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Thirty-Day Perioperative Complications, Prolonged Length of Stay, and Readmission Following Elective Posterior Lumbar Fusion Associated With Poor Nutritional Status

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Abstract

Study Design: Retrospective study.

Objective: To determine the rates of early postoperative mortality and morbidity in adults with hypoalbuminemia undergoing elective posterior lumbar fusion (PLF).

Methods: The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) was examined from 2005 to 2012. Current Procedural Terminology (CPT) codes were used to query the database for adults (≥18 years) who underwent PLF and/or posterior/transforaminal lumbar interbody fusion (PLIF/TLIF). Patients were divided into those with normal albumin concentration (≥3.5g/dL) and those with hypoalbuminemia (<3.5 g/dL). Both univariate and multivariate analyses were performed.

Results: A total of 2410 patients were included, of whom 2251 (93.4%) were normoalbuminemic and 159 (6.6%) were hypoalbuminemic. Patients with preoperative serum albumin levels <3.5 g/dL were older with a higher American Society of Anesthesiologists (ASA) score, and more comorbidities, including anemia, diabetes, dependent functional status, and preoperative history of chronic steroid therapy. Hypoalbuminemic patients had higher rates of any 30-day perioperative complication ($P < .001$), unplanned readmission ($P = .019$), and prolonged length of stay (LOS) >5 days ($P < .001$). However, hypoalbuminemia was not significantly associated with any specific perioperative complication. On multivariate analysis, preoperative hypoalbuminemia was found to be an independent predictor of prolonged LOS (OR 2.4, 95% CI 1.7-3.5; $P < .001$) and unplanned readmission (OR 2.7, 95% CI 1.1-6.3; $P = .023$).

Conclusion: Hypoalbuminemia was found to be an important predictor of patient outcomes in this population. This study suggests that clinicians should consider nutritional screening and optimization as part of the preoperative risk assessment algorithm.

Level of Evidence: III

Keywords

nutritional status, posterior lumbar fusion, American College of Surgeons National Surgical Quality Improvement Program, outcomes, complications, albumin

Introduction

There is growing evidence in the literature regarding the impact of poor preoperative nutrition and its influence on postoperative outcomes and surgical complications. Malnutrition, defined as an imbalance in nutrient intake whether over- or undernutrition, is prevalent not only in developing nations, but

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particularly also in hospitals and residential care settings in developed nations.[1,2] In the hospital setting, reported prevalence of malnutrition in the literature varies between 20% and 50%.[1,3-6] Specifically, prior to lumbar spine surgery, there have been reports of up to 25% of patients being undernourished, and this is likely to increase in the near future with a rapidly growing elderly population.

Poor preoperative nutrition status is likely to contribute to poor wound healing and delayed postoperative recovery in patients undergoing surgery. One marker of malnutrition is serum hypoalbuminemia, defined as values <3.5 g/dL. Serum albumin concentration is an established clinical marker of overall nutritional status and systemic disease.[7] Preoperative hypoalbuminemia has been suggested to be an independent risk factor for postoperative complications in various types of surgical settings, including gastrointestinal,[8,9] rectal,[10] cardiovascular,[11] gynecologic oncological,[12] and orthopedic hip procedures.[13,14]

However, its correlation to outcomes following posterior lumbar fusion (PLF) has not been previously studied. With the rising life expectancy, there is likely to be a continual rise in the number of lumbar fusion procedures being performed.[15,16] Prognostic factors for postoperative complications, wound healing, postoperative length of stay, and recovery become even more important to consider in patients undergoing PLF. Using data from a large national database, the purpose of study was to determine the effect of preoperative serum albumin levels, which is a marker of overall nutritional status, on morbidity and mortality after PLF surgery. We hypothesized that poor preoperative nutritional status as manifested by hypoalbuminemia is associated with increased morbidity and mortality.

Materials and Methods

Patient Selection and Data Collection

Patient data was obtained from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database from 2005 to 2012. Inclusion criteria for surgical cases were identified based on the Current Procedural Terminology (CPT) codes for PLF (22 612), posterior lumbar interbody fusion (PLIF) or transforaminal lumbar interbody fusion (TLIF) (22 630), and posterior lumbar fusion and PLIF/TLIF (22 633). Exclusion criteria of the present study included those who underwent spinal deformity surgery (CPT 22 800, 22 802, 22 804, 22 808, 22 810) or combined approaches with anterior lumbar interbody fusion (CTP 22 533, 22 558). Additionally, patients with missing preoperative serum albumin measurements were also excluded. Patients who underwent nonelective surgery were also excluded. Other exclusion criteria included: being pregnant, ventilator dependent, preoperative systemic sepsis, emergency operations, length of stay (LOS) >365 days, central nervous system tumor, disseminated cancer, chemotherapy for malignancy within 30 days before operation, radiotherapy for malignancy within 90 days before operation, and acute renal failure. The study was qualified as exempt from the Mount Sinai Hospital Institutional Review Board.

Baseline Variables

Among the preoperative variables collected in the NSQIP database were the preoperative serum albumin concentration and the number of days before surgery it was measured. Patients who underwent PLF were categorized into 2 groups based on preoperative serum albumin concentration: normal (≥3.5 g/dL) or hypoalbuminemic (<3.5 g/dL). Independent patient demographic variables were assessed, including sex, race, inpatient versus outpatient, age, body mass index, American Society of Anesthesiologists (ASA) score, diabetes status, smoking status, alcohol use, anemia (defined as hematocrit <36% in females and <39% in males), dyspnea status and functional status prior to surgery.

Medical comorbidity variables included anemia, diabetes, smoking, alcohol use, dyspnea, functional status, cardiac comorbidity, pulmonary comorbidity, peripheral vascular disease, neuromuscular injury, stroke or cerebrovascular accident (CVA), chronic steroid use, weight loss, bleeding disorder and preoperative blood transfusion. Cardiac comorbidity was defined as a history of congestive heart failure (within 30 days before admission), myocardial infarction (within 6 months before admission), percutaneous coronary intervention, cardiac surgery, angina (within 1 month before admission) or use of hypertensive medication. A pulmonary comorbidity was defined as history of severe chronic obstructive pulmonary disease, or current pneumonia. Peripheral vascular disease was defined as a history of revascularization or amputation for peripheral vascular conditions, and rest pain. Smoking history (current smoker within 1 year) and chronic steroid use (regular use within 30 days before admission) were also assessed. Multilevel fusions were defined as patients having any of the following CPT codes: 63 091, 22 585, 63 035, 63 048, 63 044, 22 614, 22 632, and 22 612.

Outcome Variables

The study endpoints were any 30-day postoperative complication, including mortality, pulmonary complications (pneumonia, intubation, or ventilator requirement), renal complications (progressive renal insufficiency or acute renal failure), central nervous system (CNS) complications (stroke or coma), cardiac complications (cardiac arrest or myocardial infarction), pulmonary embolism (PE), deep vein thrombosis (DVT), sepsis or septic shock, peripheral nerve injury, return to the operating room (OR), urinary tract infection (UTI), wound complications (superficial wound infection, deep incisional surgical site infection, organ space surgical site infection, or wound dehiscence), unplanned readmission (2011-2012), unplanned reoperation (2011-2012), prolonged LOS (>5 days), graft or flap failure, and intraoperative or postoperative blood transfusion. Unplanned readmission and reoperation data were not added to

the NSQIP database until 2011, and thus was not available for the years 2005-2010.

Statistical Analysis

SPSS v.19 (IBM Corp, Armonk, NY) was used for all statistical analysis. Patient demographics and the prevalence of comorbidities were compared between cases with and without preoperative albumin measurements. Student's *t* test for discrete variables and chi-square test for categorical data were used.

The rates of major postoperative complications, minor postoperative complications, and average LOS were compared between the normal albumin and hypoalbuminemia groups. Patient demographics and comorbidities were compared between patients with and without major postoperative complications.

To assess whether or not nutritional status was a potential risk factor for various postoperative complications and outcomes, univariate analysis was performed. The univariate of preoperative variables for each complication is not shown, but can be provided. Variables significant to $P < .20$ with chi-square analysis were carried forward into a multivariable logistic regression model to determine independent associations to developing a major postoperative complication, with clinical covariates. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. Statistical significance was set at a level of $P = .05$.

Results

Patient Cohort and Baseline Characteristics

We identified 2410 elective PLF cases from 2005 to 2012 in the NSQIP database. Of these cases, 2251 (93.4%) patients had normal preoperative serum albumin concentrations (≥3.5 g/dL) while 159 (6.6%) were hypoalbuminemic (<3.5 g/dL). Baseline characteristics of the 2 groups are outlined in Table 1. The hypoalbuminemic cohort was more likely to have an age ≥80 years (7.6% vs 12.0%, $P < .003$), ASA scores ≥3 (49.5% vs 80.5%, $P < .001$), anemia (19.6% vs 55.4%, $P < .001$), diabetes (18.9% vs 32.1%, $P < .001$), be on preoperative steroids (3.0% vs 10.7%, $P < .001$), and be functionally dependent prior to surgery (4.8% vs 17.0%, $P < .001$). There were no significant differences between the 2 groups in terms of obesity (46.9% vs 44.0%, $P = .487$), being smokers (22.0% vs 22.0%, $P = .995$), and being alcohol users (3.32% vs 1.9%, $P = .320$).

In terms of medical comorbidities, the hypoalbuminemic cohort had a significantly higher proportion of patients with pulmonary comorbidity (5.2% vs 15.1%, $P < .001$), cardiac comorbidity (61.0% vs 71.7%, $P = .008$), recent preoperative weight loss (0.3% vs 3.1%, $P < .001$), preoperative transfusion (0.2% vs 2.5%, $P < .001$), neuromuscular injury (6.0% vs 12.0%, $P = .0023$), and preoperative stroke or CVA (2.5% vs 6.3%, $P = .005$). There were no significant differences between the 2 cohorts in terms of peripheral vascular disease, dyspnea, and bleeding disorders.

Table 1. Baseline Patient Characteristics and Operative Variables.

	Normal Albumin (≥3.5 g/dL)	Hypoalbuminemia (<3.5 g/dL)	*P*
N	2251	159	
Female, %	56.2	59.1	.479
Age range in years, %			.003
18-64	54.7	41.5	
65-79	37.6	46.5	
≥80	7.6	12.0	
Race, %			.092
African American	6.6	10.1	
Caucasian	79.2	70.4	
Hispanic	5.7	9.4	
Other	8.5	10.1	
Obese (BMI >30 kg/m^2), %	46.9	44.0	.487
ASA Class ≥ 3, %	49.5	80.5	<.001
Comorbidities, %			
Anemia	19.6	55.4	<.001
Diabetes	18.9	32.1	<.001
Current smoker	22.0	22.0	.995
>2 alcoholic drinks/ day in 2 weeks before admission	3.3	1.9	.320
Dyspnea	10.1	13.2	.218
Dependent functional status prior to surgery	4.8	17.0	<.001
Pulmonary comorbidities	5.2	15.1	<.001
Cardiac comorbidities	61.0	71.7	.008
Peripheral vascular disease	1.1	3.1	.020
Neuromuscular injury	6.0	12.0	.003
Stroke/CVA	2.5	6.3	.005
Chronic steroid use	3.0	10.7	<.001
Weight loss	0.3	3.1	<.001
Bleeding disorder	1.6	3.1	.162
Preoperative transfusion	0.2	2.5	<.001
Operative variables			
Total RVU	53.1	55.9	0.219
Operation time >4 hours, %	32.8	32.1	0.845
Multilevel fusion, %	11.4	16.4	0.059
Number of days prior to surgery albumin measurement taken	15.1	20.3	.001

Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists; CVA, cerebrovascular accident; RVU, relative value units.

There was a statistically significant difference between the two cohorts in terms of the number of days prior to surgery that serum albumin measurements were taken (15.1 days for the normal albumin cohort vs 20.3 days for the hypoalbuminemic cohort, $P = .001$). There was no statistically significant

Table 2. Incidence of 30-Day Perioperative Complications.[a]

	Normal Albumin (≥3.5 g/dL), N = 2251	Hypoalbuminemia (<3.5 g/dL), N = 159	*P*
Any complication	19.8	31.5	<.001
Death	0.2	0.6	.320
Pulmonary complication	1.2	2.5	.135
Renal complication	0.2	0.6	.227
CNS complication	0.1	0.0	.645
Cardiac complication	0.5	0.6	.873
VTE	1.3	1.9	.561
UTI	2.4	4.4	.132
Sepsis	1.0	1.9	.308
Wound complication	2.4	3.1	.530
Intra-/postoperative blood transfusion	16.6	22.6	.051
Unplanned reoperation (2011-2012)	1.7	3.2	.383
Unplanned readmission (2011-2012)	4.6	11.3	.019
LOS >5 days	18.1	43.4	<.001

Abbreviations: VTE, venous thromboembolism; UTI, urinary tract infection; LOS = length of stay.
[a] Values are in percentage.

difference between the groups in terms of total relative value units (RVU), operative time >4 hours, and multilevel fusion (Table 1).

Unadjusted Outcomes

Postoperative complication rates as well as length of hospital stay were compared between the normal albumin (≥3.5 g/dL) and the hypoalbuminemia (<3.5 g/dL) groups (Table 2). Patients with preoperative hypoalbuminemia had significantly higher rates of any postoperative complication (31.5% vs 19.8%, $P < .001$), including higher rates of intraoperative or postoperative blood transfusions (22.6% vs 16.6%, $P = .051$). They also had a significantly higher proportion of unplanned readmissions (11.3% vs 4.6%, $P = .019$) and LOS >5 days (43.4% vs 18.1%, $P < .001$). There were no differences between the normal albumin and hypoalbuminemia groups in terms of rate of death, pulmonary, renal, CNS complications, peripheral vascular disease, cardiac complications, VTE, UTI, sepsis, wound complication, return to operating room, or unplanned reoperation.

Adjusted Outcomes

Results from the multivariate analyses including the C-statistics are outlined in Table 3. Preoperative hypoalbuminemia was significantly associated with unplanned readmission (adjusted OR 2.7, 95% CI 1.1-6.3; $P = .023$) and prolonged LOS (adjusted OR 2.4, 95% CI 1.7-3.5; $P < .001$). Bleeding disorder was the only other baseline variable significantly associated with unplanned readmission (adjusted OR 4.0, 95% CI 1.1-14.6; $P = .032$). In contrast, multiple baseline variables in addition to hypoalbuminemia were associated with prolonged LOS, including anemia (adjusted OR 0.9, 95% CI 0.9-1.0; $P = .002$), ASA ≥3 (adjusted OR 1.8, 95% CI 1.5-2.3; $P < .001$), pulmonary comorbidity (adjusted OR 1.7, 95% CI 1.2-2.6; $P = .008$), neuromuscular injury (adjusted OR 1.8, 95% CI 1.2-2.6; $P = .003$), and operative time >4 hours (adjusted OR 2.9, 95% CI 2.3-3.6; $P < .001$).

In the multivariate analysis of risk factors for any 30-day perioperative complication, hypoalbuminemia was not an independent risk factor (adjusted OR 1.1, 95% CI 0.8-1.7; $P = .492$). Independent risk factors for any perioperative complication were the presence of dyspnea (adjusted OR 1.7, 95% CI 1.2-2.3; $P = .002$) and operative time >4 hours (adjusted OR 2.7, 95% CI 2.1-3.3; $P < .001$).

Discussion

Poor preoperative nutrition status has been suggested to be a risk factor for postoperative complications in adults undergoing surgery. Impaired perioperative serum albumin has been shown to be an early marker of nutritional deficiency, and thus may act as a surrogate marker for nutritional status of patients undergoing surgery, particularly in the setting of spinal surgery where the prevalence of preoperative malnutrition is significant.[4,17]

The present study was based on data from a large, multi-institutional, nationally validated database of the ACS NSQIP. In the present retrospective analysis of 2410 patients who received preoperative serum albumin measurements, we found that preoperative hypoalbumenia was an independent risk factor for unplanned readmission and prolonged LOS >5 days in patients undergoing elective PLF surgery. These results imply that assessment of patient's baseline nutrition status by using serum hypoalbuminemia may be a valuable prognostic tool for assessing the risk of unplanned readmission and prolonged hospital stay.

Preoperative nutritional status as measured by albumin level has not been studied in the context of unplanned readmissions in patients undergoing elective lumbar spine surgery, however, there have been numerous studies elucidating the association between hypoalbuminemia and adverse postoperative outcomes, which may contribute toward unplanned readmissions.

Table 3. Multivariate Logistic Regression Analysis of Independent Risk Factors for Any 30-Day Perioperative Complication, Unplanned Readmission, and Prolonged LOS.

Risk Factor	Adjusted Odds Ratio	95% CI		*P*	C-Statistic
(1) Any 30-day perioperative complication					
Hypoalbuminemia	1.1	0.8	1.7	.492	.728
Dyspnea	1.7	1.2	2.3	.002	
Operative time >4 hours	2.7	2.1	3.3	<.001	
(2) 30-day unplanned readmission					
Hypoalbuminemia	2.7	1.1	6.3	.023	.627
Bleeding disorder	4.0	1.1	14.6	.032	
(3) Prolonged LOS (>5 days)					
Hypoalbuminemia	2.4	1.7	3.5	<.001	.705
Preoperative hematocrit	0.9	0.9	1.0	.002	
ASA $\geq$3	1.8	1.5	2.3	<.001	
Pulmonary comorbidity	1.7	1.2	2.6	.008	
Neuromuscular injury	1.8	1.2	2.6	.003	
Operative time >4 hours	2.9	2.3	3.6	<.001	

Abbreviations: ASA, American Society of Anesthesiologists Physical Status Score; LOS, length of stay.

Adogwa et al[18] investigated 136 spine fusion patients, and demonstrated a significant association between preoperative hypoalbuminemia and postoperative complications after elective surgery for degenerative and deformity cases, but not for nonelective, trauma, and neoplastic causes. Fu et al[19] recently reported preoperative and postoperative outcomes of 3671 anterior cervical discectomy and fusion (ACDF) cases and showed that preoperative serum hypoalbuminemia was an important adjunct predictor of major complications following ACDF. Tempel et al[20] retrospectively analyzed 83 patients who had presented with postoperative deep wound infection following spine surgery. They reported that all patients except one had serum prealbumin levels in the malnutrition range at time of presentation, and suggested that serum prealbumin levels can be a screening biomarker and risk stratifier for postoperative infection after spinal surgery. Similarly, Klein et al[17] assessed 114 consecutive patients who underwent lumbar decompression and fusion. Out of 13 postoperative infectious complications, 10 of these patients were malnourished. The authors concluded that 25% of patients undergoing elective lumbar spine surgery were malnourished in their experience, and that this factor was a significant independent predictor of postoperative complications.

While the present study focused on serum prealbumin levels, which is a valuable tool for assessing nutrition status, it may only capture a particular aspect of malnutrition, which is really a systemic and heterogeneous process. Malnutrition may be influenced by social and environmental factors, including stress, physical activity intensity, and parental nurturance. Other biomarkers for malnutrition have been used in the literature, including total lymphocyte count, hemoglobin, and cholesterol. However, the reliability and consistency of the association of these markers with postoperative surgical complications is not well established.[21] Nutritional status can also be assessed using questionnaires such as the Mini Nutritional Assessment Short Form (Nestle Nutrition Institute, Switzerland). However, these methods are limited by recall errors and misreporting, and as such, poor correlations with postoperative outcomes have been reported in the literature.[22] The use of serum albumin levels may also be problematic in certain subset of patients. For example, in the setting of chronic kidney disease, overhydration, or proteinuria, these patients may have reduced serum albumin levels that are not directly correlative with their nutritional status.[23-25] While this may be compensated for in the short term with increased albumin synthesis rates, in the long term there will be gradual shift of albumin from the extravascular to the intravascular space.[23-25] Future assessment of the role of nutritional biomarkers and predictive value for postoperative spinal complications should expand to metabolic profiling of patients or determination of the "food metabolome."[26] This may provide a source of more sensitive biomarkers for study of postoperative complications in the future. However, until better alternatives become available, serum preoperative albumin levels remain a feasible and economical marker of postoperative complications in surgical patients.

Our results show that hypoalbuminemia, a marker of malnutrition, is associated with unplanned readmissions in patients undergoing PLF surgery. This implies that there may be a role for nutritional supplementation in patients with hypoalbuminemia before their elective surgery. Indeed, studies in orthopedic trauma surgery have suggested that preoperative nutritional supplementation may reduce complications.[27,28] In another study of patients undergoing abdominal surgery, patients who received additional nutritional supplementation had significant lower complications (25.6% vs 50.6%) compared with patients who did not receive additional nutrition.[29] Hu et al[30] randomized patients undergoing complex spinal reconstructive surgery to either receive or not receive postoperative total parenteral nutrition. They found that the treatment group had significantly lower rates of infection such as pneumonia and urinary tract infections. However, the role of nutritional

supplementation has not specifically been studied in the elective spine surgery population and remains to be confirmed. However, based on the results of the present study and available literature, nutritional supplementation of patients with hypoalbuminemia appears to be a reasonable strategy.

The findings of this study are limited by several constraints. First, our primary finding that hypoalbuminemia is independently associated with 30-day unplanned readmission and prolonged LOS is limited as we were unable to parse out the specific underlying reasons for readmission or prolonged LOS. That is, readmission or prolonged LOS are oftentimes secondary to specific perioperative complications (eg, pulmonary complication, cardiac complication, etc), and are therefore a consequence of those complications, rather than a direct postoperative complication itself. Unfortunately, the NSQIP database does not allow us to delineate potential confounding variables that link hypoalbuminemia with readmission or prolonged LOS. This is a limitation of our study that should be addressed in future prospective or retrospective studies that examine readmission and prolonged LOS in greater detail.

Within the NSQIP database, only 38.2% of the PLF with or without PLIF/TLIF cases had preoperative serum albumin measurements and were included in this study. Patients who underwent preoperative evaluation of serum albumin levels were likely thought to be at risk for hypoalbuminemia from a nutritional standpoint or from an overall health status standpoint. Therefore, this represents an inherent selection bias toward including patients in this study who were perhaps less healthy at baseline. Moreover, the serum albumin levels were measured on average 21.1 days (SD = 25.7) prior to surgery in the hypoalbuminemia group and on 15.4 days (SD = 17.1) prior to surgery in the normal group, while the half-life of serum albumin is approximately 20 days. The lack of serum albumin level at the time nearer to the operation is a limitation of our study. Furthermore, the ACS NSQIP database is multicenter, and therefore there will inevitably be heterogeneity unaccounted for due to variations between institutions in terms of albumin measurement techniques, surgical techniques, and operative experience, which may introduce further bias. Additionally, lifestyle and dietary practices may differ from patient to patient, and center to center, and can also influence preoperative nutrition status. This factor was not recorded in the database and thus could not be accounted for in the multivariable-adjusted model. Additionally, hypoalbuminemia can be caused by a decline in plasma albumin concentrations due to renal and/or hepatic pathology, thereby potentially limiting the utility of hypoalbuminemia as an accurate measure of malnutrition.

Procedural outcomes such as pseudoarthrosis rates as well as patient functional outcomes (visual analog scale and Oswestry disability index scores) were not included in the database, which further limits the assessing between preoperative nutritional status and postoperative outcomes. Finally, the use of CPT codes is not perfect in selecting the patients of interest. For example, even though we excluded numerous CPT codes related to adult deformity cases, the CPT code pertaining to multilevel fusion (22 614) could be assigned to patients that received spinal fusion due to deformity. Nevertheless, the methodology employed in the current study is the best attempt in selecting study subjects of interest.

In conclusion, analysis of a large nationwide database demonstrated that preoperative hypoalbuminemia (<3.5 g/dL) was found to be significantly associated with unplanned readmissions and increased LOS (>5 days) in patients undergoing PLF with or without PLIF/TLIF. This study suggests that clinicians should consider nutritional screening and optimization as part of the preoperative risk assessment algorithm.

Declaration of Conflicting Interests

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