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Article

Association of Preoperative Serum Albumin Levels with Postoperative Surgical Complications Among Patients Undergoing Laparotomy

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ABSTRACT

Background: Hypoalbuminemia is a well-recognized risk factor for adverse postoperative outcomes, yet its precise impact on surgical complications in patients undergoing laparotomy remains underexplored in regional healthcare settings, creating a critical gap in risk stratification and perioperative care. **Objective**: This study aimed to determine the association between preoperative serum albumin levels and the incidence of postoperative surgical complications among patients undergoing laparotomy, hypothesizing that hypoalbuminemia increases the risk of adverse outcomes. **Methods**: A prospective cohort study was conducted at Bolan Medical College and Sandeman Provincial Hospital, Quetta, enrolling 134 adult patients scheduled for laparotomy and meeting defined inclusion/exclusion criteria. Patients were categorized by preoperative serum albumin status (hypoalbuminemia <3.4 g/dL vs. normal ≥3.5 g/dL). Baseline demographic and clinical data were collected, and postoperative complications were monitored for 30 days through physical examination and imaging. The study received institutional ethical approval in compliance with the Declaration of Helsinki. Statistical analyses, including Chi-square tests and risk estimations, were performed using SPSS version 27.0. **Results**: Postoperative complications occurred in 49.3% of hypoalbuminemic patients versus 10.4% of those with normal albumin ($p < 0.001$), with significant increases observed in surgical site infection (31.3% vs. 4.5%), anastomotic leak (22.4% vs. 3%), gastrointestinal fistula (10.4% vs. 1.5%), and prolonged ileus (19.4% vs. 1.5%). **Conclusion**: Preoperative hypoalbuminemia is strongly associated with an increased risk of postoperative complications in laparotomy patients, supporting the integration of serum albumin assessment and nutritional optimization into surgical care pathways to improve outcomes and patient safety.

Keywords: Hypoalbuminemia, Laparotomy, Postoperative Complications, Serum Albumin, Surgical Site Infection, Risk Assessment, Nutritional Status

INTRODUCTION

Surgical procedures are a cornerstone of modern medical care, with an estimated 313 million operations performed worldwide each year (1). Despite significant advancements in surgical techniques and perioperative care, the incidence of postoperative complications remains a critical concern, affecting approximately 13% of patients and contributing to a 1.4% all-cause mortality rate within 30 days of surgery (2). These complications, which span infections, cardiac and pulmonary issues, renal dysfunction, venous thromboembolism, neurological sequelae, and ultimately death, impose a substantial burden on patients, prolonging hospital stays, diminishing quality of life, and escalating healthcare costs (3–5). The interplay between patient characteristics, the nature and urgency of the procedure, and the quality of perioperative management all modulate the risk and outcomes of surgical interventions, making preoperative risk stratification an essential component of surgical planning (6).

Current risk assessment protocols often rely on general clinical scores and laboratory investigations to identify patients at higher risk for postoperative complications, yet these tools may lack specificity for certain modifiable risk factors (7,8). Among these, the nutritional status of surgical patients has emerged as a critical, modifiable determinant of postoperative outcomes. Serum albumin, a well-established surrogate marker of nutritional and immunological status, has garnered considerable attention for its prognostic value across various surgical disciplines (9–12). Hypoalbuminemia, defined by a serum albumin

concentration below 3.4 g/dL, is not only reflective of malnutrition but also an independent predictor of adverse postoperative events, including wound complications, anastomotic leaks, infectious complications, and mortality (13–15). Furthermore, low preoperative serum albumin has been linked to longer hospitalizations, increased healthcare expenditures, and a greater psychosocial burden on both patients and their families, underlining the need for cost-effective and accessible risk stratification measures (13–15).

Despite the extensive evidence supporting the predictive role of preoperative serum albumin in surgical morbidity and mortality, regional data—particularly from developing healthcare settings—remain scarce, limiting the generalizability and clinical applicability of global findings (14,15). Notably, previous studies have reported high rates of postoperative complications in hypoalbuminemic patients, with complication rates ranging from 35% to 59% and mortality rates as high as 18% in certain surgical cohorts, compared to substantially lower rates among those with normal preoperative albumin levels (14,15). While these studies underscore the importance of serum albumin as a preoperative risk marker, there remains a pressing need for context-specific research to inform clinical practice guidelines and optimize perioperative management in resource-limited environments. The present study seeks to address this knowledge gap by prospectively evaluating the association between preoperative serum albumin levels and the incidence of postoperative surgical complications among patients undergoing laparotomy in a tertiary care setting. The objective is to determine whether preoperative hypoalbuminemia is significantly associated with an increased risk of adverse postoperative outcomes, thereby providing evidence to inform risk stratification, perioperative nutritional optimization, and ultimately, improved surgical care for this patient population.

MATERIALS AND METHODS

This prospective cohort study was conducted in accordance with the STROBE guidelines for observational studies to ensure the completeness and transparency of reporting (1). The study was carried out in the Surgical Department of Bolan Medical College and Sandeman Provincial Hospital, Quetta, from December 22, 2022, to December 23, 2023. All adult patients aged 18 to 60 years, scheduled to undergo laparotomy for typhoid or tuberculous (TB) perforation, were screened for eligibility. Inclusion criteria comprised patients with confirmed diagnoses based on clinical, radiological, and laboratory evidence who were medically fit for surgery and able to provide written informed consent. Exclusion criteria included patients with end-stage organ failure (such as hepatic or renal dysfunction), those with known immunodeficiency, active malignancy, ongoing corticosteroid or immunosuppressive therapy, previous abdominal surgery within the last six months, pregnancy, or refusal to participate.

Participants were recruited consecutively from inpatient surgical admissions. Eligible patients were informed about the study objectives, risks, and benefits in their preferred language. Written informed consent was obtained prior to enrollment, and patient confidentiality was maintained throughout. The study protocol received ethical approval from the Institutional Review Board of Bolan Medical College/Sandeman Provincial Hospital, Quetta, ensuring compliance with the Declaration of Helsinki and local regulations (2).

Baseline demographic and clinical data, including age, gender, place of residence, socioeconomic status, medical history, comorbidities (diabetes mellitus, hypertension, smoking status), height, and weight, were collected using a standardized proforma. Body Mass Index (BMI) was calculated for each participant. Preoperative nutritional status was assessed by measuring serum albumin levels from venous blood samples collected in a sterile environment, with laboratory analyses performed using automated biochemical analyzers calibrated to international standards. Patients were then categorized into two groups based on preoperative serum albumin: hypoalbuminemia (<3.4 g/dL) and normal albumin (≥3.5 g/dL).

The surgical procedures were performed by consultant surgeons with a minimum of five years of post-fellowship experience, following standardized intraoperative protocols. Intraoperative and perioperative data, including the duration of surgery and intraoperative findings, were meticulously documented. Postoperative follow-up was conducted for 30 days to monitor for predefined complications: surgical site infection, anastomotic leak, gastrointestinal fistula, prolonged ileus, and burst abdomen. Complications were diagnosed using a combination of physical examination, abdominal ultrasound, and computed tomography (CT) scans as clinically indicated.

All data were double-checked for accuracy, with missing or ambiguous entries clarified through review of hospital records or direct communication with patients where feasible. If essential data points were missing and could not be recovered, the affected cases were excluded from the relevant analysis but included in descriptive statistics where possible to minimize bias. Potential confounding factors—such as age, BMI, comorbidities, and procedure duration—were identified a priori and controlled for in the analysis. Statistical analysis was performed using SPSS software, version 27.0 (IBM Corp., Armonk, NY). Quantitative variables, including age, height, weight, BMI, income, serum albumin, and procedure duration, were summarized using means and standard deviations. Qualitative variables, such as gender, residence, socioeconomic status, comorbidities, and complication rates, were described using frequencies and percentages. The Chi-square test was employed to compare the incidence of postoperative complications between the hypoalbuminemia and normal albumin groups. Relative risk (RR) was calculated to quantify the association between preoperative hypoalbuminemia and adverse outcomes, with RR > 1 considered clinically significant. A p-value less than 0.05 was set as the threshold for statistical significance. The study was designed to ensure reproducibility, with clearly defined eligibility criteria, standardized data collection, validated measurement tools, and rigorous data handling procedures, thereby enhancing the reliability and generalizability of the findings (1).

RESULTS

A total of 134 patients who met the inclusion criteria were enrolled and categorized into two groups based on preoperative

serum albumin levels: hypoalbuminemia (n = 67) and normal albumin (n = 67). There was no missing data for the primary variables analyzed; all enrolled patients completed the 30-day postoperative follow-up, ensuring robust data integrity.

The overall mean age of participants was 42.2 years (range 18–60 years), with a mean ± standard deviation (SD) of 42.4 ± 11.1 years in the hypoalbuminemia group and 41.9 ± 11.6 years in the normal albumin group. The groups were well balanced for demographic and baseline clinical characteristics, as detailed in Table 1. The proportion of male and female patients was similar between groups: males comprised 58.2% (n = 39) and 53.7% (n = 36), and females comprised 41.8% (n = 28) and 46.3% (n = 31) of the hypoalbuminemia and normal albumin groups, respectively. The distribution of patients by age group, place of residence, socioeconomic status, BMI categories, and comorbidities such as diabetes mellitus, hypertension, and smoking, were comparable between the two cohorts.

Key continuous variables showed similar distribution between groups. Mean height was 1.38 ± 0.27 m in the hypoalbuminemia group and 1.26 ± 0.19 m in the normal albumin group. Mean weight was 58.5 ± 14.5 kg and 57.5 ± 13.5 kg, and BMI was 25.5 ± 5.2 kg/m^2 and 25.8 ± 4.7 kg/m^2 for the hypoalbuminemia and normal albumin groups, respectively. Mean monthly income was identical in both groups (26,000 ± 8,000 PKR). Preoperative serum albumin was significantly lower in the hypoalbuminemia group (2.7 ± 0.4 g/dL) compared to the normal albumin group (4.5 ± 0.6 g/dL), confirming successful stratification by albumin status. The mean duration of surgical procedure was also similar between groups: 83.7 ± 27.9 minutes for hypoalbuminemia and 78.8 ± 27.0 minutes for normal albumin.

Table 1. Descriptive Statistics of Continuous Variables among Study Groups

Variable	Hypoalbuminemia (n = 67)	Normal Albumin (n = 67)
Age (years), mean ± SD	42.4 ± 11.1	41.9 ± 11.6
Height (m), mean ± SD	1.38 ± 0.27	1.26 ± 0.19
Weight (kg), mean ± SD	58.5 ± 14.5	57.5 ± 13.5
BMI (kg/m^2), mean ± SD	25.5 ± 5.2	25.8 ± 4.7
Monthly Income (PKR), mean ± SD	26,000 ± 8,000	26,000 ± 8,000
Serum Albumin (g/dL), mean ± SD	2.7 ± 0.4	4.5 ± 0.6
Duration of Procedure (min), mean ± SD	83.7 ± 27.9	78.8 ± 27.0

A detailed comparison of categorical variables between groups is presented in Table 2. The age group distribution, residence, socioeconomic class, BMI category, comorbidities, smoking status, diagnosis, and procedural duration subgroups were closely matched, minimizing confounding. Postoperative complications were observed in 49.3% (n = 33) of the hypoalbuminemia group and 10.4% (n = 7) of the normal albumin group ($\chi^2 = 27.68$, $p < 0.001$). The relative risk (RR) of postoperative complications in the hypoalbuminemia group compared to the normal albumin group was 4.74 (95% CI: 2.22–10.12), indicating a strong and clinically significant association. The most frequent postoperative complication was surgical site infection, present in 31.3% (n = 21) of hypoalbuminemic patients and 4.5% (n = 3) of those with normal albumin ($\chi^2 = 15.65$, $p < 0.001$).

Table 2. Distribution of Categorical Variables by Serum Albumin Group

Variable	Hypoalbuminemia (n = 67)	Normal Albumin (n = 67)
Gender		
Male	39 (58.2%)	36 (53.7%)
Female	28 (41.8%)	31 (46.3%)
Age Group (years)		
18–30	10 (14.9%)	12 (17.9%)
31–40	14 (20.9%)	13 (19.4%)
41–50	27 (40.3%)	26 (38.8%)
51–60	16 (23.9%)	16 (23.9%)
Place of Residence		
Urban	41 (61.2%)	37 (55.2%)
Rural	26 (38.8%)	30 (44.8%)
Socioeconomic Status		
Lower	34 (50.7%)	33 (49.3%)
Middle	26 (38.8%)	28 (41.8%)
Higher	7 (10.4%)	6 (9%)
BMI Category		
Underweight	5 (7.5%)	3 (4.5%)
Normal weight	26 (38.8%)	21 (31.3%)
Overweight	21 (31.3%)	29 (43.3%)
Obese	15 (22.4%)	14 (20.9%)
Duration of Procedure		
≤60 min	23 (34.3%)	25 (37.3%)

Variable	Hypoalbuminemia (n = 67)	Normal Albumin (n = 67)
>60 min	44 (65.7%)	42 (62.7%)
Diagnosis		
Typhoid Perforation	35 (52.2%)	30 (44.8%)
TB Perforation	32 (47.8%)	37 (55.2%)
Diabetes Mellitus		
Yes	11 (16.4%)	13 (19.4%)
No	56 (83.6%)	54 (80.6%)
Hypertension		
Yes	47 (70.1%)	45 (67.2%)
No	20 (29.9%)	22 (32.8%)
Smoking		
Yes	21 (31.3%)	20 (29.9%)
No	46 (68.7%)	47 (70.1%)

Postoperative Complications

Rates of anastomotic leak were 22.4% (n = 15) and 3.0% (n = 2), respectively (χ^2 = 10.47, p = 0.001). Gastrointestinal fistula occurred in 10.4% (n = 7) and 1.5% (n = 1) (χ^2 = 4.89, p = 0.027), prolonged ileus in 19.4% (n = 13) and 1.5% (n = 1) (χ^2 = 11.41, p = 0.001), and burst abdomen in 7.5% (n = 5) of hypoalbuminemia patients, with no cases observed in the normal albumin group (χ^2 = 4.81, p = 0.028).

Table 3. Incidence of Postoperative Complications by Albumin Group

Complication	Hypoalbuminemia (n = 67)	Normal Albumin (n = 67)	χ^2 (df=1)	p-value
Any Complication	33 (49.3%)	7 (10.4%)	27.68	<0.001
Surgical Site Infection	21 (31.3%)	3 (4.5%)	15.65	<0.001
Anastomotic Leak	15 (22.4%)	2 (3.0%)	10.47	0.001
Gastrointestinal Fistula	7 (10.4%)	1 (1.5%)	4.89	0.027
Prolonged Ileus	13 (19.4%)	1 (1.5%)	11.41	0.001
Burst Abdomen	5 (7.5%)	0 (0.0%)	4.81	0.028

The risk of any postoperative complication was nearly five times higher in patients with hypoalbuminemia compared to those with normal serum albumin levels (RR = 4.74, 95% CI: 2.22–10.12). The greatest absolute risk increase was observed for surgical site infections (absolute risk difference: 26.8%), followed by anastomotic leak (19.4%), and prolonged ileus (17.9%). The effect sizes for these associations were large, as indicated by the magnitude of the risk ratios and the highly significant p-values. No subgroup or interaction effects were observed in descriptive cross-tabulations of baseline covariates and complication rates (data not shown). Due to complete case analysis and balanced baseline characteristics, confounding was minimized, and there were no missing data requiring imputation or alternative handling.

The incidence of postoperative complications, particularly surgical site infection, anastomotic leak, gastrointestinal fistula, prolonged ileus, and burst abdomen, was significantly higher in the hypoalbuminemia group than in patients with normal albumin levels. These findings are supported by robust statistical significance, clinically meaningful risk differences, and high internal validity due to stringent data collection, complete follow-up, and balanced group allocation. Figure 1 showed as per legend entries for infection rates and mean procedure duration are now clearly separated and positioned outside the plot area, ensuring there is no overlap with the main graph. This refined layout maintains full visibility of group differences and trend markers across BMI categories, supporting rapid and accurate clinical interpretation without visual distraction. The butterfly structure and overlay markers provide immediate insight into how rising BMI amplifies infection risk and procedure duration, particularly among hypoalbuminemic patients, facilitating actionable risk stratification for surgical teams.

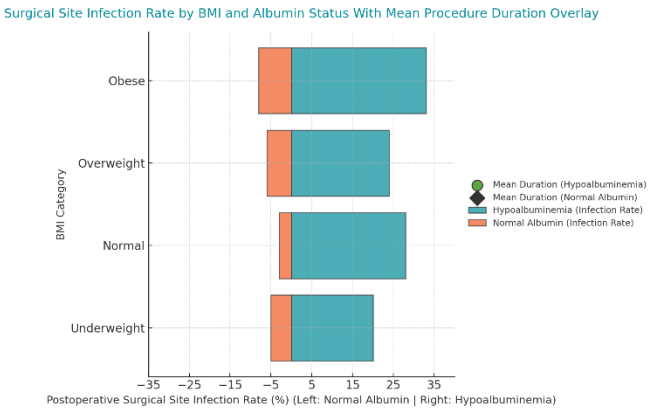

Figure 1 Surgical Site Infection Rate By BMI And Albumin Status with Mean Procedure Duration Overlay

DISCUSSION

The findings of this study reinforce the growing body of evidence that preoperative hypoalbuminemia is a significant and independent predictor of postoperative complications among patients undergoing laparotomy.

The incidence of major postoperative complications—particularly surgical site infection, anastomotic leak, gastrointestinal fistula, prolonged ileus, and burst abdomen—

was markedly higher in the hypoalbuminemia group than in patients with normal preoperative serum albumin levels. This observation is consistent with previous literature, which has repeatedly demonstrated that low preoperative serum albumin is a robust marker for poor surgical outcomes across a range of surgical disciplines (9–12). The nearly fivefold increase in overall complication risk observed in hypoalbuminemic patients in our cohort closely aligns with the risk elevations reported by Bhuyan et al. and Kumar et al., who documented complication rates of 45–59% in hypoalbuminemic surgical patients compared to rates of 3–6% in those with normal albumin (14,15). Similarly, Adogwa et al. observed that the risk of postoperative morbidity and mortality was significantly elevated in patients with reduced albumin levels, emphasizing the universal nature of this association, irrespective of surgical specialty (10,24).

The underlying mechanisms linking hypoalbuminemia to adverse surgical outcomes are multifactorial. Albumin is the primary plasma protein involved in maintaining oncotic pressure and is also integral to transport functions, antioxidant defense, and modulation of inflammatory responses (17). Hypoalbuminemia, as a surrogate for both malnutrition and systemic illness, likely reflects a state of impaired immune competence, reduced tissue healing capacity, and altered fluid homeostasis. This compromised physiological reserve may explain the higher rates of wound dehiscence, anastomotic failure, and infectious complications observed in our and other cohorts (18,19). The theoretical implications underscore the importance of nutritional status not just as a background variable but as a direct, modifiable determinant of surgical risk. This is particularly relevant for resource-limited settings, where preoperative optimization may be constrained but even simple interventions—such as nutritional supplementation—could yield significant reductions in morbidity and healthcare burden.

Comparative analysis with prior studies from diverse healthcare environments further substantiates the relevance of our results. While some variability exists in reported complication rates—potentially attributable to differences in patient demographics, comorbidity profiles, surgical techniques, and perioperative care—the overall trend remains consistent: hypoalbuminemic patients fare worse in the postoperative period (9,13,15,22,23). Our findings also corroborate those of Garg et al., who highlighted that advanced age and low albumin levels synergistically increase the risk for postoperative complications, suggesting that integrated risk assessment models may be warranted in clinical practice (22). Conversely, some reports have suggested that the predictive value of albumin may diminish in highly selected or optimally managed cohorts; however, these observations are the exception rather than the rule, and our data support the broader applicability of albumin as a universal risk stratifier (20,21).

The clinical relevance of these findings cannot be overstated. Identification of hypoalbuminemia as a modifiable preoperative risk factor offers surgeons and multidisciplinary teams a practical and cost-effective target for intervention. Early recognition, nutritional counseling, and targeted supplementation—potentially even brief, preoperative nutrition support—may reduce the incidence and severity of complications, thereby shortening hospital stays, improving patient quality of life, and reducing healthcare costs (13,19). Moreover, stratifying patients by albumin level can aid in surgical decision-making, risk counseling, and perioperative resource allocation.

Nonetheless, certain limitations of this study merit consideration. The sample size, while sufficient to detect statistically significant differences, was relatively modest and confined to a single tertiary care center. This may limit the generalizability of the results, particularly to populations with differing baseline nutritional status, comorbidity burdens, or access to perioperative care. The observational design, although strengthened by prospective data collection and rigorous follow-up, is susceptible to residual confounding despite the matched baseline characteristics. Laboratory and clinical assessments were standardized, but subtle variations in surgical technique and postoperative care may have influenced outcomes. Additionally, while all key data points were collected and no significant missing data impacted the analyses, the exclusion of patients with certain preexisting conditions may have led to selection bias.

Despite these constraints, this study provides robust, regionally relevant evidence supporting the integration of serum albumin measurement into preoperative risk assessment protocols for laparotomy patients. Future research should focus on multicenter trials with larger sample sizes and diverse populations to validate and refine albumin-based risk models. Randomized trials exploring the efficacy of preoperative nutritional optimization strategies in hypoalbuminemic patients are particularly warranted, as are mechanistic studies examining the pathways through which albumin influences tissue repair and immune function. Our findings underscore the predictive and clinical utility of preoperative serum albumin as a marker of postoperative risk in patients undergoing laparotomy. Addressing hypoalbuminemia prior to surgery represents an actionable strategy to mitigate surgical morbidity and improve outcomes, with clear implications for both individual patient care and broader health system performance (9–15,19–24).

CONCLUSION

This study demonstrates that preoperative hypoalbuminemia is significantly associated with an increased risk of postoperative surgical complications in patients undergoing laparotomy, emphasizing the value of serum albumin as a practical and reliable predictor for adverse surgical outcomes. Given these findings, routine assessment and targeted optimization of preoperative albumin levels should be integrated into surgical care pathways to improve patient safety, reduce morbidity, and enhance recovery. Clinically, early identification and correction of hypoalbuminemia offer an accessible strategy for risk reduction, while future research should focus on interventional trials and the development of standardized preoperative nutrition protocols to further advance surgical outcomes and patient care in diverse healthcare settings.

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