of obese patients with BMI > 35 kg/m^2 and likelihood of postoperative complication. We hypothesize that abnormally low albumin values will be correlated with greater likelihood of poor postoperative outcomes and greater complication rates.

Materials and methods

This study was deemed institutional review board exempt by the institutional clinical research committee. A retrospective review of 79,784 patients undergoing primary total hip arthroplasty (THA) or total knee arthroplasty (TKA) from 2016 to 2020 in the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) national database was performed. Demographics including age, sex, BMI, and procedure performed. American Society of Anesthesiologists (ASA) score was used to quantify preoperative health status. Comorbidities including diabetes (both insulin and non-insulin dependent), congestive heart failure (CHF), dyspnea, hypertension (HTN), end-stage renal disease (ESRD), chronic obstructive pulmonary disease (COPD), smoking, preoperative infection/sepsis, and anemia were recorded.

Study population

Patients with a BMI less than 35 and those without a recorded albumin lab value were excluded from this study. Patients with an albumin of less than 3.5 g/dL were considered low albumin and those with greater than or equal to 3.5 g/dL were considered normal albumin.

Study outcomes

Postoperative outcomes of interest included length of stay in days, prolonged length of stay of more than 3 days, discharge home and unplanned readmission. Complications of interest included return to operating room, superficial infection, deep wound infection, wound dehiscence, pneumonia, pulmonary embolism, deep vein thrombosis, renal failure, urinary tract infection, stroke, cardiac arrest and myocardial infarction. Prolonged length of stay was considered any stay greater than the 75th percentile which was calculated to be 3 days. Increased resource utilization was categorized as having a length of stay greater than 3 days, or a non-home discharge or an unplanned readmission. Patients were considered to have had a complication if they experience any one of the complications of interest.

Statistical analysis

Univariate analysis including Chi-square tests and two-sided independent samples t tests was used to determine demographic and comorbidity differences between those with and without low albumin. The Fisher's exact test was performed when the assumptions of Chi-square testing were not met. Multivariate logistic regression examined albumin as a predictor of increased resource utilization and complications after controlling for age, race, ASA, diabetes, CHF, ESRD, dyspnea, HTN, COPD, anemia smoking and sepsis. These variables were selected as possible confounding factors because they were significantly different at $\alpha < 0.05$ between groups in preliminary univariate analysis. The same control variables were used for both regression models. All statistical analyses were performed using RStudio (Version 1.4.1717© 2009–2021 RStudio, PBC). Statistical significance was assessed at $p < 0.05$.

Source of funding

This study did not receive any funding.

Results

Of the 79,784 patients, 3959 (4.96%) patients had low albumin and 75,825 (95.04%) had normal albumin. Those with low albumin were nearly 1.5 years older, on average, than those with normal albumin (64.79 vs. 63.35; $p<0.001$) and were more likely to be black (17.5% vs. 12.5%; $p<0.001$), female (72,5% vs. 63.3%; $p<0.001$) and have diabetes (30.5% vs. 25.0%; $p=0.035$). However, low albumin patients had a lower rate of insulin-dependent diabetes (17.3% vs. 18.7%; $p<0.001$) and a higher rate of non-insulin-dependent diabetes (13.2% vs. 6.3%; $p<0.001$). Patients with low albumin overall had a higher comorbidity burden as shown by percent of patients with ASA greater than 3 (79.7% vs. 67.4%; $p<0.001$) and higher rates of CHF (1.1% vs. 0.5%; $p<0.001$), dyspnea (11.5% vs. 7.9%; $p<0.001$), HTN (74.4% vs. 72.0%: $p<0.001$), COPD (7.7% vs. 4.2%; $p<0.001$), smoking (10.9% vs. 8.9%; $p<0.001$), preoperative infection/sepsis (1.0% vs. 0.3%: $p<0.001$) and anemia (5.1% vs. 2.1%; $p<0.001$) but had a lower rate of ESRD (0.2% vs 0.3%; $p<0.001$). Low albumin patients had fewer patients with a BMI between 35 and 40 (51.2% vs. 61.4%; $p<0.001$) but more patients with a BMI between 40 and 45 (30.1% vs. 27.0%; $p<0.001$), BMI between 45 and 50 (11.9% vs. 8.3%; $p<0.001$) and BMI 50+ (6.8% vs. 3.3%; $p<0.001$) (Table 1).

Postoperatively, patients with low albumin had a significantly longer length of stay (2.94 vs. 2.21 days; $p<0.001$), with more patients staying longer than 3 days (18.9% vs. 9.4%; $p<0.001$). Further, those with low albumin were less likely to be discharged home (72.7% vs. 84.9%; $p<0.001$) and more likely to experience unplanned readmissions (6.9% vs. 3.4%; $p<0.001$) (Table 2). Those who had a BMI between 35 and 40, 40 and 45, 45 to 50 and 50+ had significantly different rates of patients with low albumin: 4.2%, 5.5%, 7.0% and 9.8%, respectively ($p<0.001$) (Table 3). The rate of complication was higher in low albumin patients for BMI 35 to 40 ($p<0.001$), BMI 40 to 45 ($p<0.001$) and BMI 50+ ($p=0.007$) as compared to normal albumin patients but was significantly lower in the BMI 45 to 50 group ($p=0.018$) (Fig. 1).

Multivariate logistic regression examined albumin as a predictor of increased resource utilization and complications after controlling for age, race, ASA, diabetes, CHF, ESRD, dyspnea, HTN, COPD, anemia, smoking, and sepsis. Figure 2 shows low albumin is predictive of increased resource utilization for each BMI group. Those with a BMI of 35 to 40 with low albumin had 82% increased risk of increased resource utilization ($p<0.001$), BMI 40 to 45 with low albumin had 39% increased risk of increased resource utilization ($p<0.001$), BMI 45 to 50 with low albumin had 28% increased risk of increased resource utilization ($p=0.018$) and BMI 50+ with low albumin had 73% increased risk of increased resource utilization ($p<0.001$) (Fig. 2). Figure 3 shows low albumin is predictive of complication for each BMI group. Those with a

Table 1 Patient demographics

Patient demographics	Low albumin ($n=3,959$)	Normal albumin ($n=75,825$)	P value
Age	64.79 ± 9.41	63.35 ± 9.05	**< 0.001**
Black race	692 (17.5)	9478 (12.5)	**< 0.001**
Sex			**< 0.001**
Female	2872 (72.5)	48,008 (63.3)	
Male	1087 (27.5)	27,817 (36.7)	
Procedure			0.099
Hip	1058 (26.7)	21,186 (27.9)	
Knee	2901 (73.3)	54,640(72.1)	
Diabetes	1207 (30.5)	18,977 (25.0)	**< 0.001**
Insulin dependent	686 (17.3)	14,164 (18.7)	**0.035**
Non-insulin dependent	521 (13.2)	4813 (6.3)	**< 0.001**
ASA 3+	3157 (79.7)	51,113 (67.4)	**< 0.001**
BMI			
35 to 40	2027 (51.2)	46,580 (61.4)	**< 0.001**
40 to 45	1192 (30.1)	20,497 (27.0)	**< 0.001**
45 to 50	471 (11.9)	6264 (8.3)	**< 0.001**
50+	269 (6.8)	2485 (3.3)	**< 0.001**
CHF	42 (1.1)	354 (0.5)	**< 0.001**
Dyspnea	456 (11.5)	5979 (7.9)	**< 0.001**
HTN	2947 (74.4)	54,631 (72.0)	**< 0.001**
ESRD	6 (0.2)	25 (0.03)	**0.004***
COPD	303 (7.7)	3156 (4.2)	**< 0.001**
Smoker	432 (10.9)	6782 (8.9)	**< 0.001**
Preop infection/sepsis	41 (1.0)	235 (0.3)	**< 0.001**
Anemia	202 (5.1)	1572 (2.1)	**< 0.001**
Albumin	3.22 ± 0.30	4.13 ± 0.34	**< 0.001**

P values < 0.05 in bold

Data are expressed as mean ± SD or n (%)

Table 2 Resource utilization

Postoperative outcome	Low albumin ($n=3,959$)	Normal albumin ($n=75,825$)	P value
Length of stay days	2.94 ± 3.93	2.12 ± 1.98	**< 0.001****
Length of stay 3+ days	752 (18.9)	7130 (9.4)	**< 0.001**
Discharge home	2880 (72.7)	64,402 (84.9)	**< 0.001**
Unplanned readmission	274 (6.9)	2557 (3.4)	**< 0.001**

Data are expressed as mean ± SD or n (%)

P value < 0.05 are in bold

** Denotes Mann–Whitney U test

Table 3 Rates of low albumin by BMI group

Rates	BMI 35 to 40 ($n=48{,}607$)	BMI 40 to 45 ($n=21{,}689$)	BMI 45 to 50 ($n=6{,}735$)	BMI 50+ ($n=2{,}754$)	*P* value
Low albumin	2027 (4.2)	1192 (5.5)	471 (7.0)*	269 (9.8)*	**< 0.001**

P values < 0.05 in bold

Data are expressed as *n* (%)

*Post Hoc $p < 0.001$

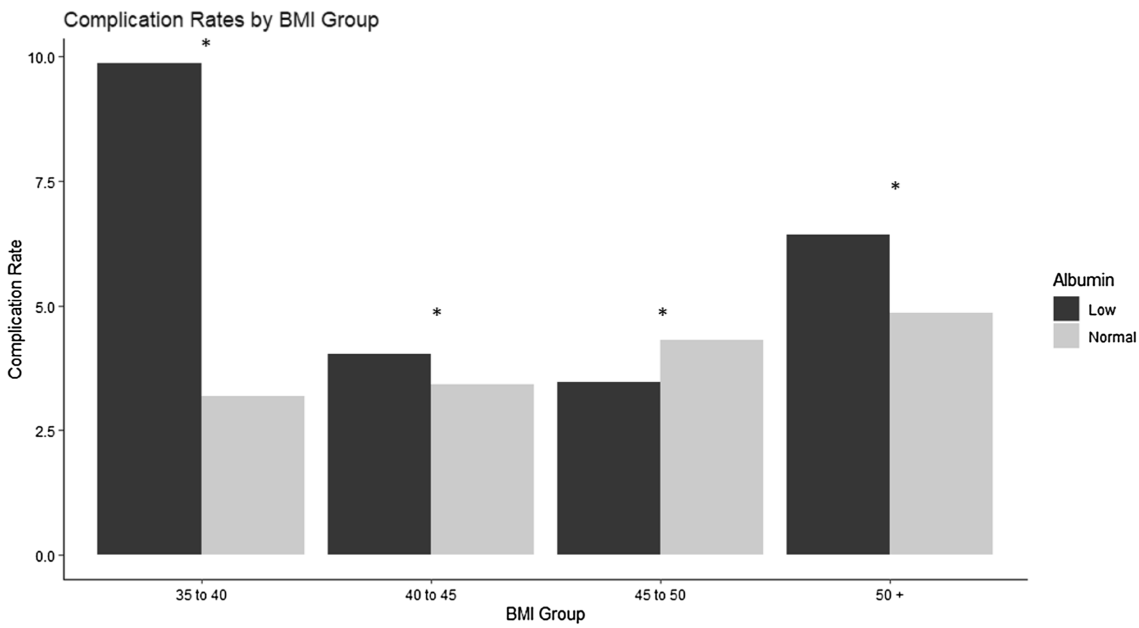

Figure 1. Complication rate by BMI group. *$p$values: <0.001, <0.001, 0.018, 0.007

BMI of 35 to 40 with low albumin had 51% increased risk of complications ($p < 0.001$), BMI 40 to 45 with low albumin had 60% increased risk of complication ($p < 0.001$), BMI 45 to 50 with low albumin had 54% increased risk of complication ($p = 0.027$) and BMI 50 + with low albumin had 71% increased risk of complication ($p = 0.026$) (Fig. 3).

Discussion

Malnutrition has shown to be a risk factor for complications and inferior postoperative outcomes in patients undergoing TJA, and recent studies have also evaluated its paradoxical association with obesity [13, 14]. The purpose of this study was to further investigate the relationship between albumin levels and postoperative outcomes and complications following TJA in obese patients. Our study demonstrated that as BMI increased from 35 to 50 +, there was a significant incremental increase in the prevalence of patients with low albumin levels. Overall, patients with low albumin appeared to have worse comorbidity burden than those with normal albumin levels as a greater proportion of these patients had an ASA of 3 or greater and had a greater proportion of patients affected by the comorbidities evaluated. Our results also demonstrated that patients with low albumin experienced greater resource utilization by way of longer lengths of stay, more unplanned readmissions, and more discharges to a non-home facility. Additionally, low albumin was a strong predictor of postoperative complications in patients with a BMI of 35 or greater as these patients were at least 1.5 times as likely to have complications compared to those with normal albumin levels in the same BMI ranges.

Our results displaying greater resource utilization and higher complication rates in patients with low albumin are consistent with results from other studies demonstrating hypoalbuminemia is an independent predictor of complications following TJA [7, 13]. In a retrospective analysis, Fryhofer et al. utilized the NSQIP database to evaluate all patients undergoing TJA from 2010 to 2016 with the exception of those undergoing TJA as treatment for a prior fracture. They demonstrated preoperative low albumin was

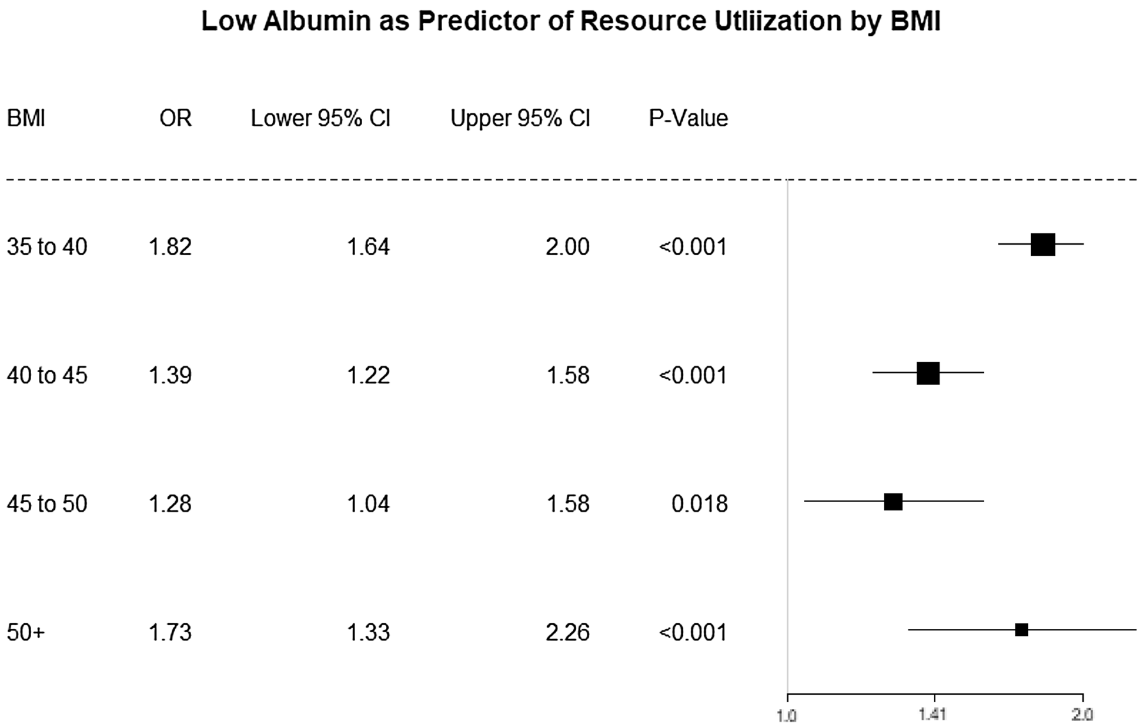

Figure 2. Multivariate logistic regression: low albumin as a predictor of resource utilization. Controlling for age, race, sex, ASA, diabetes, CHF, ESRD, dyspnea, HTN, COPD, anemia, smoking and sepsis

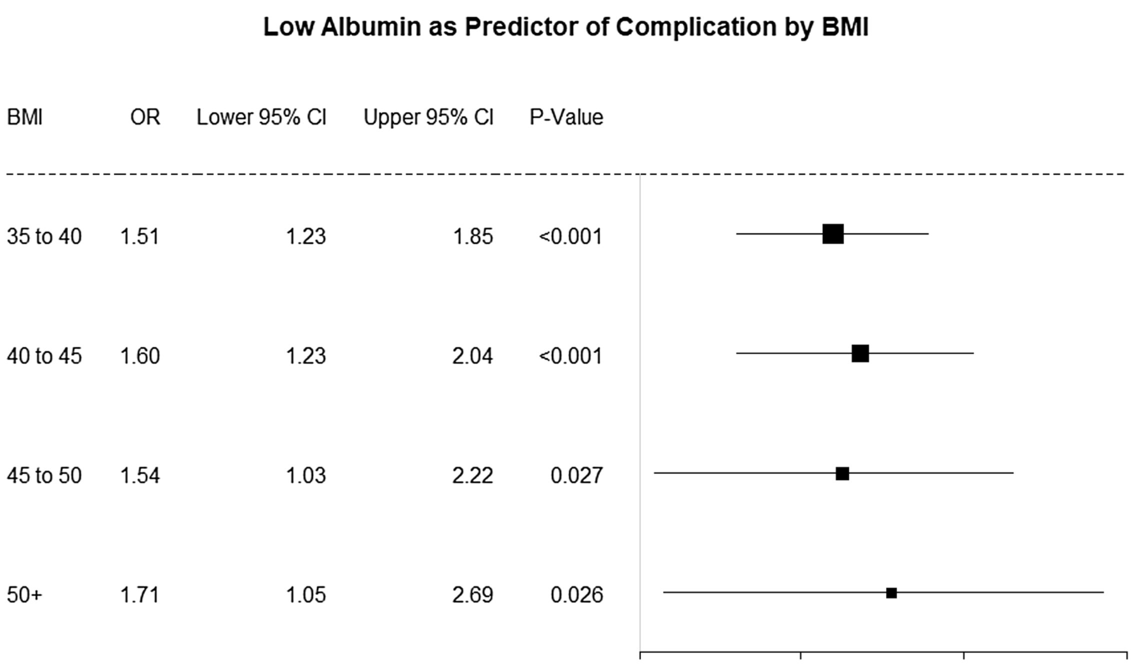

Figure 3. Multivariate logistic regression: low albumin as a predictor of complication. Controlling for age, race, sex, ASA, diabetes, CHF, ESRD, dyspnea, HTN, COPD, anemia, smoking and sepsis

associated with greater odds of readmission within 30 days, length of stay greater than five days, and discharge to a non-home facility after propensity score-matching [13]. In a separate study, Bohl et al. also utilized the NSQIP database from 2011 to 2013 to evaluate all patients undergoing elective primary TJA. They found that patients with hypoalbuminemia had increased rates of surgical site infection and pneumonia as well as longer lengths of stay and more hospital readmissions following TJA [7]. Collectively, these results suggest that preoperative albumin levels may be useful in determining a patient's operative risk.

Prior studies suggest that hypoalbuminemia is a better predictor of postoperative complications than obesity [14]. However, other studies have demonstrated that routine albumin screening is of little value in patients undergoing TJA. In a retrospective review, Rao et al. investigated the value of routine screening for preoperative nutrition status measured by preoperative albumin, transferrin, and total lymphocyte count (TLC) [3]. They identified a low prevalence of abnormal albumin (2.6%) and transferrin (5.6%) with a higher prevalence of abnormal TLC (25%). They also noted that only 13 of 819 cases had more than 1 abnormal lab marker. Ultimately, they concluded that universal nutritional lab screening does not appear to be warranted [3]. Therefore, a risk-based approach to selective albumin screening may be warranted in the TJA population. While the increased prevalence of hypoalbuminemia in underweight patients is well documented, our results suggest that elevated BMI may also be considered an indication for albumin screening.

While this study demonstrates the importance of preoperative hypoalbuminemia as a risk factor for increased resource utilization and complications in obese patients, designing interventions to optimize nutrition status prior to surgery remains a challenge to arthroplasty surgeons. However, optimization of nutritional status has previously been demonstrated to improve postoperative outcomes [8, 15]. After conducting a series of qualitative institutional interviews, O'Connor et al. suggest patients be screened by a nurse navigator or other member of the care team and if found to have abnormal nutritional metrics, they should be further screened for food security [16]. They suggest that patients with identified malnutrition and or food insecurity should be referred to a nutritionist and social work should be consulted to incorporate partners in the community [16]. Additionally, preoperative supplements such as omega-3 fatty acids, arginine, and protein shakes should be encouraged as these have been shown to decrease infectious morbidity, length of stay, and expenses [16]. Furthermore, in a prospective study, Schroer et al. investigated the effects of a nutrition intervention program that encourages high-protein, anti-inflammatory foods in addition to patient education in patients with normal albumin (> 3.4 g/dL) or hypoalbuminemia (≤ 3.4 g/dL) [15]. They found that specific nutritional intervention improved surgical outcomes and therefore decreased resource utilization [15]. Unfortunately, there is no consistent approach toward optimization, and however, the current literature suggests that nutrition optimization helps to improve postoperative outcomes; as such surgeons should evaluate albumin in high-risk populations and adopt nutritional optimization protocols in patients with concerning nutritional status [14–18].

This study was not without limitations. First, patients that had a BMI of less than 35 and those without a recorded lab value were excluded introducing potential selection bias as healthier patients may not have had albumin levels measured. Next, although hypoalbuminemia is a marker for protein-energy deficiency, other nutritional deficiencies may also be causing complications and poor outcomes; therefore, it is likely we did not control for all confounding variables. Further, patients in the hypoalbuminemia group had a higher comorbidity burden that may have confounded our results. However, the results of the multivariate models controlling for BMI and comorbidities mitigate the impact of this limitation and suggest that hypoalbuminemia remains an important risk factor for both increased resources utilization and complications after controlling for other demographics and comorbidities. Another limitation of this study is the short-term follow-up. The ACS-NSQIP database only collects data for 30 days postoperatively restricting our postoperative follow-up to this timeframe. However, a strength of our study is also the use of the ACS-NSQIP database as it has gained a high degree of acceptance in the literature as a valid and reliable source of risk-adjusted clinical investigations [19, 20].

Conclusion

In conclusion, our results demonstrated the prevalence of malnutrition as represented by albumin levels < 3.5 g/dL increases as a patients BMI increases. Further, hypoalbuminemia was associated with increased resource utilization and increased complication rates in all obese patients. Therefore, we suggest screening albumin levels in obese patients preoperatively in order to give surgeons the best opportunity to optimize a patient's nutrition before undergoing their surgery.

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Declarations

Conflict of interest The authors have no conflicts of interest related to the current study to disclose.

Ethical approval This study was deemed IRB exempt as a retrospective review of de-identified data from a national database.

Informed consent Informed consent was not required or performed for this study.

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