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Malnutrition in orthopaedic trauma outcomes (MOTO): orthopedic trauma patients can be effectively screened and stratified for risk of malnutrition using prealbumin. A preliminary outcome study

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Abstract

Objectives: To evaluate prealbumin (PAB) as a prognostic indicator for early detection of malnutrition risk upon admission and its correlation with in-hospital complications and length of stay (LOS) in patients with orthopedic trauma.

Methods:

Design: Retrospective cohort.

Setting: Urban academic Level 1 trauma center.

Patients/Participants: One hundred fifty-eight patients aged 18 years or older with acute traumatic fractures indicated for primary surgical fixation between 2019 and 2022 were included. Serum laboratory tests consisting of PAB, C-reactive protein, complete blood counts, and complete metabolic panel were obtained within 24 hours of arrival.

Outcome Measures and Comparisons: Primary outcome measures included characterization of patient risk factors for increased intensive care unit LOS, hospital LOS, and in-hospital complications. Secondary outcome measures included characterization of patients who were stratified as "at risk" for malnutrition by PAB < 20 mg/dL and identification of complication predictors.

Results: Fifty-one (32%) patients were stratified as "at risk" for malnutrition based on serum PAB < 20 mg/dL drawn within 24 hours of arrival. These patients had longer median hospital LOS ($P < 0.001$), were more likely to stay in the hospital longer than 7 days ($P < 0.009$) and >14 days (OR $= 3.20$, 95% CI 1.17–9.07, $P < 0.001$), and had twice the amount of postoperative complications during their hospital stay ($P = 0.04$) than patients with PAB ≥ 20 mg/dL.

Conclusions: Patients with orthopaedic trauma can reliably and cost-effectively be screened and stratified for risk of malnutrition using PAB drawn with immediate admission labs.

Level of Evidence: Level III.

Keywords: orthopaedic trauma, nutrition, biomarkers, fracture complications, prealbumin, C-reactive protein, injury severity score, malnutrition

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1. Introduction

1.1. Background/Rationale

Patients with orthopaedic trauma are more likely than the general orthopaedic population to experience the negative consequences associated with nutritional deficiencies due to the inflammatory nature of their injuries.[1–3] Malnutrition in this special population can be further characterized by the amount of inflammation present in the setting of acute injury as there is a strong association between inflammation and malnutrition.[4,5] After major trauma, normal metabolic pathways are rerouted during the acute phase response to synthesize more inflammatory reactants at the expense of protein use for normal physiological activities. Furthermore, the intensive treatment and prolonged immobilization needed to manage these patients catapults them into a catabolic state which may further deplete nutrition stores, decrease immune function, and lengthen hospital stay.[6,7] In patients with orthopaedic trauma, malnutrition has been shown to increase the risk of postoperative complications including impaired wound healing, wound infections, new-onset delirium, deep vein thrombosis, and fracture nonunion.[1,8–15]

There is a growing body of literature supporting the advantages of nutritional supplementation in hospitalized patients[5,16] and recently in patients with orthopaedic trauma. In a recent 2022 randomized controlled trial, Hendrickson et al[17] compared the impacts of postoperative nutritional supplementation with conditionally essential amino acid (CEAA) in patients with orthopaedic trauma requiring operative fixation and found that supplemented patients achieved better clinical outcomes including lower rates of overall complications, skeletal muscle wasting, nonunion, and mortality. Despite evidence to suggest that nutritional intervention can have protective effects against the risks of malnutrition, many cases go unrecognized and untreated.[18]

The current gold standard for diagnosing malnutrition involves a thorough clinical nutrition screening and assessment by a registered dietitian.[19] However, this method can be challenging in polytraumatized patients.[20] Biomarkers of nutrition such as albumin and prealbumin (PAB) are frequently used by physicians as easily measurable screening tools, although their prognostic accuracy in orthopedic trauma has not been well established.[3,19,21] Albumin, with an average half-life of 20 days, is an ideal marker for long-term nutrition status and is currently used as a screening biomarker in elective surgical patients.[4] PAB, with a half-life of approximately 2 days, is an appealing marker to monitor acute changes in nutritional status,[6] and is less commonly used for routine screening, though it has proven useful in monitoring nutritional status in trauma, patients having elective orthopedic procedures, and patients living with diabetes or cancer.[22–24] Owing to the rapid response of PAB to changes in nutrition and activation of the inflammatory cascade, PAB levels must be collected as early as possible to accurately direct decision-making in the acute trauma setting.[25]

1.2. Objectives

The primary objective of this study was to assess serum PAB on arrival as a means of identifying patients at risk of malnutrition, defined as PAB $<$ 20 mg/dL, and to examine the relationship between malnutrition risk, in-hospital complications, and hospital length of stay (LOS). The secondary objective was to assess trends in clinical outcomes among other biomarkers collected on admission and patient demographics. We hypothesized that orthopedic trauma patients at risk of malnutrition will present with a higher preexisting level of inflammation, will have a longer hospital LOS, and increased in-hospital complications.

2. Methods

The sample consisted of adult patients (18 years or older) admitted to our institution by orthopedic trauma, general trauma, or internal medicine services for acute orthopaedic injuries consisting of pelvic and appendicular fractures proximal to the carpals requiring operative fixation. The need for surgery was determined before admission and screening. Initial data were obtained during a resident-conducted study between November 2019 and July 2022, with 2 of the coauthors prospectively enrolling patients based on their eligibility and maintaining a database of those enrolled. Institutional review board protocols were followed, informed consents were obtained from human subjects as required, and all approvals were obtained before the start of this study. All included patients had PAB, C-reactive protein (CRP), complete blood count, and complete metabolic panel values drawn within 24 hours of arrival at our facility as part of a standardized protocol. The 2 cohorts were defined as "at risk" for malnutrition by serum PAB $<$ 20 mg/dL and "appropriately nourished" by PAB $\geq$ 20 mg/dL. Varying normal reference values for PAB have been reported in the literature with the lower limit of normal ranging from 10 mg/dL to 20 mg/dL. There is no established laboratory threshold or cutoff for assessing malnutrition risk in the orthopaedic trauma literature.[26] We used 20 mg/dL for our lower limit of normal because this is the most commonly accepted reference value in surgical, biochemical, and nutrition research.[8,27–34] Reasons for exclusion included medical comorbidities known to alter protein levels including cirrhosis of the liver, active cancer, and active infection upon admission. Patients were also excluded if they were transferred from another facility, presented with an injury that occurred $>$24 hours before arrival at the trauma center, or either elected to trial nonoperative management or were unable to undergo surgery physiologically. Electronic medical records (EMR) were reviewed for all patients that met eligibility criteria, and variables of interest were collected from the duration of their hospital stay until discharge or death.

Patient data including age, sex, body mass index (BMI), current smoking status, baseline laboratory data, injury details, operative procedures, total hospital LOS in days, and postoperative inpatient complications were obtained from the EMR. Medical history was used to calculate the Charlson Comorbidity Index (CCI) for each patient. Injury Severity Score (ISS) and intensive care unit (ICU) LOS in days were obtained from an institutional trauma database. Injury type was separated into 3 categories: 1. fragility fracture (defined as an isolated injury pattern, low-energy event, and older than 65 years), 2. polytrauma (defined as a high-energy event with multiple injuries), and 3. open fracture. Injury locations included upper extremity, lower extremity, and pelvis. Complications included any unexpected yet significant surgical or medical conditions that were encountered while inpatient post-operatively and identified in the patient's chart. Hospital LOS was considered continuously and categorically with cutoffs at greater than 7 and 14 days. Laboratory variables of interest included initial PAB (mg/dL), albumin (g/dL), CRP (mg/dL), platelet count ($\times 10^3/\mu$L), and absolute lymphocyte count ($\times 10^3/\mu$L). All laboratory data were reported continuously other than PAB, which was considered continuously and categorically with a cutoff of $\geq$20 mg/dL or $<$20 mg/dL. Trauma was defined as an

unexpected injury involving 1 or more extremities or major skeletal structures.[10] Sample size was determined based on maintaining a 10:1 ratio of total sample size to the number of independent variables assessed or 150 subjects in this case.

Univariable analyses were performed for each independent variable to assess crude differences among PAB $<$ 20 mg/dL and PAB $\geq$ 20 mg/dL groups. The Mann–Whitney *U* test was used to compare the medians of nonparametric continuous variables while the Fisher exact test was used to compare nonparametric categorical variables. Multivariable regression models were determined via two-directional stepwise multiple linear regression for continuous dependent variables and multiple logistic regression for binary categorical variables. Ratios of ISS to PAB, CRP to PAB, ISS to CRP, and platelet count to absolute lymphocyte count (PLR) were included in multivariable analyses, all of which were reported continuously other than PLR, which was explored categorically with cutoffs at 85 and 180.[35,36] Imputation was used for missing data but only for secondary outcome measures, using the kth nearest neighbor approach, with $k = 5$. A natural logarithm was used to transform skewed variables of hospital LOS and ICU LOS to normalize the distribution of the data. ISS and injury type were never considered together in the same regression model due to the dependence of ISS on injury type. All analyses were performed in R Studio 2022.07.1 Build 554 (RStudio, PBC, Boston, MA). In all models, a significance level of $\alpha = 0.05$ was used to determine statistical significance, and 95% confidence intervals were calculated.

3. Results

A total of 220 potentially eligible patients were identified in the database. Patient selection criteria are shown in Figure 1. A total of 158 patients with 257 injuries met eligibility criteria and were included for analysis. Sixty-five percent of injuries (n = 167) involved the lower extremities, 22.6% included the upper extremities (n = 58), and 12.5% were pelvic injuries (n = 32).

The patients were then further stratified into 2 cohorts, "well-nourished (PAB $\geq$ 20 mg/dL) and "at risk" for malnutrition (PAB $<$ 20 mg/dL).

3.1. Patient Characteristics Between Cohorts (Prealbumin $<$ 20 mg/dL vs. Prealbumin $\geq$ 20 mg/dL)

Patient characteristics by study cohort and in total are displayed in Table 1. There were 107 patients in the well-nourished group (PAB $\geq$ 20 mg/dL) and 51 (32%) in the "at risk" for malnutrition group (PAB $<$ 20 mg/dL). The median age of the sample was 42 years (interquartile range [IQR] = 32.5), and the majority (n = 93) were male (58.9%). Median ISS was 9 (IQR = 8.3), and median PAB was 22.5 mg/dL (IQR = 8.8) (Table 1). Between the 2 cohorts, there were no significant differences in age ($P = 0.0574$), smoking status ($P = 0.6058$), BMI ($P = 0.6892$), polytraumatic injuries ($P = 0.1324$), and ISS ($P = 0.1141$). The group "at risk" for malnutrition had more females (56.9% vs. 33.6%; $P = 0.0062$), more fragility fractures (25.5% vs. 12.1%, $P = 0.0410$), and more comorbidities (median CCI of 1, IQR = 5.0 vs. median CCI of 0, IQR = 2.0; $P = 0.0349$) than their counterparts. Albumin was lower in the "at risk" of malnutrition group with median and IQR values of 3.3 g/dL and 0.7, respectively, versus 3.9 g/dL and 0.8 in the well-nourished group ($P < 0.0001$); and median CRP was higher in the "at risk" group at 1.0 mg/dL (IQR = 3.7) compared with 0.3 mg/dL (IQR = 0.8) in the well-nourished group ($P = 0.0007$). We did not observe significant differences in platelet ($P = 0.1362$) and absolute lymphocyte counts ($P = 0.2380$).

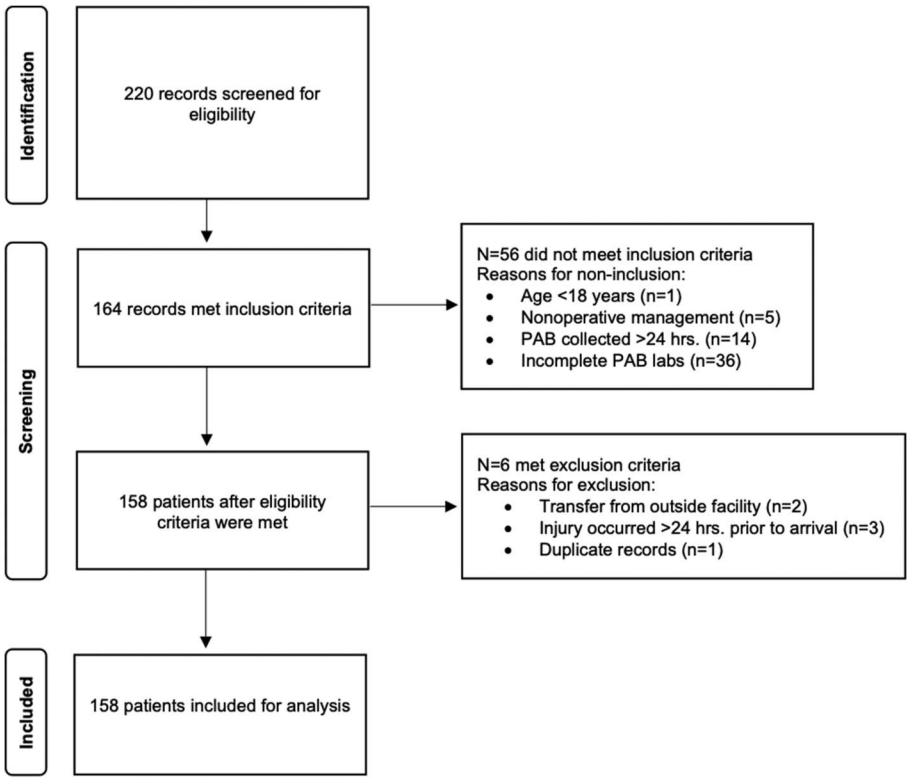

Figure 1. Screening and inclusion of the sample. PAB, prealbumin.

Table 1

Patient characteristics displayed as the total sample and among cohorts of "at risk" of malnutrition (prealbumin < 20) and not malnourished (prealbumin ≥ 20) in orthopedic trauma patients.

Characteristics	Total sample (n = 158)	PAB ≥ 20 group (n = 107)	PAB < 20 group (n = 51)	*P*
Categorical variables expressed as n (%); *P* value calculated with Fisher exact test				
Sex (female)	65 (41.1)	36 (33.6)	29 (56.9)	0.0062*
Smoker (yes/no)	69 (43.7)	49 (45.8)	20 (39.2)	0.6058
Injury type (yes/no)				
Polytrauma	31 (19.6)	17 (15.9)	14 (27.4)	0.1324
Open fracture	35 (22.2)	27 (25.2)	8 (15.7)	0.2208
Fragility	26 (16.5)	13 (12.1)	13 (25.5)	0.0410*
Continuous variables expressed as median (IQR); *P* value calculated with the Mann–Whitney *U* test				
Age (y)	42 (32.5)	38 (31.0)	49 (37.0)	0.0574
BMI (kg/m^2)	26.7 (7.4)	26.8 (6.1)	26.2 (10.3)	0.6892
CCI (count)	0 (3.0)	0 (2.0)	1 (5.0)	0.0349*
ISS (0–75)	9 (8.3)	8 (9.0)	9 (7.0)	0.1141
ALB (g/dL)	3.7 (0.8)	3.9 (0.8)	3.3 (0.7)	<0.0001***
CRP (mg/dL)	0.3 (1.3)	0.3 (0.8)	1.0 (3.7)	0.0007**
PLT (×10^3/μL)	242.5 (100.0)	250 (90.0)	229 (148.0)	0.1362
ALC (×10^3/μL)	2.0 (1.6)	2.0 (1.8)	1.8 (1.6)	0.2380

*$P \leq 0.05$; **$P < 0.01$; ***$P < 0.0001$.
ALB, albumin; ALC, absolute lymphocyte count; BMI, body-mass index; CCI, Charlson Comorbidity Index; CRP, C-reactive protein; IQR, interquartile range; ISS, injury severity score; PAB, prealbumin; PLT, platelet count.

3.2. Risk of Malnutrition, Complications, ICU Admission, and Length of Stay

3.2.1. Complications. Thirty-five postoperative complications occurred in a total of 28 patients (Table 2). The "at risk" of malnutrition group had proportionally twice as many postoperative complications during their hospital stay (27.5% vs. 13.1%, $P = 0.0432$) (Table 3). Female sex (OR = 0.20, 95% confidence interval = 0.05–0.69; $P = 0.0154$), fragility injury (OR = 17.89, 3.86–103.41; $P = 0.0005$), increasing CRP (OR = 1.34, 1.11–1.85; $P = 0.0168$), and ratios of ISS:PAB (OR = 13.09, 4.36–47.80; $P = <0.0001$) and ISS:CRP (OR = 1.01, 1.00–1.01; $P = 0.0033$) were significant independent predictors of complications (Table 4).

3.2.2. Length of Stay. Median (IQR) hospital LOS was significantly higher in the "at risk" of malnutrition group (8.4 [IQR = 15.8] vs. 4.1 [IQR = 6.4] days, $P = 0.0007$), and this group was more likely to stay in the hospital longer than 7 days (54.9% vs. 31.7%, $P = 0.0086$) (Table 3). When looking at the combined influence of multiple variables on LOS: PAB < 20 mg/dL (β = 1.43, 95% confidence interval = 1.09–1.88; $P = 0.0096$), ISS (β = 1.07, 1.06–1.09; $P = <0.0001$), CRP (β = 1.03, 1.01–1.06; $P = 0.0214$), and PLR < 85 (β = 1.58, 1.20–2.07; $P = 0.0014$) were all independent significant predictors of total hospital LOS (Table 5). For hospital LOS exceeding 14 days, PAB < 20 mg/dL (OR = 3.20, 1.17–9.07; $P = 0.0246$) and ISS (OR = 1.16, 1.10–1.24; $P = <0.0001$) were both independent significant predictors adjusting for sex, absolute lymphocyte count, and PLR (Table 6).

Table 2

Postoperative complications of patients with orthopaedic trauma during hospital stay.

Complication type	Total (n = 35)
Sepsis	2 (5.7%)
DVT	6 (17.1%)
Rhabdomyolysis	2 (5.7%)
Pneumonia	6 (17.1%)
Cardiac arrest	2 (5.7%)
Blood loss anemia	4 (11.4%)
Surgical site infection	2 (5.7%)
Stroke/CVA	1 (2.9%)
Delirium	2 (5.7%)
Unplanned intubation	2 (5.7%)
Other	6 (17.1%)

"Other" includes acute kidney injury, urinary tract infection, central line-associated bloodstream infection, postop ileus, small bowel obstruction.
CVA, cerebral vascular accident; DVT, deep vein thrombosis.

3.2.3. ICU Admission. Forty-one patients were admitted to the ICU. ISS (OR = 1.23, 1.15–1.34; $P < 0.0001$) and PLR > 180 (OR = 0.20, 0.04–0.73; $P = 0.0294$) were significant predictors of admission into the ICU (Table 7). Among patients admitted to the ICU, ISS (β = 1.06, 1.03–1.09; $P < 0.0001$) and PAB:CRP (β = 1.001, 1.000–1.002; $P = 0.0092$) were significant independent predictors of ICU LOS (Table 8). Low PAB was not significantly associated with higher ICU LOS ($P = 0.1819$) (Table 3).

4. Discussion

This study aimed to evaluate the use of serum PAB obtained upon patient arrival as a means of identifying those at risk of malnutrition (defined as PAB < 20 mg/dL) and to investigate the relationship between malnutrition risk, in-hospital complications, and hospital LOS. In addition, we analyzed patient demographics to identify risk factors predisposing patients with orthopaedic trauma to malnutrition. Key findings from our analysis revealed that, in patients with orthopaedic trauma, a serum PAB < 20 mg/dL on arrival was predictive of longer hospital LOS and twice the amount of complications during hospitalization compared to appropriately nourished patients. The observed rate of malnutrition risk in our study was 32%, which is within the reported national prevalence of 20%–50%

Table 3

Length of stay and complication rates per cohort of "at risk" for malnutrition (prealbumin < 20) and not malnourished (prealbumin ≥ 20) in patients with orthopaedic trauma.

Characteristic	Total (n = 158)	PAB ≥ 20 group (n = 107)	PAB < 20 group (n = 51)	*P*
Continuous variables expressed as median (IQR); *P* value calculated with the Mann–Whitney *U* test				
LOS (d)	4.9 (8.6)	4.1 (6.4)	8.4 (15.8)	0.0007**
ICU LOS (d)	4.0 (11.0)	4.0 (10.0)	7.0 (18.0)	0.1819
Categorical variables expressed as n (%); *P* value calculated with Fisher exact test				
LOS > 7 (d)	62 (39.2)	34 (31.7)	28 (54.9)	0.0086**
LOS > 14 (d)	34 (21.5)	18 (16.8)	16 (31.2)	0.0610
Complications	28 (17.7)	14 (13.1)	14 (27.5)	0.0432*

*$P \leq 0.05$; **$P < 0.01$; ***$P < 0.0001$.
IQR, interquartile range; LOS, length of stay (d); PAB, prealbumin.

[37–39] and prevalence amongst other recent orthopaedic trauma nutrition research.[2,10] In a recent prospective trial conducted in 2022 by Firoozabadi et al,[2] 41% of patients were identified as malnourished based on admission serum prealbumin levels. Those authors examined the prevalence of malnutrition based on serum nutritional markers in the context of orthopedic injury and tracked nutritional status changes during the hospital stay. Similar to our study, their most notable finding was that patients who experienced complications had significantly lower prealbumin levels on admission. Their analysis also revealed that the patients at risk of malnourishment had increased hospital length of stay, a high mean number of comorbidities, and increased age. These findings closely parallel our observations that the "at risk" for malnutrition group had significantly more comorbidities and a near significant trend towards increasing age compared to their counterparts ($P = 0.0574$). When examining independent predictors of complications in the patients "at risk" of malnutrition in our study, we also found that female sex, fragility injury, and elevated CRP levels were significant predictors. Overall, the findings of this study were consistent with our hypothesis that patients with orthopaedic trauma at risk of malnutrition will present with a higher preexisting level of inflammation, will have a longer hospital LOS, and increased in-hospital complications.

Use of biomarkers such as PAB and albumin for diagnosis of malnutrition is controversial and often misinterpreted. A recent 2020 American Society for Parenteral and Enteral Nutrition (ASPEN) position statement aimed to correct the misconception that these proteins definitively reflect nutritional status. The authors suggested that instead, these biomarkers are closely associated with inflammation and therefore are a single component of a multifactorial nutrition risk assessment.[5] In the setting of orthopedic trauma, where inflammation is the direct outcome of injury and is also a necessary component of fracture healing, we should aim to maintain the appropriate inflammatory response as a desired process in recovery. Current literature in orthopaedic trauma investigating the amount of inflammation that is considered acceptable is scarce.

When evaluating the relationship between inflammation and malnutrition, we observed several trends. There was no significant difference in median ISS between the "at risk" (PAB < 20) and well-nourished (PAB ≥ 20) groups. However, median CRP levels were higher in the "at risk" group and were a significant predictor of complications. When interpreting the CRP results, it is important to note that it is a relative measure. An increase of 1 unit of CRP resulted in an approximate increased odd of complication by a factor of 1.34 (OR = 1.34, 1.11–1.85; $P = 0.0168$) (Table 4). We aimed to explore this relationship by looking at ratios of ISS:PAB and ISS:CRP, both of which were found to be significant predictors of complications. In the "at risk" group, we also noted that a lower ISS:CRP ratio was observed, indicating that the "at risk" patients had a higher presence of inflammation for the same injury severity score as patients in the well-nourished group. These findings further support our hypothesis that, depending on the injury type, the inflammatory response and subsequent outcomes differ based on the host's ability to modulate the inherent inflammation. This effect is especially pronounced if the individual is already in a state of heightened inflammation at the time of injury due to preexisting comorbidities and risk factors.

Our findings align with the position statement of ASPEN.[4] Therefore in conjunction with other orthopaedic trauma and surgical researchers,[2,3,27] we recommend early screening of adult

Table 4

Multivariate logistic regression model to show associations with patient complications in patients with orthopaedic trauma.

Predictor	Odds ratio	95% CI	*P*
Female sex	0.20	0.05 to 0.69	0.0154*
Smoker (yes/no)	2.64	0.78 to 10.30	0.1342
CRP (mg/dL)	1.34	1.11 to 1.85	0.0168*
PLT ($\times 10^3/\mu L$)	0.99	0.99 to 1.00	0.1063
ALC ($\times 10^3/\mu L$)	1.04	1.00 to 1.13	0.1212
Fragility Injury (yes/no)	17.89	3.86 to 103.41	0.0005**
ISS:PAB	13.09	4.36 to 47.80	<0.0001***
CRP:PAB	0.02	0.00 to 0.42	0.0721
ISS:CRP	1.01	1.00 to 1.01	0.0033**

*$P \leq 0.05$; **$P < 0.01$; ***$P < 0.0001$.
ALC, absolute lymphocyte count; CRP, C-reactive protein; ISS, injury severity score; PAB, prealbumin; PLT, platelet count.

Table 5

Multivariate linear regression model to show association with the log of hospital length of stay in patients with orthopaedic trauma.

Predictor	Regression coefficient	95% CI	*P*
Age (y)	1.01	1.00–1.01	0.0541
BMI (kg/m^2)	1.02	0.99–1.06	0.1555
ISS (0–75)	1.07	1.06–1.09	<0.0001***
PAB < 20	1.43	1.09–1.88	0.0096**
CRP (mg/dL)	1.03	1.01–1.06	0.0214*
PLR < 85	1.58	1.20–2.07	0.0014**

*$P \leq 0.05$; **$P < 0.01$; ***$P < 0.0001$.
BMI, body-mass index; CRP, C-reactive protein; ISS, injury severity score; PAB, prealbumin; PLR, platelet-lymphocyte ratio.

Table 6

Multivariate logistic regression model to show association with hospital length of stay exceeding 14 days in patients with orthopaedic trauma.

Predictor	Odds ratio	95% CI	P
Female sex	0.38	0.12–1.06	0.0752
ISS (0–75)	1.16	1.10–1.24	<0.0001***
PAB < 20	3.20	1.17–9.07	0.0246*
ALC ($\times 10^3/\mu L$)	1.05	1.00–1.15	0.1180
PLR < 85	2.07	0.77–5.53	0.1436

*$P \leq 0.05$; **$P < 0.01$; ***$P < 0.0001$.
ALC, absolute lymphocyte count; ISS, injury severity score; PAB, prealbumin; PLR, platelet-lymphocyte ratio.

patients with orthopaedic trauma for risk of malnutrition at time of admission before the reactive inflammatory period to identify those patients at risk for increased complications and longer hospital stay. We recommend using serum PAB as a means of identifying patients who are at high risk of developing clinical malnutrition and poor clinical outcomes if nutritional support is not provided.[4] Performing a serum PAB test could be an easy addition to preoperative laboratory tests when done as a part of a standardized protocol whether it is done as an adjunct to preoperative/admission labs in the emergency department or as initial blood work for patients presenting to the trauma bay. Identification of such patients would allow for early evaluation and intervention by a registered dietitian providing a formal nutrition assessment, education, and possibly nutritional supplementation as needed. Patients often get individualized nutritional care and support in the ICU. However, those patients who either transfer out of critical care or are directly admitted to the general trauma and orthopaedic medical surgical floors would benefit most from appropriate selection for nutritional supplementation as recommended by the registered dietitian. Moreover, early intervention could provide the ability to decrease postoperative complications in patients with orthopaedic trauma by providing CEAA supplementation as demonstrated by Hendrickson et al.[17] Ultimately, enrollment of the adult patient with trauma into an early hospital-based nutrition care program can decrease health care costs by up to 42%.[40]

There are several important limitations that must be addressed. The study design was a retrospective observational analysis, and therefore, temporality and causation cannot be determined. The data were only examined for the duration of the hospital admission, and therefore, long-term outcomes are not provided, and a long-term follow-up analysis is warranted. Ideally, PAB should be monitored throughout the duration of fracture healing until time of union. While we attempt to explain trends in our analysis, the purpose of our research is primarily to highlight the use of PAB for identification of risks rather than diagnosing a condition of malnutrition. Another limitation was selection bias. This was addressed by screening all patients with a serum PAB order during their hospital admission, which was part of a standardized protocol for patients with orthopaedic trauma at our institution. A notable strength of our study is that our institution is located in one of the most racially and ethnically diverse areas in the nation, a minority-majority community with minorities accounting for 62% of the population. Within the research site's service area, roughly 13.5% of patients live below the federal poverty line; a majority lack health insurance and knowledge of how to navigate an often complex health care system. These demographics make our study highly generalizable to the orthopaedic trauma population.

Table 7

Multivariate logistic regression model to show an association with intensive care unit admission in patients with orthopaedic trauma.

Predictor	Odds ratio	95% CI	P
ISS (0–75)	1.23	1.15–1.34	<0.0001***
PLR > 180	0.20	0.04–0.73	0.0294*

*$P \leq 0.05$; **$P < 0.01$; ***$P < 0.0001$.
ISS, injury severity score; PLR, platelet-lymphocyte ratio.

Table 8

Multivariate linear regression model to predict intensive care unit length of stay in patients with orthopaedic trauma.

Predictor	Regression coefficient	95% CI	P
Smoker (yes/no)	0.691	0.419–1.140	0.1427
ISS (0–75)	1.062	1.034–1.091	<0.0001***
ALC ($\times 10^3/\mu L$)	0.786	0.588–1.050	0.1008
PLR < 85	1.522	0.709–3.266	0.2719
PAB:CRP	1.001	1.000–1.002	0.0092**

*$P \leq 0.05$; **$P < 0.01$; ***$P < 0.0001$.
ALC, absolute lymphocyte count; CRP, C-reactive protein; ISS, injury severity score; PAB, prealbumin; PLR, platelet-lymphocyte count.

5. Conclusions

Serum PAB < 20 mg/dL, when obtained within 24 hours of arrival, has promising potential to identify patients "at risk" of malnutrition with levels of preexisting inflammation that may favor catabolic states, and lead to longer hospital LOS and increased in-hospital complications. Screening for risk of malnutrition and preexisting inflammatory states in patients with orthopaedic trauma has the potential to improve patient outcomes and result in decreased hospital costs. Further research is warranted in the orthopaedic trauma population investigating serum biomarkers and whether their prognostic value could be used to guide nutritional interventions and reduce the complications in patients identified as at risk of malnourishment.

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