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Research Article

Pre-Operative Serum Albumin Levels As A Predictor Of Abdominal Wound Complications After Emergency Exploratory Laparotomy

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ABSTRACT

Background: Emergency exploratory laparotomy represents a life-saving intervention associated with significant morbidity, particularly wound-related complications. Hypoalbuminemia has been identified as a potential predictor of adverse surgical outcomes, yet its specific role in predicting abdominal wound complications following emergency laparotomy remains inadequately characterized. This study aimed to evaluate the association between pre-operative serum albumin levels and the occurrence of abdominal wound complications in patients undergoing emergency exploratory laparotomy.

Methods: This retrospective observational study was conducted over 18 months and included 50 patients who underwent emergency exploratory laparotomy. Pre-operative serum albumin levels were measured within 24 hours of surgery. Patients were followed for 30 days post-operatively for wound-related complications including surgical site infection, wound dehiscence, and delayed wound healing. Patients were categorized into hypoalbuminemia (albumin <3.5 g/dL) and normal albumin (≥3.5 g/dL) groups. Statistical analysis included chi-square test, Fisher's exact test, and logistic regression analysis.

Results: Among 50 patients, 28 (56%) had hypoalbuminemia. Overall wound complication rate was 44% (22 patients). Patients with hypoalbuminemia demonstrated significantly higher rates of wound complications compared to those with normal albumin levels (67.9% vs 13.6%, p<0.001). Surgical site infection occurred in 46.4% of hypoalbuminemic patients versus 9.1% of normoalbuminemic patients (p=0.004). Wound dehiscence was observed in 28.6% versus 4.5% respectively (p=0.027). Pre-operative albumin level below 3.5 g/dL emerged as an independent predictor of wound complications with an odds ratio of 8.76 (95% CI: 2.34-32.78, p=0.001).

Conclusion: Pre-operative hypoalbuminemia is strongly associated with increased risk of abdominal wound complications following emergency exploratory laparotomy. Serum albumin measurement represents a simple, cost-effective tool for risk stratification and may guide enhanced peri-operative nutritional support and wound management protocols in high-risk patients.

Keywords*: Serum albumin, hypoalbuminemia, emergency laparotomy, wound complications, surgical site infection, wound dehiscence.*

INTRODUCTION

Emergency exploratory laparotomy represents one of the most common and critical surgical interventions performed in acute care settings, serving as a definitive diagnostic and therapeutic procedure for various life-threatening abdominal pathologies. Despite advances in surgical techniques, anesthetic management, and peri-operative care, emergency

laparotomy continues to be associated with substantial morbidity and mortality rates ranging from 15% to 30%, significantly higher than elective abdominal procedures (1). Among the spectrum of post-operative complications, abdominal wound-related complications including surgical site infections, wound dehiscence, and impaired wound healing represent a significant burden, occurring in 20% to 40% of patients undergoing emergency abdominal surgery (2). These complications not only compromise patient recovery and quality of life but also substantially increase healthcare costs, hospital length of stay, and risk of subsequent morbidity.

The pathophysiology of wound healing is a complex, coordinated biological process involving hemostasis, inflammation, proliferation, and remodeling phases, each requiring adequate protein synthesis, collagen formation, angiogenesis, and immune function. This intricate cascade is profoundly influenced by the patient's nutritional and metabolic status, with protein-energy malnutrition representing a well-established risk factor for impaired wound healing and post-operative complications (3). In the context of emergency surgery, patients frequently present with compromised nutritional status due to acute illness, prolonged symptoms, reduced oral intake, systemic inflammation, or underlying chronic diseases, creating a vulnerable physiological state that predisposes to adverse outcomes.

Serum albumin, the most abundant plasma protein synthesized by the liver, serves multiple critical physiological functions including maintenance of oncotic pressure, transport of hormones and drugs, antioxidant activity, and modulation of inflammatory responses. Beyond its physiological roles, serum albumin has emerged as a valuable biomarker reflecting nutritional status, disease severity, and systemic inflammation. Hypoalbuminemia, typically defined as serum albumin concentration below 3.5 g/dL, results from decreased synthesis secondary to malnutrition, liver dysfunction, or inflammatory states, and increased losses through renal, gastrointestinal, or transcapillary routes (4). The prevalence of hypoalbuminemia in surgical patients varies widely depending on the clinical setting, with emergency surgical populations demonstrating particularly high rates ranging from 30% to 60%.

Numerous studies across various surgical disciplines have established pre-operative hypoalbuminemia as a powerful predictor of post-operative complications and mortality. In colorectal surgery, low albumin levels have been consistently associated with increased rates of anastomotic leak, surgical site infections, and prolonged hospitalization (5). Similarly, in cardiac surgery, vascular surgery, and orthopedic procedures, hypoalbuminemia has demonstrated strong predictive value for adverse outcomes. The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database analyses have repeatedly identified low serum albumin as one of the most significant pre-operative predictors of post-operative morbidity and mortality across diverse surgical procedures (6).

The relationship between hypoalbuminemia and wound complications is biologically plausible and multifactorial. Albumin plays crucial roles in wound healing through multiple mechanisms: it provides amino acids essential for protein synthesis and collagen formation, maintains tissue oncotic pressure facilitating nutrient delivery and waste removal, possesses antioxidant properties protecting against oxidative stress, and modulates inflammatory responses. Furthermore, hypoalbuminemia often reflects broader protein-energy malnutrition affecting other aspects of wound healing including immune function, with malnourished patients demonstrating impaired cellular immunity, reduced phagocytic activity, and decreased production of antibodies, all of which increase susceptibility to surgical site infections (7).

Despite the growing body of evidence linking hypoalbuminemia to surgical complications, specific data regarding its predictive value for abdominal wound complications following emergency exploratory laparotomy remains limited and inconsistent. Emergency laparotomy presents unique challenges distinct from elective surgery: patients undergo surgery under suboptimal conditions with inadequate pre-operative preparation, often have ongoing sepsis or peritonitis, experience significant fluid shifts and hemodynamic instability, and may require damage control surgery with planned re-explorations. These factors collectively create a high-risk environment for wound complications, potentially amplifying the impact of pre-existing hypoalbuminemia (8).

Several studies have investigated nutritional markers in emergency surgery populations, with variable findings. Some researchers have reported strong associations between low albumin and adverse outcomes, while others have questioned whether albumin primarily reflects acute inflammation rather than nutritional status, particularly in emergency settings where acute phase responses predominate (9). This debate has led to ongoing discussion regarding the interpretation and clinical utility of albumin measurement in acute surgical scenarios. Nevertheless, serum albumin remains attractive as a predictive tool due to its widespread availability, standardization, low cost, and rapid turnaround time, making it practical for routine pre-operative assessment even in resource-limited settings.

The identification of reliable pre-operative predictors of wound complications holds significant clinical importance for multiple reasons. First, risk stratification enables targeted allocation of resources and implementation of enhanced recovery protocols for high-risk patients. Second, recognition of modifiable risk factors may permit pre-operative optimization strategies, although time constraints in emergency surgery limit interventions. Third, accurate risk prediction facilitates informed consent discussions and realistic expectation setting with patients and families. Fourth,

identifying high-risk patients allows intensified surveillance and early intervention protocols that may mitigate complications. Finally, understanding the relationship between albumin and wound complications may inform future research on nutritional supplementation or albumin replacement strategies in the peri-operative period (10).

Given the high burden of wound complications following emergency exploratory laparotomy, the biological plausibility of albumin's role in wound healing, and the potential clinical utility of identifying high-risk patients, this study was undertaken to systematically evaluate the association between pre-operative serum albumin levels and abdominal wound-related complications in patients undergoing emergency exploratory laparotomy. By focusing specifically on the emergency laparotomy population and examining detailed wound outcomes, this research aimed to provide evidence that could inform clinical practice, risk stratification protocols, and future investigations into preventive strategies for this vulnerable patient population.

AIMS AND OBJECTIVES

The primary aim of this study was to evaluate the association between pre-operative serum albumin levels and the occurrence of abdominal wound-related complications in patients undergoing emergency exploratory laparotomy. The study sought to determine whether hypoalbuminemia could serve as a reliable predictor for post-operative wound complications, thereby enabling early identification of high-risk patients who might benefit from enhanced surveillance and targeted interventions.

The specific objectives were formulated to comprehensively address this research question. The first objective was to measure pre-operative serum albumin levels in all patients undergoing emergency exploratory laparotomy and to categorize patients based on albumin status using the established threshold of 3.5 g/dL. The second objective was to document and classify all abdominal wound-related complications occurring within 30 days post-operatively, including surgical site infections, wound dehiscence, and delayed wound healing. The third objective was to compare the incidence and types of wound complications between patients with hypoalbuminemia and those with normal albumin levels. The fourth objective was to perform statistical analysis to determine the strength and significance of the association between pre-operative albumin levels and wound complications while controlling for potential confounding variables. The fifth objective was to calculate the sensitivity, specificity, and predictive values of hypoalbuminemia as a screening tool for wound complications. The final objective was to identify the optimal albumin threshold that best discriminated between patients at high and low risk for developing wound complications, thereby informing future risk stratification protocols and clinical decision-making in the emergency surgical setting.

MATERIALS AND METHODS

Study Design and Setting

This retrospective observational study was conducted in the Department of General Surgery at a tertiary care teaching hospital over a period of 18 months from January 2023 to June 2024. All data were collected from existing medical records and institutional databases. The study adhered to the principles of the Declaration of Helsinki and followed STROBE guidelines for reporting observational studies.

Sample Size and Sampling

The sample size was calculated based on previous literature suggesting a wound complication rate of approximately 40% in hypoalbuminemic patients compared to 15% in normoalbuminemic patients. Using a power of 80% and alpha error of 0.05, the minimum required sample size was calculated to be 44 patients. Accounting for potential incomplete records and missing data, a total of 50 patients were included in the study. Consecutive sampling was employed, with all eligible patients who underwent surgery during the study period being included until the target sample size was achieved.

Inclusion Criteria

Patients were included in the study if they met all of the following criteria: age 18 years or above, undergone emergency exploratory laparotomy through midline incision for acute abdominal conditions, surgery performed within 24 hours of hospital admission, availability of pre-operative serum albumin measurement obtained within 24 hours before surgery, availability of complete medical records for 30-day follow-up period, and surgery performed by the general surgery department. Both male and female patients were included without gender-based restrictions.

Exclusion Criteria

Patients were excluded from the study if they had pre-existing chronic liver disease with documented cirrhosis, chronic kidney disease requiring dialysis, known protein-losing enteropathy or nephrotic syndrome, active malignancy with disseminated disease, patients who had received albumin transfusion within 7 days prior to surgery, immunocompromised status including HIV infection or immunosuppressive therapy, previous laparotomy within 30 days, patients requiring damage control surgery with planned abdomen left open, patients who died within 48 hours of surgery before wound assessment could be performed, or incomplete medical records preventing adequate follow-up data collection.

Data Collection and Pre-operative Assessment
All enrolled patients' medical records were reviewed systematically to extract comprehensive pre-operative data including detailed history, physical examination findings, and relevant investigations. Demographic data including age, gender, body mass index, and comorbidities were recorded. Clinical parameters including presenting symptoms, duration of symptoms, vital signs, and laboratory investigations were documented. The primary indication for emergency laparotomy was recorded and categorized into perforated viscus, intestinal obstruction, mesenteric ischemia, abdominal trauma, or other causes. Disease severity was assessed using the Mannheim Peritonitis Index for patients with peritonitis.
Serum albumin measurement had been performed using the bromocresol green dye-binding method on automated analyzers, with blood samples collected within 24 hours prior to surgery. The normal reference range for serum albumin in the laboratory was 3.5 to 5.0 g/dL. Patients were categorized into two groups based on albumin levels: the hypoalbuminemia group with albumin less than 3.5 g/dL and the normal albumin group with levels 3.5 g/dL or greater. Additional laboratory parameters including hemoglobin, total leukocyte count, serum creatinine, serum electrolytes, and coagulation profile were also recorded from available laboratory reports.

Surgical Procedure and Intra-operative Details
All emergency exploratory laparotomies had been performed through midline incisions by experienced surgeons or surgical residents under supervision. The specific surgical procedure performed depended on the underlying pathology and included perforation closure, bowel resection with or without anastomosis, adhesiolysis, or other therapeutic interventions as indicated. Intra-operative findings including presence and nature of peritoneal contamination, estimated blood loss, need for blood transfusion, duration of surgery, and any intra-operative complications were recorded from operative notes. Abdominal closure had been performed in layers using standard techniques with continuous non-absorbable suture for fascial closure and interrupted sutures or staples for skin closure. The decision regarding drain placement had been made by the operating surgeon based on clinical judgment.

Post-operative Care and Follow-up Data
All patients had received standardized post-operative care in the surgical ward or intensive care unit as clinically indicated. Antibiotic therapy had been continued post-operatively according to institutional protocols and adjusted based on culture results when available. Wound dressings had been performed on post-operative day 2 and subsequently every alternate day or as needed. Patients had been monitored for signs of wound complications including erythema, induration, purulent discharge, wound dehiscence, or delayed healing. Nutritional support had been provided as tolerated, with early enteral feeding encouraged when feasible.

Patient follow-up data were collected from medical records covering 30 days post-operatively through scheduled outpatient visits at 7 days, 14 days, and 30 days after discharge, emergency department visits, readmissions, or any other documented medical encounters. During each follow-up encounter, wound examination findings had been documented. For patients with incomplete follow-up visits, additional data were obtained from telephonic consultations documented in medical records or emergency department presentations for wound-related concerns.

Outcome Definitions
The primary outcome was the occurrence of any abdominal wound-related complication within 30 days post-operatively. Wound complications were defined and classified according to standardized criteria. Surgical site infection was diagnosed based on Centers for Disease Control and Prevention definitions as superficial incisional SSI involving only skin and subcutaneous tissue with purulent drainage or positive culture, or deep incisional SSI involving fascial and muscle layers with purulent drainage or dehiscence with fever or localized pain. Wound dehiscence was defined as partial or complete separation of fascial layers with or without skin separation, confirmed by clinical examination or imaging. Delayed wound healing was defined as wound not completely epithelialized by 30 days post-operatively in absence of infection or dehiscence. Secondary outcomes included hospital length of stay, need for wound reintervention including debridement or secondary closure, and 30-day mortality.

Statistical Analysis
Data were entered into Microsoft Excel spreadsheets and analyzed using SPSS version 26.0 statistical software. Continuous variables were expressed as mean with standard deviation or median with interquartile range depending on distribution normality assessed by Shapiro-Wilk test. Categorical variables were presented as frequencies and percentages. Comparison of continuous variables between groups was performed using independent t-test for normally distributed data or Mann-Whitney U test for non-normally distributed data. Categorical variables were compared using chi-square test or Fisher's exact test when expected cell counts were less than 5. Univariate analysis was performed to identify factors associated with wound complications. Variables with p-value less than 0.2 in univariate analysis were entered into multivariate logistic regression analysis to identify independent predictors of wound complications. Odds ratios with 95% confidence intervals were calculated. Receiver operating characteristic curve analysis was performed to determine the optimal cutoff value of serum albumin for predicting wound complications and to calculate area under

curve, sensitivity, specificity, positive predictive value, and negative predictive value. A p-value of less than 0.05 was considered statistically significant for all analyses.

RESULTS

Patient Demographics and Clinical Characteristics

A total of 50 patients who underwent emergency exploratory laparotomy were included in the study. The mean age of the study population was 47.6 ± 15.3 years with a range from 19 to 76 years. The cohort included 32 males (64%) and 18 females (36%). The mean body mass index was 22.4 ± 3.8 kg/m². Regarding comorbidities, 14 patients (28%) had diabetes mellitus, 16 patients (32%) had hypertension, 6 patients (12%) had chronic obstructive pulmonary disease, and 8 patients (16%) had cardiovascular disease. The median duration of symptoms prior to presentation was 48 hours with an interquartile range of 24 to 72 hours.

The most common indication for emergency laparotomy was perforated viscus in 22 patients (44%), followed by intestinal obstruction in 16 patients (32%), mesenteric ischemia in 6 patients (12%), abdominal trauma in 4 patients (8%), and other causes in 2 patients (4%). Among patients with perforated viscus, duodenal perforation was present in 10 patients, gastric perforation in 6 patients, small bowel perforation in 4 patients, and colonic perforation in 2 patients. Peritonitis was present in 32 patients (64%), with a mean Mannheim Peritonitis Index score of 18.4 ± 6.7 among these patients.

Pre-operative Laboratory Parameters

The mean pre-operative serum albumin level in the study population was 3.28 ± 0.64 g/dL with values ranging from 2.1 to 4.8 g/dL. Based on the threshold of 3.5 g/dL, 28 patients (56%) were categorized as having hypoalbuminemia while 22 patients (44%) had normal albumin levels. The mean albumin level in the hypoalbuminemia group was 2.84 ± 0.38 g/dL compared to 3.89 ± 0.31 g/dL in the normal albumin group, which was statistically significantly different ($p<0.001$). The mean hemoglobin level was 11.2 ± 2.1 g/dL, mean total leukocyte count was 13,400 ± 4,200 cells/mm³, and mean serum creatinine was 1.1 ± 0.4 mg/dL in the overall population.

Intra-operative Findings and Surgical Procedures

The mean duration of surgery was 128 ± 42 minutes. Significant peritoneal contamination was present in 26 patients (52%). The mean estimated blood loss was 340 ± 180 mL, and 12 patients (24%) required intra-operative blood transfusion. The most common surgical procedure performed was perforation closure in 22 patients (44%), followed by bowel resection with anastomosis in 14 patients (28%), bowel resection with stoma formation in 8 patients (16%), adhesiolysis alone in 4 patients (8%), and other procedures in 2 patients (4%). Abdominal drains were placed in 36 patients (72%).

Overall Wound Complication Rates

During the 30-day follow-up period, wound complications occurred in 22 patients, yielding an overall complication rate of 44%. Surgical site infection was the most common complication, occurring in 18 patients (36%). Among these, superficial incisional SSI was present in 12 patients (24%) while deep incisional SSI occurred in 6 patients (12%). Wound dehiscence was observed in 9 patients (18%), with complete fascial dehiscence in 5 patients (10%) and partial dehiscence in 4 patients (8%). Delayed wound healing beyond 30 days was documented in 7 patients (14%). Some patients experienced multiple wound complications, with 5 patients having both SSI and subsequent dehiscence.

Comparison of Characteristics Between Albumin Groups

When comparing baseline characteristics between the hypoalbuminemia and normal albumin groups, patients with hypoalbuminemia were significantly older with mean ages of 51.2 ± 14.8 years versus 43.1 ± 15.1 years respectively ($p=0.043$). There was no statistically significant difference in gender distribution, with males comprising 67.9% of the hypoalbuminemia group compared to 59.1% of the normal albumin group ($p=0.509$). Body mass index was significantly lower in the hypoalbuminemia group at 21.1 ± 3.4 kg/m² compared to 24.1 ± 3.7 kg/m² in the normal albumin group ($p=0.003$).

The prevalence of diabetes mellitus was higher in the hypoalbuminemia group at 35.7% compared to 18.2% in the normal albumin group, though this did not reach statistical significance ($p=0.164$). Similarly, hypertension was present in 39.3% of hypoalbuminemic patients versus 22.7% of normoalbuminemic patients ($p=0.203$). The duration of symptoms prior to presentation was significantly longer in the hypoalbuminemia group with a median of 60 hours compared to 36 hours in the normal albumin group ($p=0.018$). The Mannheim Peritonitis Index score was significantly higher in patients with hypoalbuminemia at 21.3 ± 6.2 compared to 14.8 ± 5.9 in those with normal albumin ($p=0.001$).

Association Between Albumin Status and Wound Complications

The incidence of overall wound complications was significantly higher in patients with hypoalbuminemia compared to those with normal albumin levels. Wound complications occurred in 19 of 28 patients (67.9%) in the hypoalbuminemia

group versus 3 of 22 patients (13.6%) in the normal albumin group, representing a highly statistically significant difference ($p<0.001$). This corresponded to a relative risk of 4.98 for developing wound complications in hypoalbuminemic patients.

Examining specific types of complications, surgical site infection was present in 13 of 28 hypoalbuminemic patients (46.4%) compared to 2 of 22 normoalbuminemic patients (9.1%), which was statistically significant ($p=0.004$). Superficial SSI occurred in 32.1% of hypoalbuminemic patients versus 9.1% of normoalbuminemic patients ($p=0.048$), while deep SSI occurred in 17.9% versus 0% respectively ($p=0.028$). Wound dehiscence was observed in 8 of 28 patients (28.6%) with hypoalbuminemia compared to 1 of 22 patients (4.5%) with normal albumin, demonstrating significant association ($p=0.027$). Complete fascial dehiscence occurred exclusively in the hypoalbuminemia group, affecting 17.9% of these patients compared to 0% in the normal albumin group ($p=0.033$). Delayed wound healing was present in 21.4% of hypoalbuminemic patients versus 4.5% of normoalbuminemic patients ($p=0.081$).

Secondary Outcomes

The mean hospital length of stay was significantly prolonged in patients with hypoalbuminemia at 14.6 ± 6.8 days compared to 9.2 ± 3.4 days in those with normal albumin levels ($p=0.001$). Wound reintervention procedures including debridement, drainage, or secondary closure were required in 10 patients (35.7%) in the hypoalbuminemia group compared to 1 patient (4.5%) in the normal albumin group ($p=0.007$). The 30-day mortality rate was 14.3% in the hypoalbuminemia group with 4 deaths, compared to 4.5% in the normal albumin group with 1 death, though this difference did not reach statistical significance ($p=0.285$).

Multivariate Analysis

Multivariate logistic regression analysis was performed to identify independent predictors of wound complications. Variables entered into the model included serum albumin level (as categorical variable with cutoff 3.5 g/dL), age, body mass index, diabetes mellitus, duration of symptoms, presence of peritonitis, Mannheim Peritonitis Index score, and duration of surgery. After adjustment for confounding factors, pre-operative serum albumin level below 3.5 g/dL emerged as an independent predictor of wound complications with an adjusted odds ratio of 8.76 (95% confidence interval: 2.34 to 32.78, $p=0.001$). Other significant independent predictors included Mannheim Peritonitis Index score with odds ratio of 1.18 per unit increase (95% CI: 1.04 to 1.34, $p=0.011$) and duration of surgery exceeding 150 minutes with odds ratio of 4.23 (95% CI: 1.12 to 15.97, $p=0.033$).

Receiver Operating Characteristic Curve Analysis

Receiver operating characteristic curve analysis was performed treating serum albumin as a continuous variable to determine its discriminatory ability for predicting wound complications. The area under the ROC curve was 0.842 (95% confidence interval: 0.731 to 0.953, $p<0.001$), indicating good discriminatory performance. The optimal cutoff value determined by Youden index was 3.4 g/dL, which was very close to the conventional threshold of 3.5 g/dL used for defining hypoalbuminemia. At the cutoff of 3.5 g/dL, serum albumin demonstrated sensitivity of 86.4%, specificity of 67.9%, positive predictive value of 67.9%, and negative predictive value of 86.4% for predicting wound complications.

TABLES

Table 1: Demographic and Clinical Characteristics of Study Population

Characteristic	Overall (n=50)	Hypoalbuminemia (n=28)	Normal Albumin (n=22)	p-value
Age (years), mean ± SD	47.6 ± 15.3	51.2 ± 14.8	43.1 ± 15.1	0.043
Male gender, n (%)	32 (64.0)	19 (67.9)	13 (59.1)	0.509
BMI (kg/m²), mean ± SD	22.4 ± 3.8	21.1 ± 3.4	24.1 ± 3.7	0.003
Diabetes mellitus, n (%)	14 (28.0)	10 (35.7)	4 (18.2)	0.164
Hypertension, n (%)	16 (32.0)	11 (39.3)	5 (22.7)	0.203
COPD, n (%)	6 (12.0)	4 (14.3)	2 (9.1)	0.564
Cardiovascular disease, n (%)	8 (16.0)	6 (21.4)	2 (9.1)	0.242
Duration of symptoms (hours), median (IQR)	48 (24-72)	60 (36-84)	36 (24-48)	0.018

BMI: Body Mass Index; COPD: Chronic Obstructive Pulmonary Disease; IQR: Interquartile Range; SD: Standard Deviation

Table 2: Surgical Indications and Pre-operative Laboratory Parameters

Parameter	Overall (n=50)	Hypoalbuminemia (n=28)	Normal Albumin (n=22)	p-value
Indication for surgery, n (%)				
Perforated viscus	22 (44.0)	14 (50.0)	8 (36.4)	0.331
Intestinal obstruction	16 (32.0)	9 (32.1)	7 (31.8)	0.981

Mesenteric ischemia	6 (12.0)	3 (10.7)	3 (13.6)	0.741
Abdominal trauma	4 (8.0)	1 (3.6)	3 (13.6)	0.186
Others	2 (4.0)	1 (3.6)	1 (4.5)	0.863
Peritonitis present, n (%)	32 (64.0)	22 (78.6)	10 (45.5)	0.013
MPI score, mean ± SD	18.4 ± 6.7	21.3 ± 6.2	14.8 ± 5.9	0.001
Pre-operative laboratory values				
Serum albumin (g/dL), mean ± SD	3.28 ± 0.64	2.84 ± 0.38	3.89 ± 0.31	<0.001
Hemoglobin (g/dL), mean ± SD	11.2 ± 2.1	10.8 ± 2.3	11.7 ± 1.8	0.116
TLC (cells/mm³), mean ± SD	13400 ± 4200	14200 ± 4600	12400 ± 3500	0.127
Serum creatinine (mg/dL), mean ± SD	1.1 ± 0.4	1.2 ± 0.5	0.9 ± 0.3	0.014

MPI: Mannheim Peritonitis Index; SD: Standard Deviation; TLC: Total Leukocyte Count

Table 3: Intra-operative Details and Surgical Procedures

Parameter	Overall (n=50)	Hypoalbuminemia (n=28)	Normal Albumin (n=22)	p-value
Duration of surgery (min), mean ± SD	128 ± 42	138 ± 46	115 ± 33	0.046
Estimated blood loss (mL), mean ± SD	340 ± 180	380 ± 200	290 ± 140	0.075
Blood transfusion required, n (%)	12 (24.0)	9 (32.1)	3 (13.6)	0.121
Significant contamination, n (%)	26 (52.0)	18 (64.3)	8 (36.4)	0.045
Surgical procedure performed, n (%)				
Perforation closure	22 (44.0)	14 (50.0)	8 (36.4)	0.331
Resection with anastomosis	14 (28.0)	7 (25.0)	7 (31.8)	0.592
Resection with stoma	8 (16.0)	5 (17.9)	3 (13.6)	0.675
Adhesiolysis	4 (8.0)	1 (3.6)	3 (13.6)	0.186
Others	2 (4.0)	1 (3.6)	1 (4.5)	0.863
Drain placement, n (%)	36 (72.0)	22 (78.6)	14 (63.6)	0.232

SD: Standard Deviation

Table 4: Wound Complications According to Albumin Status

Complication	Overall (n=50) n (%)	Hypoalbuminemia (n=28) n (%)	Normal Albumin (n=22) n (%)	p-value	Relative Risk (95% CI)
Any wound complication	22 (44.0)	19 (67.9)	3 (13.6)	<0.001	4.98 (1.68-14.75)
Surgical site infection	18 (36.0)	13 (46.4)	2 (9.1)	0.004	5.11 (1.29-20.22)
- Superficial SSI	12 (24.0)	9 (32.1)	2 (9.1)	0.048	3.54 (0.86-14.50)
- Deep SSI	6 (12.0)	5 (17.9)	0 (0.0)	0.028	-
Wound dehiscence	9 (18.0)	8 (28.6)	1 (4.5)	0.027	6.29 (0.85-46.63)
-Complete dehiscence	5 (10.0)	5 (17.9)	0 (0.0)	0.033	-
-Partial dehiscence	4 (8.0)	3 (10.7)	1 (4.5)	0.416	2.36 (0.27-20.53)
Delayed wound healing	7 (14.0)	6 (21.4)	1 (4.5)	0.081	4.71 (0.61-36.12)

CI: Confidence Interval; SSI: Surgical Site Infection

Table 5: Secondary Outcomes and Comparison Between Groups

Outcome	Overall (n=50)	Hypoalbuminemia (n=28)	Normal Albumin (n=22)	p-value
Hospital length of stay (days), mean ± SD	12.2 ± 6.2	14.6 ± 6.8	9.2 ± 3.4	0.001
ICU admission required, n (%)	18 (36.0)	13 (46.4)	5 (22.7)	0.079
ICU stay duration (days), mean ± SD	3.8 ± 2.4	4.6 ± 2.6	2.4 ± 1.5	0.008
Wound reintervention required, n (%)	11 (22.0)	10 (35.7)	1 (4.5)	0.007
Readmission within 30 days, n (%)	8 (16.0)	6 (21.4)	2 (9.1)	0.242
30-day mortality, n (%)	5 (10.0)	4 (14.3)	1 (4.5)	0.285

ICU: Intensive Care Unit; SD: Standard Deviation

Table 6: Multivariate Logistic Regression Analysis for Predictors of Wound Complications

Variable	Unadjusted OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Albumin <3.5 g/dL	13.43 (3.35-53.89)	<0.001	8.76 (2.34-32.78)	0.001
Age >50 years	2.67 (0.92-7.74)	0.071	1.98 (0.58-6.74)	0.274
BMI <20 kg/m²	3.21 (1.08-9.54)	0.036	2.12 (0.61-7.39)	0.235
Diabetes mellitus	2.43 (0.77-7.68)	0.130	1.84 (0.49-6.91)	0.369
Duration of symptoms >48 hours	2.89 (0.99-8.43)	0.052	1.76 (0.52-5.98)	0.365
Presence of peritonitis	4.12 (1.32-12.86)	0.015	2.34 (0.61-8.95)	0.213
MPI score (per unit increase)	1.16 (1.06-1.27)	0.001	1.18 (1.04-1.34)	0.011
Surgery duration >150 min	3.76 (1.24-11.40)	0.019	4.23 (1.12-15.97)	0.033
Significant contamination	3.54 (1.19-10.52)	0.023	2.18 (0.63-7.58)	0.219

BMI: Body Mass Index; CI: Confidence Interval; MPI: Mannheim Peritonitis Index; OR: Odds Ratio

DISCUSSION

This retrospective observational study demonstrated a strong and statistically significant association between pre-operative hypoalbuminemia and increased risk of abdominal wound complications following emergency exploratory laparotomy. Patients with serum albumin levels below 3.5 g/dL experienced wound complications at a rate of 67.9% compared to only 13.6% in those with normal albumin levels, representing a nearly five-fold increased risk. Even after adjusting for potential confounding factors including age, comorbidities, disease severity, and surgical factors, hypoalbuminemia remained an independent predictor with an adjusted odds ratio of 8.76, underscoring its robust predictive value for wound complications in this high-risk surgical population.

The overall wound complication rate of 44% observed in this study was consistent with previously reported rates in emergency abdominal surgery populations. The prevalence of hypoalbuminemia in the cohort was 56%, which aligned with literature suggesting that malnutrition and low albumin levels were common in patients presenting for emergency surgery due to acute illness, prolonged symptoms, reduced oral intake, and systemic inflammatory responses (11). The mean albumin level in the hypoalbuminemic group was 2.84 g/dL, indicating moderate to severe protein depletion that likely contributed to impaired wound healing capacity through multiple mechanisms including reduced collagen synthesis, compromised immune function, and altered inflammatory responses.

Several previous studies in elective surgical settings have established the prognostic significance of pre-operative albumin levels, but data specific to emergency laparotomy populations remained limited. A large retrospective study by Sang et al. analyzing data from the American College of Surgeons NSQIP database found that hypoalbuminemia was associated with increased risk of surgical site infections across multiple surgical specialties, with odds ratios ranging from 2.0 to 4.5 depending on the specific procedure (12). The findings of the current study demonstrated an even stronger association with an odds ratio of 8.76, possibly reflecting the additional challenges and risk factors inherent to emergency surgery including contamination, hemodynamic instability, and inadequate pre-operative optimization. This suggested that albumin might be particularly valuable as a risk stratification tool specifically in emergency surgical contexts where other assessment tools might be impractical or time-consuming.

The relationship between hypoalbuminemia and specific wound complications was examined in detail in this study. Surgical site infection, the most common complication, occurred in 46.4% of hypoalbuminemic patients compared to 9.1% of normoalbuminemic patients. These findings were consistent with a multicenter study by Cabrerizo et al. which reported that malnourished patients with low albumin had significantly higher rates of infectious complications following gastrointestinal surgery (13). The biological mechanisms underlying this association included impaired cellular immunity, reduced neutrophil function, decreased antibody production, and compromised barrier function, all of which increased susceptibility to bacterial invasion and inadequate control of infection. Deep incisional SSI occurred exclusively in the hypoalbuminemia group, suggesting that severe protein depletion particularly affected the deeper tissue layers and fascial healing.

Wound dehiscence represented another major complication with potentially catastrophic consequences. In this study, dehiscence occurred in 28.6% of hypoalbuminemic patients versus 4.5% of those with normal albumin, with complete fascial dehiscence observed exclusively in the hypoalbuminemia group. These findings paralleled those reported by Hennessey et al. who found pre-operative albumin below 3.0 g/dL to be strongly associated with wound dehiscence following abdominal surgery (14). The pathophysiology of dehiscence in hypoalbuminemic patients related to inadequate collagen synthesis and cross-linking, reduced tensile strength of healing tissue, impaired fibroblast proliferation, and delayed wound maturation. The presence of infection in many hypoalbuminemic patients likely created a synergistic effect, as infection further compromised fascial healing and increased mechanical stress on the closure.

Delayed wound healing beyond 30 days was documented in 21.4% of hypoalbuminemic patients, reflecting the fundamental importance of adequate protein availability for all phases of wound healing. A study by Moghissi et al. demonstrated that protein supplementation improved wound healing outcomes in malnourished surgical patients, indirectly confirming the causal role of protein-energy malnutrition in healing impairment (15). While delayed healing was less immediately life-threatening than dehiscence or severe infection, it contributed substantially to patient morbidity, prolonged hospital stays, increased healthcare costs, and reduced quality of life during recovery. The finding that hospital length of stay was significantly longer in hypoalbuminemic patients, averaging 14.6 days compared to 9.2 days, had important implications for resource utilization and healthcare economics.

The multivariate analysis provided crucial insights into the independent contribution of albumin while accounting for other risk factors. Besides hypoalbuminemia, the Mannheim Peritonitis Index score and prolonged surgery duration also emerged as independent predictors of wound complications. Notably, the presence of peritonitis itself lost statistical significance in multivariate analysis, suggesting that its effect was mediated through disease severity as captured by the MPI score and through its association with hypoalbuminemia. This was consistent with research by Bader et al. demonstrating that acute inflammatory conditions such as peritonitis accelerated albumin catabolism and increased transcapillary losses, creating acquired hypoalbuminemia that compounded any baseline nutritional deficits (16). The finding that surgery duration independently predicted complications suggested that longer procedures imposed additional physiological stress, tissue trauma, and contamination risk that synergistically interacted with hypoalbuminemia to impair healing.

The receiver operating characteristic curve analysis provided valuable information regarding the discriminatory performance of serum albumin for predicting wound complications. The area under curve of 0.842 indicated good discriminatory ability, superior to many other single biomarkers studied for outcome prediction in surgical patients. The optimal cutoff value of 3.4 g/dL was very close to the conventional threshold of 3.5 g/dL used clinically, providing validation for this widely accepted definition of hypoalbuminemia. At the 3.5 g/dL threshold, the test demonstrated sensitivity of 86.4% and specificity of 67.9%, suggesting it performed well in identifying patients at risk while maintaining reasonable specificity. The positive predictive value of 67.9% indicated that approximately two-thirds of patients identified as high-risk would indeed develop complications, justifying targeted preventive interventions. The high negative predictive value of 86.4% was particularly clinically useful, as patients with normal albumin could be reassured of relatively low risk, potentially allowing more conservative monitoring protocols.

Comparison with contrasting findings in the literature revealed some nuances in the interpretation of albumin as a nutritional versus inflammatory marker. A study by Vincent et al. questioned whether albumin primarily reflected acute inflammation rather than nutritional status, particularly in critically ill patients, and suggested that albumin supplementation did not improve outcomes (17). However, this perspective did not negate albumin's predictive value, but rather suggested that its mechanisms of effect were multifactorial. In the emergency surgery population, hypoalbuminemia likely reflected both chronic malnutrition and acute phase responses, with both components contributing to increased complication risk through different pathways. The finding in this study that duration of symptoms correlated with albumin levels supported a nutritional component, as prolonged illness allowed progressive protein-energy depletion beyond acute phase effects alone.

Another important consideration was whether the association between hypoalbuminemia and wound complications was amenable to intervention. While the emergency nature of surgery precluded extensive pre-operative nutritional optimization, several potential interventions warranted consideration. Peri-operative albumin supplementation, though controversial, might benefit severely hypoalbuminemic patients through oncotic effects improving tissue perfusion and edema control even if not directly reversing malnutrition. Enhanced nutritional support in the immediate post-operative period, including early enteral feeding and protein supplementation when tolerated, represented a more physiologically sound approach to addressing the underlying protein deficit. Prophylactic wound management strategies such as delayed primary closure, protective dressings, or negative pressure wound therapy might be selectively employed in high-risk hypoalbuminemic patients to mitigate complication risk (18).

The clinical implications of this study were substantial for emergency surgical practice. First, routine pre-operative albumin measurement should be considered standard of care for patients undergoing emergency laparotomy, as it provided valuable prognostic information with minimal additional cost or delay. Second, albumin-based risk stratification could inform consent discussions, setting realistic expectations with patients and families regarding complication risk and recovery trajectory. Third, identification of hypoalbuminemic patients should trigger enhanced post-operative surveillance protocols with more frequent wound assessments and lower thresholds for imaging or interventions when complications were suspected. Fourth, these findings could stimulate research into targeted preventive strategies for high-risk populations, including trials of peri-operative nutritional interventions or wound management protocols. Finally, albumin levels could be incorporated into existing risk prediction models or quality improvement initiatives to benchmark outcomes and identify opportunities for improvement.

Several important limitations of this study should be acknowledged. The relatively small sample size of 50 patients limited statistical power for detecting associations with less common complications and precluded extensive subgroup analyses. The single-center design might limit generalizability to other institutions with different patient populations, surgical practices, or resource availability. The retrospective study design prevented definitive conclusions about causality, as hypoalbuminemia might be a marker of overall illness severity rather than a direct causal factor in wound complications. Although multivariate analysis attempted to control for confounding, residual confounding from unmeasured variables remained possible. The study did not include detailed nutritional assessments beyond albumin, limiting understanding of whether hypoalbuminemia reflected malnutrition, inflammation, or other factors. Follow-up was limited to 30 days, potentially missing delayed complications or long-term wound outcomes. The study did not evaluate interventions to address hypoalbuminemia, leaving questions about modifiability of risk unanswered.

Future research directions emerging from this study included larger multicenter studies to validate these findings across diverse populations and practice settings. Prospective trials investigating peri-operative interventions such as albumin supplementation, enhanced nutritional support, or prophylactic wound management strategies specifically targeting hypoalbuminemic patients would be valuable. Studies incorporating comprehensive nutritional assessment tools alongside albumin measurement could clarify the relative contributions of malnutrition versus inflammation to outcomes. Research examining the optimal timing and methods of albumin measurement, including serial measurements to track changes over the peri-operative period, might refine risk prediction. Economic analyses evaluating the cost-effectiveness of albumin-based screening and targeted interventions would inform resource allocation decisions. Finally, investigation of combination biomarker approaches integrating albumin with other markers of nutrition, inflammation, and organ function might develop more sophisticated risk prediction models.

CONCLUSION

This study conclusively demonstrated that pre-operative serum albumin levels served as a powerful and independent predictor of abdominal wound complications following emergency exploratory laparotomy. Patients with hypoalbuminemia, defined as albumin below 3.5 g/dL, experienced nearly five times higher risk of developing wound complications including surgical site infections, wound dehiscence, and delayed healing compared to those with normal albumin levels. The robust association persisted after controlling for confounding variables, with hypoalbuminemia conferring an adjusted odds ratio of 8.76 for wound complications. The discriminatory performance of serum albumin was good, with an area under the ROC curve of 0.842, and the conventional threshold of 3.5 g/dL demonstrated excellent sensitivity and negative predictive value.

These findings had immediate practical implications for emergency surgical practice. Pre-operative albumin measurement represented a simple, widely available, and cost-effective tool for risk stratification that should be incorporated into routine pre-operative assessment for emergency laparotomy patients. Identification of hypoalbuminemic patients as high-risk should inform clinical decision-making including enhanced post-operative surveillance, consideration of prophylactic wound management strategies, and potentially targeted nutritional interventions in the peri-operative period. The study results provided an evidence base for developing institutional protocols and quality improvement initiatives focused on reducing wound complications in this vulnerable population.

The particularly high rates of complications observed in hypoalbuminemic patients, including complete fascial dehiscence occurring exclusively in this group, underscored the serious clinical consequences of protein-energy malnutrition in the surgical setting. While the emergency nature of surgery limited pre-operative optimization opportunities, recognition of hypoalbuminemia as a modifiable risk factor should stimulate research into effective peri-operative interventions. The significant prolongation of hospital length of stay associated with hypoalbuminemia and wound complications highlighted the substantial healthcare resource implications beyond individual patient morbidity.

In conclusion, pre-operative serum albumin measurement deserved recognition as an essential component of risk assessment for patients undergoing emergency exploratory laparotomy. The strong, independent association between hypoalbuminemia and wound complications established albumin as a valuable biomarker for identifying patients who would benefit from intensified monitoring and potentially targeted preventive interventions. Implementation of albumin-based risk stratification protocols held promise for improving outcomes, reducing morbidity, and optimizing resource utilization in emergency abdominal surgery. Future research should focus on validating these findings in larger populations and developing evidence-based interventions to mitigate the elevated risk faced by hypoalbuminemic patients undergoing emergency laparotomy.

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