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Preoperative Hypocholesterolaemia and Hypoalbuminemia as Predictors of Surgical Site Infections in Elective Abdominal Surgeries: A Prospective Study

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ABSTRACT

Background: Hypocholesterolaemia, defined as total cholesterol and LDL-C levels below the 5th percentile for age, sex, and race, and hypoalbuminemia, defined as serum albumin below 3.5 g/dL, have been associated with impaired immune response and delayed wound healing. Recent studies have demonstrated a significant correlation between these biochemical markers and postoperative surgical site infections (SSI), particularly among patients undergoing abdominal surgeries.

Objective: This study aimed to evaluate the relationship between preoperative hypocholesterolaemia, hypoalbuminemia, and the incidence of SSI in elective abdominal surgeries and to identify predictive markers for postoperative complications.

Methods: A prospective observational study was conducted over 18 months on 66 patients undergoing elective abdominal surgeries at JSS Hospital, Mysuru. Preoperative serum cholesterol and albumin levels were measured and categorized into hypo-, hyper-, or normo-cholesterolaemia and hypo-, hyper-, or normo-albuminemia. Patients were monitored daily until discharge for signs of SSI, including erythema, pain, swelling, and pus discharge. Statistical analysis was performed to evaluate the correlation between biochemical parameters, SSI incidence, hospital stay duration, and demographic variables.

Results: The incidence of SSI was significantly higher among patients with hypocholesterolaemia (79.3%) compared to those with normal cholesterol levels (20.7%, $p<0.05$). Similarly, hypoalbuminemia was associated with an increased risk of SSI (79% versus 21%, $p<0.05$). Prolonged hospital stays, advanced age, and higher BMI were also significantly associated with the development of SSI.

Conclusion: Preoperative hypocholesterolaemia and hypoalbuminemia are strong predictors of postoperative SSI and longer hospital stays. Routine screening for these parameters, along with the assessment of BMI and age, may facilitate early identification of high-risk patients and enable targeted nutritional interventions to improve surgical outcomes and reduce SSI-related complications.

Keywords: *Hypocholesterolaemia, Hypoalbuminemia, Surgical Site Infection, Abdominal Surgery, Malnutrition, Cholesterol, Albumin, Preoperative Assessment, SSI Prevention, Nutritional Risk Screening*

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1. INTRODUCTION

Surgical site infections (SSI) remain one of the most common and significant postoperative complications worldwide, particularly following abdominal surgeries. They contribute substantially to prolonged hospital stays, increased morbidity, and higher healthcare costs. Despite advances in aseptic techniques, antibiotic prophylaxis, and surgical practices, the burden of SSI remains considerable, especially in low- and middle-income countries (LMICs), where infection control resources are often limited [1]. SSI is defined as an infection occurring at or near the surgical incision within 30 days of the procedure, or within 90 days when a prosthetic implant is involved [2]. The Centers for Disease Control and Prevention (CDC) classify SSI into three categories: superficial incisional, deep incisional, and organ/space infections [3].

The global prevalence of SSI varies widely, with developed countries reporting incidence rates of less than 5%, while LMICs experience substantially higher rates ranging from 5.4% to 18.7% [4]. In India, studies have reported SSI incidences between 3.4% and 36.1%, depending on surgical procedures and institutional practices [5]. Factors contributing to these variations include prolonged surgical duration, wound contamination, delayed diagnosis, poor infection control measures, lack of skilled personnel, and limited access to essential resources. The resulting economic burden is considerable, with hospital stays extending by an average of 10 to 11 days and treatment costs rising by up to 36% among patients developing SSI [6].

Hypocholesterolaemia has recently gained attention as an independent predictor of SSI. Defined as total cholesterol levels below the 5th percentile of population-specific norms, it is most commonly secondary to conditions such as malabsorption, critical illness, malignancy, and chronic systemic diseases [7]. Cholesterol plays an essential role in maintaining cell membrane integrity and modulating immune responses. Reduced levels may impair leukocyte activation and hinder tissue repair, thereby predisposing surgical patients to infectious complications [8]. Several studies have demonstrated a statistically significant association between preoperative hypocholesterolaemia and increased postoperative SSI rates [9].

Similarly, hypoalbuminemia, characterized by serum albumin levels below 3.5 g/dL, has been strongly associated with impaired wound healing, reduced immune competence, and increased susceptibility to infection [10]. Albumin is the most abundant plasma protein and serves multiple physiological functions, including maintaining oncotic pressure, transporting hormones and fatty acids, and acting as an antioxidant [11]. A meta-analysis has shown that patients with hypoalbuminemia have a 2.5-fold higher risk of developing SSI compared to those with normal levels [12].

The consequences of SSI are especially severe in resource-limited settings. Longer hospital stays, higher readmission rates, and increased treatment costs add to the burden on healthcare systems. Given these challenges, there is growing interest in identifying reliable, cost-effective preoperative predictors of SSI to enable early risk stratification and preventive interventions [13]. In this context, measuring serum cholesterol and albumin levels before surgery may provide valuable insights into patient vulnerability and guide appropriate perioperative strategies.

This study was undertaken to evaluate the association between preoperative hypocholesterolaemia, hypoalbuminemia, and the incidence of SSI in patients undergoing elective abdominal surgeries. By establishing the predictive value of these parameters, the findings aim to inform targeted nutritional interventions and improve surgical outcomes in both clinical and resource-constrained settings.

2. AIMS AND OBJECTIVES

The primary objective of this study was to evaluate the preoperative levels of serum albumin and serum cholesterol in patients undergoing elective abdominal surgeries at a tertiary care hospital. The secondary objective was to assess the development of postoperative surgical site infections in these patients and analyze their correlation with preoperative biochemical markers.

3. MATERIALS AND METHODS

Study Design

This was a prospective observational study conducted over a period of 18 months in the Department of General Surgery at JSS Hospital, Mysuru. The study aimed to evaluate the association between preoperative hypocholesterolaemia, hypoalbuminemia, and the incidence of surgical site infections in patients undergoing elective abdominal surgeries. Approval was obtained from the Institutional Ethics Committee prior to commencement of the study.

Study Setting

The study was conducted in a tertiary care teaching hospital equipped with advanced surgical facilities. All elective abdominal surgeries were performed in operation theatres maintaining standard sterilization and aseptic precautions. Postoperative patient monitoring was carried out in dedicated surgical wards by trained nursing and surgical staff to ensure consistent evaluation and accurate SSI detection.

Study Duration

The study was conducted over a period of 18 months, during which consecutive patients fulfilling the eligibility criteria were enrolled.

Study Population

A total of 66 patients undergoing elective abdominal surgeries were included in the study. The patient population comprised both males and females aged 18 years and above. Elective procedures included inguinal hernia repair, incisional hernia repair, umbilical hernia repair, cholecystectomy, and other major abdominal operations performed within the general surgery department.

Sample Size Calculation

The sample size was determined using the formula $n = Z^2 \times p(1-p)/d^2$, where Z represents the standard normal deviation at the required confidence level (1.96), p is the assumed prevalence of surgical site infection (12.5%), and d is the absolute precision (8%). Using these parameters, the required sample size was calculated to be 66 patients, which was achieved during the study period.

Eligibility Criteria

Patients aged 18 years and above undergoing elective abdominal surgeries were eligible for inclusion in the study. Those with existing wound infections, diabetes mellitus, immunocompromised states such as HIV positivity, corticosteroid therapy, or chemotherapy were excluded. Pregnant women, critically ill patients requiring emergency surgery, and individuals lost to follow-up were also excluded to maintain homogeneity of the study population.

Preoperative Assessment

All eligible patients underwent a comprehensive preoperative evaluation, including detailed history taking, physical examination, and necessary investigations. Informed written consent was obtained prior to enrollment. Blood samples were collected for measurement of serum total cholesterol and albumin levels using standardized biochemical assays performed in the hospital's central laboratory. Serum cholesterol was classified as hypocholesterolaemia (<151 mg/dL), hypercholesterolemia (>240 mg/dL), or normal. Serum albumin levels were categorized as hypoalbuminemia (<3.5 g/dL), hyperalbuminemia (>5.5 g/dL), or normal.

Intraoperative and Postoperative Management

All surgical procedures were performed under strict aseptic conditions. Perioperative antibiotic prophylaxis was administered as per institutional protocol. Patients were closely monitored postoperatively in surgical wards until discharge. Operative wounds were examined daily for evidence of SSI, which was identified based on the presence of erythema, local rise of temperature, swelling, pain, and pus discharge.

Outcome Measures

The primary outcome assessed was the incidence of surgical site infections among patients undergoing elective abdominal surgeries. Secondary outcomes included the correlation of SSI with preoperative serum cholesterol and albumin levels, duration of hospital stay, age, body mass index, and other demographic parameters.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee of JSS Hospital, Mysuru. Confidentiality of patient information was strictly maintained, and no additional financial burden was imposed on participants as the costs of relevant investigations were covered by the study investigator.

4. RESULTS

Patient Demographics

A total of 66 patients undergoing elective abdominal surgeries were included in the study. The age distribution is shown in Table 1. The majority of patients (36.4%) were between 51 and 60 years, followed by 25.8% between 41 and 50 years. Patients younger than 40 years accounted for 24.2% of the sample, while 13.7% were aged over 60 years.

Gender distribution was almost equal, with 34 males (51.5%) and 32 females (48.5%), ensuring balanced representation between sexes. No statistically significant difference was observed between gender and SSI occurrence (p=0.306), indicating that gender did not influence postoperative infection risk.

Table 1. Demographic Characteristics

Variable	Categories	Frequency	Percentage
Age (years)	21–30	8	12.1%
	31–40	8	12.1%
	41–50	17	25.8%
	51–60	24	36.4%
	61–70	5	7.6%
	71–80	4	6.1%
Gender	Male	34	51.5%
	Female	32	48.5%

Older patients (>50 years) demonstrated a significantly higher incidence of SSI (p=0.005). Among those aged 51–60 years, 37.9% developed SSI, compared to 17.2% in the 41–50 years group and none below 30 years. This suggests advancing age is a significant risk factor for SSI, likely due to reduced immune response and comorbid conditions.

Incidence and Classification of SSI

Out of 66 patients, 29 (43.9%) developed SSI, whereas 37 (56.1%) had uneventful postoperative recovery. Among SSIs, superficial infections accounted for 34.8%, deep incisional infections for 7.6%, and organ-space infections for 1.5% (Table 2). The predominance of superficial infections indicates that most SSIs were confined to the skin and subcutaneous tissues, whereas deep and organ-space infections, though less frequent, represent more severe complications requiring targeted interventions.

Table 2. Incidence and Classification of SSI

SSI Category	Frequency	Percentage
No SSI	37	56.1%
Superficial SSI	23	34.8%
Deep SSI	5	7.6%
Organ-space SSI	1	1.5%
Total	66	100%

Biochemical Parameters and SSI Correlation

Serum albumin and cholesterol levels were evaluated preoperatively to assess their predictive role in SSI. Exactly half of the patients had hypoalbuminemia, and 47% had hypocholesterolaemia. A strong correlation was observed between these biochemical markers and SSI incidence (Table 3). Among patients with hypoalbuminemia, 79.3% developed SSI compared to 20.7% in those with normal albumin levels (p<0.05). Similarly, 79.3% of patients with hypocholesterolaemia developed SSI versus 20.7% among those with normal cholesterol levels (p<0.05).

Additionally, low HDL levels were observed in 62.1% of patients, representing an additional nutritional risk factor, though HDL was not statistically analyzed separately for SSI prediction.

Table 3. Relationship Between Biochemical Parameters and SSI

Parameter	Category	SSI Present n (%)	SSI Absent n (%)	p-value
Serum Albumin	Hypoalbuminemia	23 (79.3%)	10 (27.0%)	<0.05
	Normal	6 (20.7%)	27 (73.0%)	
Total Cholesterol	Hypocholesterolaemia	23 (79.3%)	8 (21.6%)	<0.05
	Normal	6 (20.7%)	29 (78.4%)	
HDL Levels	Low	41 (62.1%)		
	Borderline	25 (37.9%)		

The results demonstrate that both hypoalbuminemia and hypocholesterolaemia are strong predictors of SSI. The findings highlight the importance of including preoperative screening for these parameters in surgical risk assessment protocols.

BMI, Surgical Factors, and Hospital Stay

Body mass index (BMI) was another significant factor influencing SSI incidence. Overweight patients (BMI ≥25) had a higher risk of SSI (34.5%) compared to those with normal BMI (10.8%), and this association was statistically significant ($p=0.019$).

The type of surgical procedure also impacted SSI risk, with higher infection rates observed in incisional hernia hernioplasty (20.7%) and laparoscopic cholecystectomy (13.8%). However, the association between surgical type and SSI occurrence did not reach statistical significance ($p=0.11$).

Duration of hospital stay was strongly correlated with SSI incidence. Patients without SSI had shorter stays (4–8 days in 91.9% cases), while 48.3% of patients with SSI required hospitalization for 9–13 days and 37.9% for 14–18 days ($p<0.05$).

Table 4. Association of BMI, Surgery Type, and Hospital Stay With SSI

Factor	Category	SSI Present n (%)	SSI Absent n (%)	p-value
BMI	Normal	19 (65.5%)	33 (89.2%)	0.019
	Overweight	10 (34.5%)	4 (10.8%)	
Surgery Type	Incisional Hernia Repair	6 (20.7%)	5 (13.5%)	0.11
	Laparoscopic Cholecystectomy	4 (13.8%)	14 (37.8%)	
	Others*	19 (65.5%)	18 (48.7%)	
Hospital Stay	4–8 days	3 (10.3%)	34 (91.9%)	<0.05
	9–13 days	14 (48.3%)	3 (8.1%)	
	14–18 days	11 (37.9%)	0 (0.0%)	
	>18 days	1 (3.4%)	0 (0.0%)	

*Includes hepaticojejunostomy, open cholecystectomy and umbilical hernioplasty.

This study demonstrated a high overall SSI rate of 43.9%. Significant associations were observed between SSI and older age, low serum albumin, low serum cholesterol, higher BMI, and longer hospital stays. Gender and type of surgical procedure did not show statistically significant correlations with SSI incidence. These findings emphasize the predictive value of preoperative nutritional markers and anthropometric measures in identifying high-risk patients and preventing postoperative complications.

5. DISCUSSION

In this prospective cohort study, the incidence of postoperative surgical site infections (SSI) was notably high at 43.9%, echoing rates observed in resource-limited settings and underlining the need for enhanced predictive strategies. The significant associations identified between SSI and preoperative hypoalbuminemia, hypocholesterolaemia, lower HDL levels, higher BMI, advanced age, and prolonged hospital stay reinforce the multifactorial nature of SSI risk with nutritional status emerging as a central theme.

Age emerged as a significant determinant, with individuals aged 51–60 years experiencing the highest SSI incidence (37.9%, $p = 0.005$). This finding dovetails with evidence indicating age-related decline in serum albumin and impaired healing capacity, as shown by Weaving et al. [11]. Advanced age is well-known to undermine both innate and adaptive immunity, and comorbidities more prevalent in older populations compound this vulnerability.

Although males comprised a slightly higher proportion of SSI cases (58.6%), gender was not a statistically significant predictor ($p = 0.306$). This aligns with findings by Platt et al. [12], where gender lost significance once confounding factors were accounted for, suggesting gender per se does not exert an independent effect on SSI risk.

Certain surgical procedures showed higher SSI incidence incisional hernia repairs (20.7%) and laparoscopic cholecystectomies (13.8%) though this did not reach statistical significance ($p = 0.11$). Platt and colleagues [12] emphasized that procedural complexity, duration, and wound contamination outweigh the procedure type itself in determining infection risk.

Microbiologically, SSI cases were predominantly associated with pathogens such as *Escherichia coli* (13.8%), *Staphylococcus epidermidis* (10.3%), and *Staphylococcus haemolyticus* (10.3%), alongside multidrug-resistant organisms like *Pseudomonas aeruginosa* and *Klebsiella pneumoniae*. This finding resonates with Brock et al. [13], who highlighted that malnourished patients are predisposed to infection with resistant bacteria due to compromised immune defenses.

Preoperative hypoalbuminemia showed a striking association with SSI: 79.3% of hypoalbuminemic patients developed infection, compared to just 20.7% with normal albumin levels ($p < 0.05$). Mean serum albumin among SSI cases (2.91 g/dL) was significantly lower than in non-infected individuals (3.67 g/dL). These results mirror the conclusions of Brock et al. [13], confirming hypoalbuminemia (<3.5 g/dL) as a robust predictor of poor wound healing and infection. Levitt and Levitt [14] further support the mechanistic plausibility, noting that hypoalbuminemia may signify chronic inflammation and catabolic stress.

Equally compelling was the predictive value of hypocholesterolaemia: 79.3% of patients with low total cholesterol developed SSI, compared to 20.7% with normal levels ($p < 0.05$). Cholesterol is essential for cellular repair, immune function, and endotoxin neutralization. Although data directly linking low cholesterol to SSI are limited, Brock et al. [13] recognized hypocholesterolaemia's association with increased postoperative infections in malnourished populations. The role of cholesterol and lipoproteins in modulating immune responses provides a strong pathophysiological basis [19].

High-density lipoprotein (HDL) levels were also notably diminished in SSI cases (mean 25.24 mg/dL) versus non-SSI cases (35.35 mg/dL). HDL is known to exert anti-inflammatory and immunomodulatory effects; Lee et al. [22] reported that low HDL predicts higher infection risk. Reduced HDL may therefore compromise the body's ability to regulate oxidative stress, inflammatory response, and innate immunity.

Body mass index (BMI) demonstrated a clear association with SSI risk: 34.5% of overweight individuals developed infection compared to only 10.8% with normal BMI ($p = 0.019$). This supports the findings of Egbert et al. [15], who documented obesity's contribution to tissue hypoperfusion, suboptimal oxygenation, and local inflammation factors that predispose to infection.

Length of hospital stay was significantly prolonged in SSI patients: 48.3% stayed 9–13 days and 37.9% stayed 14–18 days, while 91.9% of non-SSI patients were discharged within 4–8 days ($p < 0.05$). This underscores a well-documented cycle where SSI prolongs hospitalization, which in turn increases exposure risk and healthcare costs, as described by Perencevich et al. [16].

Superficial SSI accounted for 34.8% of cases, with deep and organ-space infections comprising 7.6% and 1.5%, respectively. Although less frequent, deeper infections are more resource-intensive and have greater morbidity, aligning with observations by Owens and Stoessel [17].

The clinical implications of these findings are clear. Routine preoperative assessment of serum albumin, total cholesterol, HDL, BMI, and age should become integral to SSI risk stratification. Patients identified as high-risk could benefit from targeted nutritional interventions such as protein supplementation, dietary optimization, and possibly albumin or lipid support alongside aggressive perioperative infection control measures. Lee et al. [22] and Brock et al. [13] support the efficacy of such interventions in improving healing and lowering complication rates.

In resource-constrained settings, where advanced perioperative monitoring may be limited, these simple, cost-effective biomarkers offer valuable predictive power. Implementing preoperative "nutritional optimization bundles" that include these parameters could significantly reduce SSI incidence and associated costs.

Strengths

This study comprehensively evaluated multiple preoperative and intraoperative factors influencing surgical site infections (SSI) in patients undergoing elective abdominal surgeries. Unlike previous studies that primarily focused on demographic or surgical characteristics, this work integrated biochemical markers such as serum albumin, total cholesterol, and HDL levels, providing a multidimensional risk assessment. The use of a structured STROBE-compliant methodology improved data quality and transparency. Additionally, the inclusion of detailed perioperative variables allowed meaningful stratification of SSI risk across patient subgroups, enhancing the clinical applicability of the findings.

Limitations

Despite its strengths, this study has certain limitations. The single-center design may restrict generalizability to broader populations. The relatively small sample size reduces the power to detect weaker associations, particularly for less common risk factors. Post-discharge surveillance was not performed beyond 30 days, potentially underestimating late-onset SSI. Lastly, residual confounding cannot be excluded despite careful adjustment for potential variables.

6. FUTURE DIRECTIONS

Future research should validate these findings through multicenter, large-scale prospective studies to enhance external validity. Integration of microbiological profiling alongside biochemical and clinical parameters may provide a more personalized risk prediction model. Incorporating advanced predictive analytics, such as machine learning–based SSI risk stratification, could support preoperative decision-making and optimize prophylactic strategies. Furthermore, interventional studies assessing the impact of nutritional optimization protocols targeting serum albumin, cholesterol, and HDL levels could clarify their causal relationship with SSI reduction.

7. CONCLUSION

This study demonstrates that nutritional status, biochemical markers, and perioperative factors significantly influence the risk of surgical site infections following elective abdominal surgeries. Hypoalbuminemia, hypocholesterolemia, low HDL levels, and elevated BMI emerged as independent predictors of SSI, underscoring the importance of preoperative metabolic and nutritional assessment. The findings highlight the need for multifaceted infection control strategies encompassing surgical technique, perioperative antibiotic prophylaxis, and prehabilitation measures aimed at improving patients' nutritional and immune status. By integrating these insights into clinical practice, healthcare teams can potentially reduce SSI incidence, improve surgical outcomes, and optimize resource utilization.

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