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Use of the Geriatric Nutritional Risk Index to Assess Risk for Postoperative Complications Following Posterior Cervical Decompression/Fusion

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ABSTRACT

Background: Posterior cervical decompression with or without fusion (PCD/F) is used to manage degenerative spinal conditions. Malnutrition has been implicated for poor outcomes in spine surgery. The aim of this study was to assess the ability of the Geriatric Nutritional Risk Index (GNRI) as a risk calculator for postoperative complications in patients undergoing PCD/F.

Methods: The 2006 to 2018 American College of Surgeons National Surgery Quality Improvement Program Database was queried for patients undergoing PCD/F. Nutritional status was categorized as normal (GNRI greater than 98), moderately malnourished (GNRI 92–98), or severely malnourished (GNRI less than or equal to 92). Complications within 30 days of surgery were compared among the groups. Preoperative data that were statistically significant ($P < 0.05$) upon univariate χ^2 analysis were included in the univariate then multivariate binary regression model to calculate adjusted ORs. All ORs were assessed at the 95% CI.

Results: Of the 7597 PCD/F patients identified, 15.6% were severely malnourished and 19.1% were moderately malnourished. Severe and moderate malnourishment were independent risk factors for mortality (OR = 3.790, 95% CI 2.492–5.763, $P < 0.001$; OR = 2.150, 95% CI 1.351–3.421, $P = 0.011$). Severe malnourishment was an independent risk factor for sepsis/septic shock (OR = 3.448, 95% CI 2.402–4.948, $P < 0.001$).

Conclusions: In elderly patients undergoing PCD/F, severe malnutrition, as defined by the GNRI, was an independent risk factor for mortality and sepsis/septic shock.

Clinical Relevance: The GNRI may be more useful than other indices for risk stratification in elderly patients because it accounts for confounding variables such as hydration status and paradoxical malnourishment in obese patients.

Level of Evidence: 3

Cervical Spine

Keywords: posterior cervical decompression and fusion (PCD/F), geriatric nutritional risk index (GNRI), malnutrition, spinal fusion, NSQIP

INTRODUCTION

Posterior cervical decompression with or without fusion (PCD/F) is commonly employed as the surgical strategy to manage conditions such as spondylosis, spinal stenosis, neoplastic disease, previous laminectomy, and other degenerative disc disorders.[1,2] From 2001 to 2013, the utilization of PCD/F for degenerative spine conditions has increased 2.7-fold.[3] In elderly patients with multilevel stenosis, the posterior approach is often favored over anterior or combined approaches. This surgical strategy is largely successful with an observed 98% success rate; however, in the same meta-analysis, 9% of people experienced complications.[4] Complications of this procedure include surgical site infection (SSI), sepsis, wound healing problems, adjacent segment degeneration, C5 nerve palsy, and axial neck pain.[5,6] Mitigation of adverse postoperative outcomes in patients undergoing PCD/F is paramount in ensuring improved prognosis and quality of life after surgery.

Malnutrition is frequently underdiagnosed in surgical patients.[7] Especially in spine surgery, malnutrition has been associated with worse outcomes, namely infection.[8,9] In a study conducted on nutritional status in lumbar spine fusion, malnourishment was associated with increased risk of mortality, infection, and wound dehiscence. Prior studies have attempted to use preoperative albumin levels of less than 3.5 g/dL as a surrogate for malnutrition in assessing adverse outcomes.[10,11] However, previous studies have questioned its efficacy as a marker because hypoalbuminemia may be more indicative of inflammation or hydration status.[10,12] Given that PCD/F is commonly performed in elderly individuals, the Geriatric Nutritional Risk Index (GNRI) may be helpful in the evaluation of preoperative nutrition in these patients. The calculation of this index can be easily obtained, as described by Bouillanne et al; it considers the height and weight of a patient alongside albumin levels to mitigate confounding variables such as hydration status.[10] In adjusting for these variables, it also accounts for overweight/obese patients who may be paradoxically malnourished, as this is a common phenomenon seen in elderly patients.[13] GNRI has been proven as an efficacious prognostic factor in cancer patients undergoing curative surgery.[14–16]

Other orthopedic procedures have been analyzed using this metric, including total hip and knee arthroplasty.[7] To the author's knowledge, no study has examined the association between GNRI and outcomes following PCD/F. The purpose of this study was to assess whether malnutrition status, as measured by the GNRI, has validity as an independent risk factor of adverse outcomes following PCD/F.

METHODS

Since this study only used deidentified data from a national database, institutional review board approval was deemed not required as per the authors' institutional guidelines.

Patient Selection

The 2006 to 2018 American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) Database was queried for patients aged >65 years who underwent PCD/F using current procedural terminology codes (Table 1). Single- and multilevel procedures are indicated in the table. Patients who had missing preoperative albumin values, height, or weight were excluded from the study. Patients with current pneumonia or American Society of Anesthesiologists (ASA) classification greater than 4 were excluded.

Table 1. CPT codes for posterior cervical decompression with or without fusion.

Code	Description
22600	Arthrodesis, posterior or posterolateral technique, single level
63001	Laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, 1 or 2 vertebral segments
63015	Laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, 2 or more vertebral segments
63035	Laminotomy of one cervical interspace with decompression of the nerve root(s)
63040	Laminotomy of each additional cervical or lumbar interspace with decompression of the nerve root(s)
63043	Laminotomy of each additional cervical interspace with decompression of the nerve root(s)
63045	Single cervical vertebral laminectomy, facetectomy, and foraminotomy
63050	Laminoplasty with decompression of the spinal cord and includes 2 vertebral segments
63051	Cervical laminoplasty with decompression of the spinal cord and includes 2 or more vertebral segments with reconstruction of the posterior bony elements
63275	Laminectomy for biopsy/excision of intraspinal neoplasm

Abbreviation: CPT, Current Procedural Terminology.

Variable Definitions

Preoperative data included age, body mass index (BMI), gender, race/ethnicity (Caucasian, African American, Hispanic, and other), admission status (inpatient or outpatient), ASA classification, serum albumin levels, levels of repair (single or multiple), and preoperative comorbidities, such as smoking history (within 1 year of surgery), diabetes (noninsulin-dependent diabetes mellitus or insulin-dependent diabetes mellitus), chronic obstructive pulmonary disease (COPD; ≤30 days prior to surgery), dyspnea (≤30 days prior to surgery), ventilator dependence (≤48 hours prior to surgery), history of congestive heart failure (≤30 days prior to surgery), prior cardiac intervention (PCI), myocardial infarction, previous cardiac surgery, acute renal failure (≤24 hours prior to surgery) or dialysis (≤2 weeks prior to operation), hypertension requiring medication (≤30 days prior to surgery), history of cerebrovascular accident/transient ischemic attack, hemiplegia/quadriplegia/paraplegia, steroid use, >10% weight loss within the past 6 months, disseminated cancer, and cases done as emergency status. ASA classifications were stratified into a high- (ASA > 3) and low-risk category (ASA < 3). ASA has been used to report postoperative outcomes following a variety of orthopedic and neurological surgeries.[17,18] The surgical subspecialty of the attending physician was also recorded.

The primary outcomes evaluated included death, unplanned reoperation, sepsis/septic shock, extended length of stay (eLOS), and other minor complications, such as SSI, wound disruption, urinary tract infection, and intraoperative transfusion. eLOS was defined as a hospital stay greater than the 75th percentile (5 days). The ACS-NSQIP database tracks patients through 30 days postoperatively, so only developments within this time frame are recorded.

Geriatric Nutritional Risk Index

The GNRI was extrapolated from variables collected by ACS-NSQIP, including sex, weight (kg), height (cm), and preoperative albumin. GNRI was calculated using the formula outlined in Bouillanne et al: GNRI = (1.489 × serum albumin) + (41.7 × [weight/WLo]).

WLo is the ideal weight calculated by the Lorentz formula based on gender: WLo,men = height − 100 − (height − 150/4) and WLo,women = height − 100 − (height − 150/2.5). The weight/WLo ratio was capped at 1 for patients with weight exceeding ideal weight, as to not miss overweight/obese patients who may be malnourished.[10] Nutritional status was categorized as normal (GNRI >98), moderately malnourished (GNRI 92–98), or severely malnourished (GNRI <92).

Statistical Methods

Descriptive statistics of demographics, comorbidities, preoperative details, and postoperative complications were assessed using univariate Pearson χ^2 goodness-of-fit tests to determine distributional differences in nutritional status. Age and BMI were analyzed via the Kruskal–Wallis test due to there being a non-normal distribution when stratified by nutrition status. Preoperative variables that were significant at $P < 0.05$ in the χ^2 analysis were advanced to the univariate binary regression analysis to assess individual associations with each individual postoperative complication of interest. $P < 0.05$ in univariate binary regression advanced preoperative variables to multivariate binary regression models to assess whether they were independent risk factors of complications after PCD/F (Supplemental Tables 1-3). Emergency cases were not advanced to the multivariate analysis. $P < 0.05$ was considered statistically significant. This model was used to determine the strength of nutritional status as a risk factor of adverse outcomes following PCD/F. All ORs were reported with a 95% CI. Multiple comparison adjustments were made via Bonferroni correction ($n = 3$; $\alpha = 0.017$) for multivariate analysis. All analyses were performed using IBM SPSS v28 (IBM; Armonk, NY).

RESULTS

Overall, 7597 patients who underwent PCD/F were included in the final analysis. The demographic and comorbidity characteristics are summarized in Table 2. Of these patients, 4961 (65.3%) had a normal (GNRI > 98) nourishment status, 1452 (19.1%) were moderately malnourished (GNRI 92–98), and 1184 (15.6%) were severely malnourished (GNRI < 92).

All baseline demographics, other than gender, differed among groups. All comorbidities, other than hypertension requiring medication, PCI, and previous cardiac surgery, differed among groups. The variables PCI and previous cardiac surgery were missing for most patients ($n = 7069$). Approximately one-fifth of patients with normal albumin (>3.5 g/dL) fell into the category of moderate or severe malnourishment. Surgical subspecialty, albumin levels, ASA classification, and levels of repair all differed among groups. All significant variables at $P < 0.05$ were advanced to binary regression analyses.

Univariate analysis of postoperative complications showed that death ($P < 0.001$), unplanned reoperation ($P < 0.001$), sepsis ($P < 0.001$), SSI ($P = 0.027$), urinary tract infection ($P < 0.001$), intraoperative transfusion ($P < 0.001$), and eLOS ($P < 0.001$) were significantly associated with malnutrition status (Table 3). Mortality, sepsis, and infection were advanced to multivariate analysis due to clinical relevance. Three hundred thirty-three patients (4.4%) were emergency (nonelective) cases and excluded from multivariate analysis.

Upon adjusted multivariate regression analysis, moderate and severe malnourishment were found to be independent risk factors of mortality (OR = 1.762, 95% CI 1.074–2.888, $P = 0.011$; OR = 3.332, 95% CI 2.145–5.177, $P < 0.001$). An age of 81+ years was an independent risk factor for mortality (OR = 2.007, 95% CI 1.332–3.024, $P < 0.001$). Ventilator dependence was an independent risk factor for mortality (OR = 4.665, 95% CI 2.243–9.703, $P < 0.001$). COPD was associated with mortality (OR = 1.385, 95% CI 0.803–2.387, $P = 0.242$). These findings are displayed in Figure 1. More information on preoperative factors associated with mortality are shown in Supplemental Table 1.

Upon adjusted multivariate regression analysis, only severe malnourishment was found to be an independent risk factor for sepsis/septic shock (OR = 3.448, 95% CI 2.402–4.948, $P < 0.001$). Moderate malnourishment was associated with sepsis/septic shock (OR = 1.253, 95% CI 0.807–1.944, $P = 0.314$). An age of 81+ years was associated with sepsis/septic shock (OR = 1.244, 95% CI 0.850–1.820, $P = 0.262$). Ventilator dependence was an independent risk factor for sepsis/septic shock (OR = 6.880, 95% CI 3.761–12.585, $P < 0.001$). COPD was associated with sepsis/septic shock (OR = 1.642, 95% CI 1.028–2.621, $P = 0.038$). These findings are displayed in Figure 2. More information on preoperative factors associated with sepsis/septic shock are shown in Supplemental Table 2.

Upon adjusted multivariate analysis, moderate and severe malnourishment were found to be associated with SSI (OR = 1.218, 95% CI 0.825–1.799, $P = 0.321$; OR = 1.542, 95% CI 1.033–2.304, $P = 0.034$). Ventilator

Table 2. Patient demographic, comorbidity, and preoperative characteristics in American College of Surgeons National Surgical Quality Improvement Program patients undergoing posterior cervical decompression with or without fusion.

Variable	Normal (GNRI >98)	Moderately Malnourished (GNRI 92–98)	Severely Malnourished (GNRI <92)	*P*
Age, y, median (IQR)	72 (68–76)	73 (68–79)	74 (69–80)	**<0.001**
BMI, kg/m^2, median (IQR)	28.7 (25.5–32.4)	28.3 (24.7–32.5)	26.3 (22.1–31.3)	**<0.001**
Gender				
Male	2900 (58.5%)	820 (56.5%)	685 (57.9%)	0.402
Female	2061 (41.5%)	632 (43.5%)	499 (42.1%)	
BMI cohorts, kg/m^2				
Underweight (<18.5)	24 (0.5%)	34 (2.3%)	79 (6.7%)	**<0.001**
Normal weight (18.5–24.9)	1042 (21.0%)	359 (24.7%)	410 (34.6%)	
Overweight (25.0–29.9)	1908 (38.5%)	491 (33.8%)	350 (29.6%)	
Obese (>30.0)	1987 (40.1%)	568 (39.1%)	345 (29.1%)	
Age cohorts, y				
65–81	4367 (88.0%)	1189 (81.9%)	906 (76.5%)	**<0.001**
81+	594 (12.0%)	263 (18.1%)	278 (23.5%)	
Race				
White	3821 (81.7%)	1030 (76.4%)	753 (70.8%)	**<0.001**
Black	446 (9.0)	185 (12.8)	184 (15.6)	
Hispanic	412 (8.3)	133 (9.2)	127 (10.2)	
Other	277 (5.6)	102 (7.0)	118 (10.0)	
Admission status				
Inpatient	4202 (84.7%)	1290 (88.8%)	1135 (95.9%)	**<0.001**
Outpatient	759 (15.3%)	162 (11.2%)	49 (4.1%)	
Comorbidities				
Smoking history	525 (10.6%)	210 (14.5%)	192 (16.2%)	**<0.001**
Diabetes mellitus	1315 (26.5)	429 (29.5)	350 (29.6)	0.018
Hypertension requiring medication	3660 (73.8%)	1102 (75.9%)	872 (73.6%)	0.243
Cerebrovascular accident/transient ischemic attack	34 (0.7%)	14 (1.0%)	18 (1.5%)	0.019
Hemiplegia/quadraplegia/paraplegia	33 (0.7%)	19 (1.3%)	24 (2.0%)	**<0.001**
Steroid use	275 (5.5%)	126 (8.7%)	128 (10.8%)	**<0.001**
>10% weight loss within past 6 mo	28 (0.6%)	20 (1.4%)	50 (4.2%)	**<0.001**
Disseminated cancer	102 (2.1%)	45 (3.1%)	95 (8.0%)	**<0.001**
Pulmonary comorbidity	583 (11.8%)	246 (16.9%)	218 (18.4%)	**<0.001**
Dyspnea	357 (7.2)	135 (9.3)	96 (8.1)	**0.027**
Ventilator dependent	7 (0.1)	13 (0.9)	47 (4.0)	**<0.001**
Chronic obstructive pulmonary disease	322 (6.5)	143 (9.8)	116 (9.8)	**<0.001**
Cardiac comorbidity	108 (2.2%)	40 (2.8%)	46 (3.9%)	**0.003**
Congestive heart failure	36 (0.7)	24 (1.7)	36 (3.0)	**<0.001**
Prior cardiac intervention	44 (!2.4)	10 (10.8)	7 (8.9)	0.655
Previous cardiac surgery	40 (11.2)	9 (9.7)	7 (8.9)	0.784
Renal comorbidity	21 (0.4%)	25 (1.7%)	61 (5.2%)	**<0.001**
Renal failure	2 (0.0)	3 (0.2)	14 (1.2)	**<0.001**
On dialysis	20 (0.4)	24 (1.7)	57 (4.8)	**<0.001**
ASA class > 3	3476 (70.1%)	1164 (80.2%)	1094 (92.3%)	**<0.001**
Surgical specialty				
Orthopedic surgery	1464 (29.5%)	397 (27.3%)	268 (22.6%)	**0.002**
Neurosurgery	3479 (70.1%)	1049 (72.2%)	914 (77.2%)	
Other subspecialty	26 (0.4%)	6 (0.5%)	2 (0.2%)	
Albumin (g/dL)				
<3.5	0 (0.0%)	217 (14.9%)	1094 (92.4%)	**<0.001**
3.5–3.79	0 (0.0%)	1127 (77.6%)	70 (5.9%)	
≥3.8	4961 (100.0%)	108 (7.4%)	20 (1.7%)	
ASA classification				
1	22 (0.4)	3 (0.2)	3 (0.3)	**<0.001**
2	1459 (29.4)	285 (19.6)	86 (7.3)	
3	3188 (64.3)	974 (67.1)	756 (64.0)	
4	288 (5.8)	190 (13.1)	338 (28.5)	
5	0 (0.0)	0 (0.0)	0 (0.0)	
Levels of repair				
Single	4015 (80.5)	1127 (77.6)	897 (75.8)	**<0.001**
Multiple	946 (19.1)	325 (22.4)	287 (24.2)	

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; GNRI, geriatric nutritional risk index; IQR, interquartile range.
Note: Data presented as *n* (%) unless otherwise indicated. *P* values in boldface indicate statistically significant comparisons.

dependence was associated with SSI (OR = 2.166, 95% CI 0.761–6.164, *P* = 0.148). COPD was associated with SSI (OR = 1.664, 95% CI 1.043–2.655, *P* = 0.033). These findings are displayed in Figure 3. More

Table 3. Unadjusted 30-d postoperative outcomes in American College of Surgeons National Surgical Quality Improvement Program patients undergoing posterior cervical decompression with or without fusion.

Variable	Normal	Moderate	Severe	*P*
Any postoperative complication	700 (14.1%)	304 (20.9%)	415 (35.1%)	**<0.001**
Death	45 (0.9%)	35 (2.4%)	82 (6.9%)	**<0.001**
Return to operating room	180 (3.6%)	71 (4.9%)	92 (7.8%)	**<0.001**
Sepsis/septic shock	69 (1.4%)	31 (2.1%)	83 (7.0%)	**<0.001**
Minor complication	507 (10.2%)	206 (14.2%)	288 (24.3%)	**<0.001**
Surgical site infection	97 (2.0%)	36 (2.5%)	38 (3.2%)	**0.027**
Wound disruption	31 (0.6%)	13 (0.9%)	7 (0.6%)	0.505
Urinary tract infection	131 (2.6%)	53 (3.7%)	62 (5.2%)	**<0.001**
Intraoperative transfusion	293 (5.9%)	130 (9.0%)	212 (17.9%)	**<0.001**
Extended length of stay (≥5 d)	1213 (24.5%)	532 (36.6%)	693 (58.5%)	**<0.001**

Note: P values in boldface indicate statistically significant comparisons.

information on preoperative factors associated with SSI are shown in Supplemental Table 3.

Table 4 summarizes the continuous association of GNRI, albumin (g/L), age, and BMI on each outcome assessed. A decrease of one unit in GNRI and albumin are both associated with increased risk of mortality, sepsis/septic shock, and SSI. Every 1-year increase in age is associated with increased risk of mortality and protective in SSI. Every 1 unit decrease in BMI is associated with increased risk of SSI.

DISCUSSION

The reduction of postoperative complications is essential to limiting readmissions, improving overall patient satisfaction, and limiting the costs imposed on both the patient and health care system.[19] Especially in the typical population undergoing posterior cervical procedures, employing a robust preoperative evaluation can guide perioperative care, which, in turn, will optimize outcomes.[20] Previous studies in orthopedics have examined the impact of malnutrition status on perioperative and postoperative outcomes after total hip arthroplasty and elective lumbar spine surgery, stating that elderly, malnourished patients are at an increased risk of infection and eLOS.[21,22] However, no study has been conducted on the use of GNRI and its association with adverse outcomes in PCD/F despite the increase in frequency of such procedures. Given this paucity in the literature, we performed a retrospective study on 7597 individuals using the ACS-NSQIP database. The prevalence of malnutrition, defined as a GNRI <98 was approximately 34.7%. This figure is similar to other studies with a similar sample size that found the prevalence of malnutrition to be between 25.1% and 37.6% in patients undergoing similar spinal decompression or laminectomy procedures.[23–25] In our study, we found

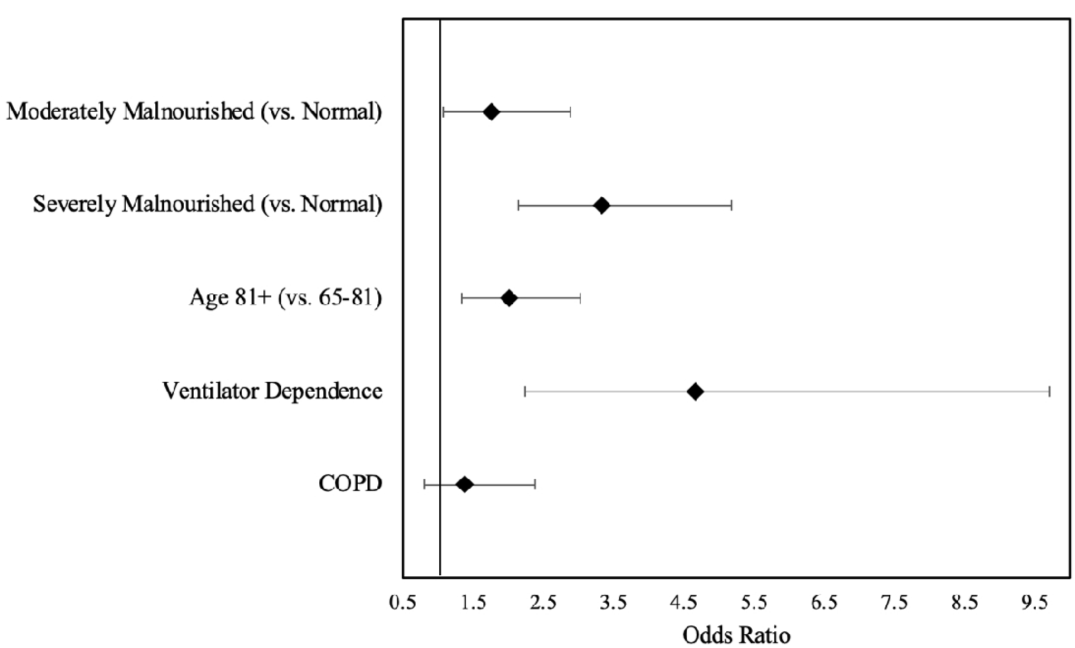

Figure 1. Adjusted odds ratios of mortality for selected preoperative risk factors. Age is given in years. COPD, chronic obstructive pulmonary disease.

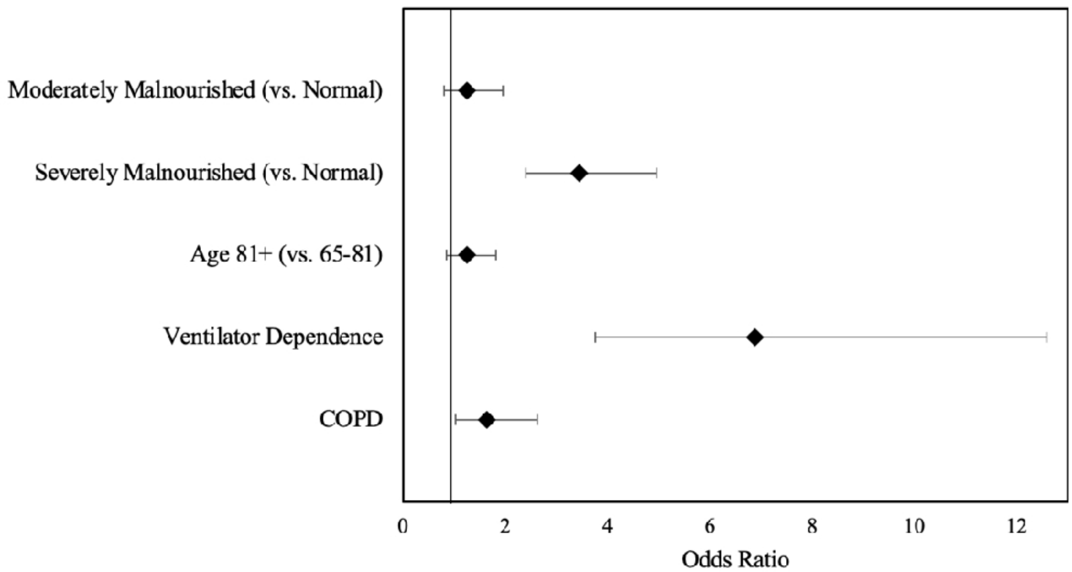

Figure 2. Adjusted odds ratio of sepsis/septic shock for selected preoperative risk factors. Age is given in years. COPD, chronic obstructive pulmonary disease.

that malnutrition (as defined by GNRI) is an independent risk factor for mortality, sepsis, and SSI.

According to Hussain et al, preoperative hypoalbuminemia (<3.5 g/dL), as a surrogate for malnutrition, is an independent risk factor of mortality, sepsis, and transfusion in patients undergoing any spinal decompression procedure.[23] Similarly, we found that incremental decreases in albumin levels (g/L) are continuously associated with mortality. Especially in the elderly, malnutrition increases both mortality and infection rates in spinal fusion procedures.[26] Given that PCD/F is frequently performed in the elderly, GNRI can be an efficacious prognostic tool for this procedure, as it has proven to be for others. Upon categorical (moderate or severe GNRI) and continuous (for every one decrease in GNRI) assessment, we found that lower GNRI levels are associated with adverse outcomes in the elderly. By incorporating GNRI in the evaluation of malnutrition, we were able to incorporate a larger subset of the population into the malnutrition category despite having a normal albumin level, as evidenced in Table 2. When comparing ORs to those of well-established drivers of adverse outcomes following spine surgery, such as COPD, ventilator dependence, or increased age, moderate/severe malnutrition by the GNRI was more

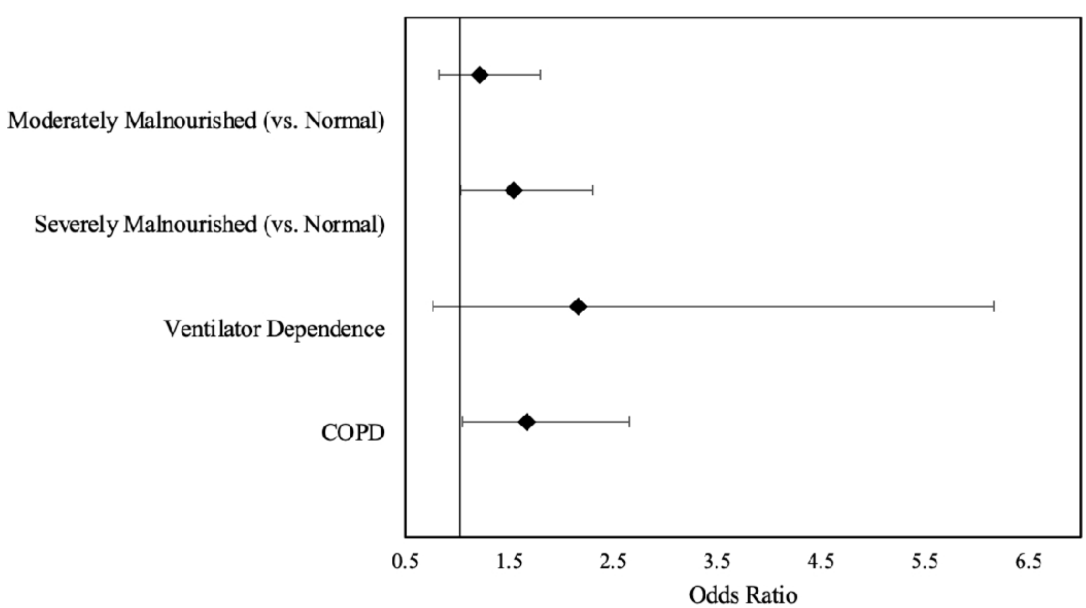

Figure 3. Adjusted odds ratios of surgical site infection for selected preoperative risk factors. COPD, chronic obstructive pulmonary disease.

Table 4. Results of adjusted, multivariate regression analysis for continuous variables.

Outcome	Death			Sepsis			Surgical Site Infection		
Factor	OR	95% CI	*P*	OR	95% CI	*P*	OR	95% CI	*P*
For every one decrease in geriatric nutritional risk index	1.058	1.038–1.078	**<0.001**	1.058	1.042–1.075	**<0.001**	1.021	1.004–1.041	**0.016**
For every one decrease in albumin (g/L)	1.086	1.056–1.117	**<0.001**	1.091	1.066–1.186	**<0.001**	1.032	1.004–1.060	**0.023**
For every one increase in age (y)	1.061	1.033–1.089	**<0.001**	1.007	0.984–1.031	0.536	0.970	0.944–0.996	**0.022**
For every one decrease in body mass index	0.989	0.961–1.019	0.475	0.998	0.978–1.003	0.612	1.032	1.008–1.056	**0.008**

Note: P values in boldface indicate statistically significant comparisons.

consistent as an independent risk factor for mortality in our study.[27–29] Given the increasing number of indications for undergoing an elective spine procedure and higher incidence of revision surgery, future interventional models that include malnutrition as part of the preoperative risk assessment for mortality are needed to ensure better prognostication.[30,31]

Malik et al determined that COPD is an independent predictor of adverse postoperative complications following anterior lumbar discectomy and fusion, namely infection.[28] Ventilator dependence prior to spinal surgery has been well established to lead to poorer outcomes in patients, namely sepsis and infection.[27,32] For this reason, we deemed it appropriate to contrast malnourishment (as defined by GNRI) to previously established predictors of poor outcomes in spine procedures. We found that malnourished patients were at an increased risk of developing SSI and sepsis. In fact, severe malnutrition was an independent risk factor for sepsis. Given that the current paradigm of malnutrition assessment includes laboratory parameters, including glucose, electrolytes, albumin, and liver tests, the institution of such a robust and convenient index can help decrease the burden of SSI.[33] Support from other GNRI studies conducted on orthopedics procedures lends support to its efficacy as a screening tool.[34,35] Rigorous prophylactic measures perioperatively, such as home chlorhexidine showers, preoperative nasal screenings, and intrawound antibiotic powder, might be justified in patient subsets that have multiple risk factors for such infectious complications. In patients without time-sensitive indications for surgery, delaying the procedure and obtaining preoperative nutritional consultation and optimization may be appropriate.

Some medical disciplines still consider BMI as a prognostic marker for malnutrition.[36] However, we found that decreasing BMI did not have as strong of an association for mortality and sepsis as GNRI or albumin levels, as evidenced in Table 4. It was, on the other hand, an independent risk factor for infection. In a similar NSQIP study on cervical spine surgery, Otteson et al uncovered that both underweight and morbidly obese patients had similar rates of sepsis and infection.[37] While underweight patients generally had higher likelihoods of falling into the severely malnourished category, 11.89% of all obese patients were malnourished in our study population. Previous prognostic models that only use BMI may discount obese, malnourished patients, but it is paramont to consider this population. A previous survey discovered that malnourishment percentile is 49.7% for elderly people whose BMI is higher than 25.[13] Due to GNRI incorporating both patient height, weight, and serum albumin values, it has a greater ability to identify malnourished patients across all body compositions.

Strengths of this study include the large patient population (>7500) as afforded by large database studies of this nature. Additionally, the ease of the GNRI as an index, using laboratory values that are typically obtained, allowed for a robust analysis. However, certain limitations to this study include the short-term nature of the data recorded. NSQIP only collects postoperative outcome data up to 30 days after discharge. Therefore, complications such as delayed infection, reoperation for pseudarthrosis, implant failure, and adjacent segment/junctional breakdown or instability would not be captured. Additionally, the data were limited to patients who had albumin, height, and weight recorded, eliminating a subset of people in whom these values were not obtained. We excluded emergency cases because surgery in this setting could be a potential confounder in this study. On that same note, there are likely inherent biases and confounding variables in the data for which we cannot account and are likely concurrently influencing some outcomes. For example, disseminated cancer and renal comorbidities may contribute to malnutrition as well as other physiological burdens that may collectively predispose to complications. Similarly, we were limited to the conditions captured by NSQIP, so other premorbid conditions that we could not account for may have influenced our findings. Last, data regarding postoperative protocols and intraoperative techniques were not available, and these too may influence postoperative outcomes.

CONCLUSION

In elderly patients undergoing PCD/F, severe malnutrition, as defined by the GNRI, was an independent risk factor for adverse outcomes such as mortality and sepsis/septic shock. Additionally, since it accounts for confounding factors commonly seen in the elderly, such as dehydration and paradoxical malnutrition in obesity, the GNRI may be more useful than other employed measures. Given its simplicity as a screening tool, the GNRI can be used as a further risk stratification tool in patients undergoing PCD/F. Further study on strategies to address nutritional disorders in patients requiring surgery is necessary to help improve outcomes.

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