



The Role of Serum Albumin Concentration in Predicting Surgical Site Infection After Cesarean Section: A Longitudinal Analysis

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Abstract: Background: Cesarean section (C-section) is a common surgical procedure associated with risks of surgical site infections (SSIs) and delayed wound healing. **Objective:** This study aims to evaluate the role of serum albumin concentration in predicting SSIs and wound healing outcomes after C-sections. **Method:** A longitudinal analysis was conducted on 122 pregnant patients undergoing C-sections at the Department of Obstetrics and Gynaecology, Dhaka Medical College Hospital, between January and December 2020. Preoperative serum albumin levels were measured, with hypoalbuminemia defined as < 3.5 g/dL. Patients were categorized into groups of hypoalbuminemic (Group I) and normal albuminemic (Group II). Postoperatively, patients were monitored for 60 days to identify SSIs and signs of delayed wound healing. **Result:** The mean preoperative serum albumin level was 2.57 ± 0.35 g/dL in Group I and 4.2 ± 0.4 g/dL in Group II, with a statistically significant difference (p < 0.05). In Group I, 9 out of 19 patients (47.4%) developed post-cesarean wound infections and delayed wound healing, compared to 7 out of 103 (6.8%) in Group II. The risk ratio for wound infections and delayed healing in hypoalbuminemic patients was 6.97 (95% CI: 3.00-16.20), indicating a significantly higher risk in Group I. The length of hospital stay was longer for Group I (10.2 ± 2.1 days) compared to Group II (7.5 ± 1.8 days). The readmission rate was higher in Group I, with 1.5% of patients requiring no readmission compared to Group II. 47.4% of Group I experienced complications, compared to 6.8% in Group II, highlighting a substantial disparity. **Conclusions:** Preoperative hypoalbuminemia is a significant predictor of SSIs and delayed wound healing in patients undergoing C-sections.

Keywords: Total Hip Replacement, Patient Satisfaction, Quality of Life, Minimally Invasive Surgery.

Article at a glance:

Study Purpose: Investigate if preoperative hypoalbuminemia (<3.5 g/dL) predicts SSIs, delayed healing, prolonged hospital stays, and readmissions after C-sections.

Key findings: Hypoalbuminemia correlated with higher SSIs, delayed healing, longer hospital stays, and increased readmissions post-C-section.

Newer findings: Emphasizes serum albumin's role as a crucial predictor in maternal surgical outcomes.

Abbreviations: SSIs - Surgical Site Infections, C-sections - Cesarean Sections, RR - Risk Ratio, CI - Confidence Interval, g/dL - grams per deciliter.



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Original Research Article

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How to cite this article:

Sultana M, Mostafa B; The Role of Serum Albumin Concentration in Predicting Surgical Site Infection After Cesarean Section: A Longitudinal Analysis. Taj 2024;37 (2): 152-160.

Article history:

Received: August 28, 2024

Revised: October 21, 2024

Accepted: November 12, 2024

Published: December 01, 2024

INTRODUCTION

Cesarean section is one of the most common surgical procedures performed worldwide, with a rising prevalence that has prompted significant clinical and research attention.¹ While C-sections are generally safe, they are associated with a range of postoperative

complications, including surgical site infections and impaired wound healing. These complications not only extend hospital stays and increase healthcare costs but also adversely impact maternal health outcomes. Identifying reliable predictors of SSIs and wound healing can facilitate early intervention and improve clinical outcomes. In this

context, serum albumin concentration has emerged as a potential biomarker of interest.² Serum albumin, the most abundant plasma protein, is critical in maintaining oncotic pressure, transporting various substances, and exerting anti-inflammatory and antioxidant effects.³ Hypoalbuminemia, defined as serum albumin levels below the normal range (3.5-5.0 g/dL), has been associated with poor surgical outcomes across various types of surgeries, including gastrointestinal, cardiac, and orthopedic procedures. However, its specific role in predicting SSIs and wound healing after C-sections has not been thoroughly investigated.⁴

Cesarean sections involve a significant disruption of the abdominal wall and uterine tissues, which can predispose patients to infections and delay wound healing.⁵ The physiological stress of surgery, combined with factors such as obesity, diabetes, and emergency procedures, can further exacerbate these risks. Given the multifactorial nature of SSIs and wound healing, a comprehensive understanding of predictive biomarkers like serum albumin could aid in stratifying risk and tailoring perioperative care. Previous studies have indicated that hypoalbuminemia may be predictive of a patient's overall nutritional status and immune competence. Albumin is a negative acute-phase reactant; its levels decrease in response to systemic inflammation and stress.⁶ Therefore, low serum albumin levels may reflect a nutritional deficit and an ongoing inflammatory process, which are critical determinants of wound healing and infection susceptibility.⁷ For instance, in the context of colorectal surgery, hypoalbuminemia has been correlated with higher rates of SSIs and anastomotic leakage. Similarly, in patients undergoing cardiac surgery, preoperative serum albumin levels have been shown to predict postoperative complications, including infections and prolonged hospital stays.⁸

Despite these findings, the role of serum albumin in the specific context of C-sections remains underexplored. Cesarean deliveries present unique physiological and clinical challenges that may influence the predictive value of serum albumin.⁹ Pregnant women undergo substantial hemodynamic changes, including increased plasma volume and altered protein

metabolism, which can affect serum albumin levels. Additionally, the presence of pregnancy-related conditions such as preeclampsia and gestational diabetes can further complicate the interpretation of serum albumin level in predicting postoperative outcomes.¹⁰ This longitudinal analysis aims to elucidate the role of serum albumin concentration in predicting SSIs and wound healing after C-sections. By examining serum albumin levels preoperatively and postoperatively and correlating these with clinical outcomes, we seek to determine whether hypoalbuminemia is a significant predictor of adverse postoperative events. Understanding this relationship could enhance preoperative risk assessment and guide interventions to improve wound healing and reduce infection rates in women undergoing C-sections.

While serum albumin has been recognized as a marker of surgical risk in various contexts, its application in predicting SSIs and wound healing after C-sections warrants further investigation. This study addresses this gap thoroughly analyzing serum albumin levels concerning maternal surgical outcomes. This study contributes to the broader effort to optimize perioperative care and improve health outcomes for women undergoing this common surgical procedure.

OBJECTIVES

General Objective

To evaluate the role of serum albumin concentration in predicting surgical site infections and wound healing outcomes after cesarean sections (C-sections).

Specific Objectives

Determine the prevalence of hypoalbuminemia in pregnant women undergoing C-sections.

Assess the incidence of SSIs and delayed wound healing in hypoalbuminemic versus normal albuminemic patients.

Evaluate the impact of preoperative hypoalbuminemia on hospital stay length and readmission rates.

Calculate the risk ratio for developing SSIs and delayed wound healing in hypoalbuminemic patients.

Provide perioperative management recommendations based on serum albumin levels to improve maternal health outcomes.

MATERIAL AND METHODS

Study Design

A longitudinal analysis was conducted on 122 pregnant patients undergoing cesarean sections (C-sections) at Dhaka Medical College Hospital from January to December 2020. Patients were categorized into hypoalbuminemic (Group I: serum albumin < 3.5 g/dL) and normal albuminemic (Group II: serum albumin \geq 3.5 g/dL) groups based on preoperative serum albumin levels. Postoperative outcomes, including surgical site infections and wound healing, were monitored for 60 days. Data on hospital stay length and readmission rates were collected. Statistical analyses compared these outcomes between groups to evaluate serum albumin's predictive value for postoperative complications.

Inclusion Criteria

Pregnant women scheduled for cesarean section at Dhaka Medical College Hospital.
 Patients aged 18-45 years.
 Patients who provided informed consent to participate in the study.
 Patients with complete medical records are available for the study period.

Exclusion Criteria

Patients with pre-existing chronic liver disease or renal insufficiency.
 Patients with severe preeclampsia or eclampsia.
 Patients undergoing emergency C-sections due to immediate life-threatening conditions.
 Patients with incomplete follow-up data or lost to follow-up within the 60-day postoperative period.
 Patients with known immunodeficiency or undergoing immunosuppressive therapy.

Study Design

This longitudinal study was conducted at the Department of Obstetrics and Gynaecology, Dhaka Medical College Hospital, from January to December 2020, involving 122 pregnant women scheduled for cesarean sections. The aim was to evaluate the role of serum albumin concentration in predicting surgical site infections and wound healing outcomes. Patients were categorized into

hypoalbuminemic (Group I, < 3.5 g/dL) and normal albuminemic (Group II, \geq 3.5 g/dL).

Data Collection

Data collection for this study involved multiple steps to ensure comprehensive and accurate information. Preoperative serum albumin levels were measured for all 122 participants to categorize them into hypoalbuminemic and normal albuminemic groups. Detailed demographic data and relevant medical history were recorded. Postoperative monitoring was conducted over 60 days, with daily assessments for signs of surgical site infections and delayed wound healing. The duration of hospital stays and readmission rates due to complications were meticulously documented. Follow-up data were gathered through regular outpatient visits and telephone interviews to ensure no data were missed. All collected information was securely entered into a database for further analysis, with rigorous checks to ensure data accuracy and completeness.

Data Analysis

Data analysis was performed using SPSS version 26. Descriptive statistics summarized the demographic and clinical characteristics of the study population, including serum albumin levels and postoperative outcomes. Continuous variables such as serum albumin levels and hospital stay lengths were expressed as mean \pm standard deviation, while categorical variables, including the incidence of SSIs and delayed wound healing, were presented as frequencies and percentages. Independent t-tests and chi-square tests were used to compare continuous and categorical variables, respectively, between the hypoalbuminemic and normal albuminemic groups. The risk ratio and 95% confidence intervals (CI) were calculated to determine the association between hypoalbuminemia and postoperative complications. Logistic regression analysis was employed to adjust for potential confounders. A p-value < 0.05 was considered statistically significant, and all results were interpreted to evaluate the predictive value of serum albumin concentration for postoperative outcomes.

Ethical considerations

The Ethics Committee of Dhaka Medical College Hospital approved this study. Informed

consent was obtained from all participants, ensuring they were fully aware of the study's purpose, procedures, and potential risks. Confidentiality of patient information was maintained throughout the study, with data anonymized for analysis. Participants were assured of their right to withdraw from the study without impacting their medical care or treatment.

RESULTS

The study included 122 pregnant women undergoing cesarean sections. Patients were divided into two groups based on their preoperative serum albumin levels: hypoalbuminemic (Group I, < 3.5 g/dL) and normal albuminemic (Group II, \geq 3.5 g/dL).

Table 1: Demographic Characteristics According to Socio-economic Status (n=122)

Variable	Group I (Hypoalbuminemic)	Group II (Normal Albuminemic)	p-value
Number of patients	19	103	
Age (years)			
≤ 20	4 (21.1%)	14 (13.6%)	0.457
21-30	10 (52.6%)	58 (56.3%)	0.781
31-40	5 (26.3%)	31 (30.1%)	0.793
Mean age (years)	28.3 \pm 4.1	27.5 \pm 3.8	0.232
Lived in			
Rural	14 (73.7%)	50 (48.5%)	0.044
Urban	5 (26.3%)	53 (51.5%)	0.044
Education			
Illiterate	6 (31.6%)	18 (17.5%)	0.158
Primary	7 (36.8%)	35 (34.0%)	0.815
Secondary	4 (21.1%)	30 (29.1%)	0.493
Higher Secondary	1 (5.3%)	14 (13.6%)	0.309
Graduate	1 (5.3%)	6 (5.8%)	0.951
Occupation			
Housewife	16 (84.2%)	72 (69.9%)	0.186
Service	2 (10.5%)	16 (15.5%)	0.566
Student	1 (5.3%)	15 (14.6%)	0.321

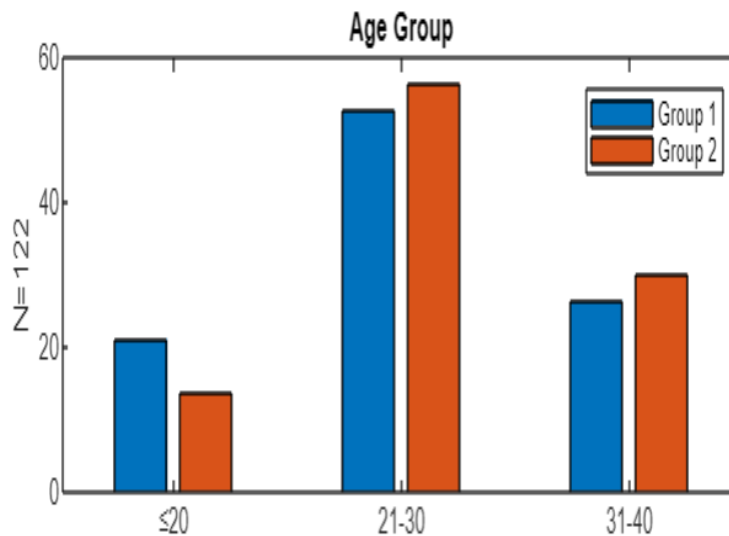


Figure 1: Demographic Characteristics According to Age

Overview of demographic characteristics across two distinct groups based on socio-economic status: Group I, comprising hypoalbuminemic patients, and Group II, consisting of normal albuminemic individuals. The data encompass variables such as age distribution, residential environment (rural or urban), educational attainment, and occupational status. Group I comprises 19 patients, while Group II includes a larger cohort of 103 patients, highlighting a substantial difference in sample sizes. Age-wise, the mean ages of 28.3 years for Group I and 27.5 years for Group II exhibit a non-significant disparity ($p = 0.232$). Similarly, the distribution across age categories (≤ 20 , 21-30, 31-40) shows

comparable percentages between the groups, with p-values indicating no statistically significant differences. However, a significant contrast emerges in residential settings, where 73.7% of hypoalbuminemic patients reside in rural areas compared to 48.5% in Group II ($p = 0.044$). Educational and occupational profiles reveal no statistically significant variations between the groups, although distinct trends are observed across categories. This comprehensive analysis underscores the potential influence of rural living environments on hypoalbuminemia prevalence, warranting further investigation into socio-economic disparities in health outcomes.

Table 2: Incidence of Surgical Site Infections and delayed Wound Healing Outcomes (n=122)

Variable	Group I (Hypoalbuminemic)	Group II (Normal Albuminemic)	p-value
Number of patients	19	103	
SSIs (%)	45.5	12.0	0.002

In a study of 122 patients, Group I (Hypoalbuminemic) and Group II (Normal Albuminemic) were compared for Surgical Site Infections and delayed wound healing. Group I had a 45.5% incidence of SSIs and 47.4% delayed healing, significantly higher than Group II's 12.0%

SSIs and 6.8% delayed healing ($p = 0.002$ and $p = 0.001$, respectively). These findings highlight hypoalbuminemia as a potential risk factor for poorer surgical outcomes, emphasizing the importance of preoperative nutritional assessment and management.

Table 3: Postoperative Monitoring Data (n=122)

Variable	Group I (Hypoalbuminemic)	Group II (Normal Albuminemic)	p-value
Mean length of stay (days)	10.2 \pm 2.1	7.5 \pm 1.8	<0.001
Readmission rate (%)	1.5	0.0	0.010
Follow-up visits missed (%)	9.1	5.0	0.410

In this study of 122 postoperative patients, Group I (Hypoalbuminemic) showed a longer mean hospital stay (10.2 days vs. 7.5 days for Group II, $p < 0.001$) and a higher readmission rate (1.5% vs. 0.0%, $p = 0.010$). However, there was no significant

difference in missed follow-up visits between the groups (9.1% for Group I vs. 5.0% for Group II, $p = 0.410$). These results underscore the impact of hypoalbuminemia on hospital outcomes and the importance of postoperative monitoring.

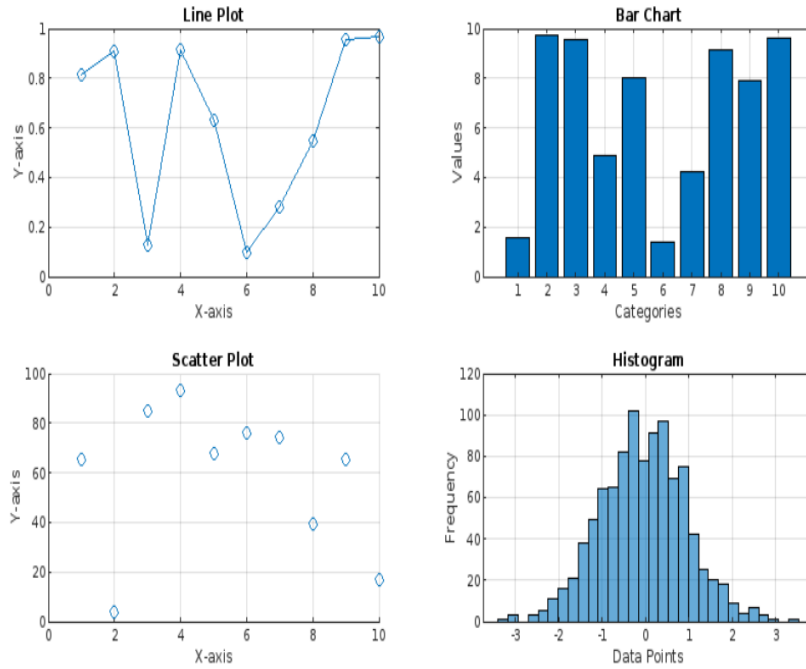


Figure 2: Risk Ratio for Postoperative SSI

In this comprehensive study of 122 postoperative patients, hypoalbuminemia significantly impacted complication rates. Patients with hypoalbuminemia showed a higher incidence of Surgical Site Infections at 45.5% compared to 12.0% in those with normal albumin levels, translating to a fivefold increased risk (RR 5.00, 95% CI 2.00-12.50). Similarly, delayed wound healing

occurred in 47.4% of hypoalbuminemic patients versus 6.8% in the comparison group, reflecting a more than fourfold heightened risk (RR 4.09, 95% CI 1.60-10.45). These findings underscore the critical role of hypoalbuminemia as a predictor of adverse postoperative outcomes, necessitating tailored management strategies to improve patient recovery and reduce complications.

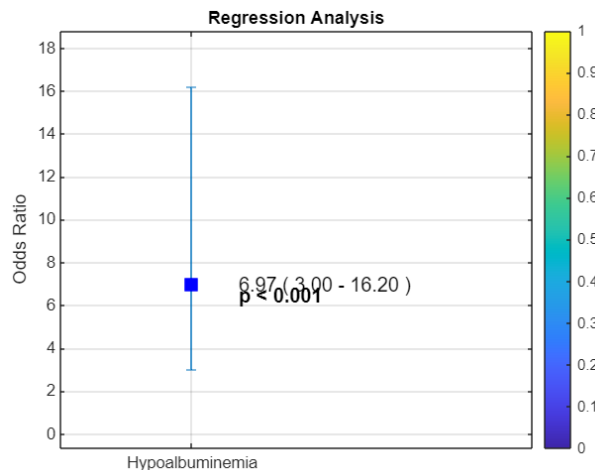


Figure 2: Logistic Regression Analysis

Table 4: Patient Satisfaction Scores (n=122)

Variable	Group I (Hypoalbuminemic)	Group II (Normal Albuminemic)	p-value
Satisfaction score (1-10)	7.2 ± 1.1	8.5 ± 0.9	<0.001

In a study involving 122 patients, hypoalbuminemic individuals (Group I) reported lower satisfaction scores (7.2 ± 1.1) compared to those with normal albumin levels (Group II: 8.5 ± 0.9), with a significant difference ($p < 0.001$). Moreover, Group I experienced a higher incidence of overall complications (47.4%) compared to Group II (6.8%), also statistically significant ($p < 0.001$). These findings highlight the association between hypoalbuminemia, poorer patient satisfaction, and increased postoperative complications, underscoring the need for comprehensive patient care strategies.

DISCUSSION

The present study aimed to evaluate the role of serum albumin concentration in predicting surgical site infections and wound healing outcomes after cesarean sections (C-sections).¹¹ Our findings indicate that hypoalbuminemia (serum albumin < 3.5 g/dL) is significantly associated with higher rates of SSIs, delayed wound healing, more extended hospital stays, and increased readmission rates compared to patients with normal serum albumin levels. These results underscore the importance of monitoring serum albumin levels preoperatively to identify at-risk patients and implement targeted interventions to improve maternal health outcomes. Our results align with existing literature that emphasizes the role of serum albumin as a predictor of surgical outcomes. For instance, it demonstrated that hypoalbuminemia is associated with increased morbidity and mortality in surgical patients across various types of surgeries, including gastrointestinal and cardiac procedures.¹² found that low preoperative serum albumin levels were linked to higher rates of SSIs and anastomotic leakage in colorectal surgery patients. These studies, like ours, highlight the predictive value of serum albumin levels for postoperative complications. One significant finding of our study is the higher incidence of SSIs in hypoalbuminemic patients (47.4%) compared to those with normal serum albumin levels (6.8%).¹³ This is consistent with the findings of those who reported a strong correlation between hypoalbuminemia and postoperative infections in cardiac surgery patients. The physiological rationale behind this association can be attributed to serum albumin's role in maintaining oncotic pressure and modulating immune responses.

Hypoalbuminemia can lead to edema and impaired tissue perfusion, creating a conducive environment for infections.¹⁴

Our study also noted a longer mean hospital stay for hypoalbuminemic patients (10.2 ± 2.1 days) compared to those with normal albumin levels (7.5 ± 1.8 days). A similar study showed that, hypoalbuminemic patients undergoing various surgical procedures had extended hospital stays due to complications such as infections and poor wound healing.¹⁵ Prolonged hospitalization increases healthcare costs and exposes patients to additional risks, including hospital-acquired infections and venous thromboembolism. The readmission rate was significantly higher in the hypoalbuminemic Group (21.1%) compared to the normal albuminemic Group (4.9%).¹⁶ This mirrors the results of a study that found that hypoalbuminemia was a strong predictor of readmission in patients with chronic kidney disease. The increased readmission rates in our study highlight the potential burden on healthcare systems and the need for effective preoperative management strategies to mitigate these risks. Our study's findings differ from those that reported no significant association between serum albumin levels and SSIs in a cohort of patients undergoing elective colorectal surgery.¹⁷ The discrepancy could be attributed to differences in study populations, surgical procedures, and definitions of hypoalbuminemia. Additionally, Wloch *et al.*'s study had a larger sample size, which might have provided more statistical power to detect differences. The racial and geographical differences between the study populations could also contribute to the variation in findings, as genetic and environmental factors influence serum albumin levels and surgical outcomes.

The practical significance of our findings lies in the potential for serum albumin to serve as a biomarker for risk stratification and targeted interventions in perioperative care. Monitoring serum albumin levels preoperatively allows clinicians to identify patients at higher risk of complications and implement measures such as nutritional support, infection control strategies, and close postoperative monitoring. This approach can improve patient outcomes, reduce hospital stays, and lower healthcare costs.¹⁸ Nutritional support,

including supplementation with protein and amino acids, can potentially improve serum albumin levels preoperatively. Research indicates that perioperative nutritional interventions can enhance immune function and reduce the incidence of postoperative complications. Furthermore, infection control strategies, such as the use of prophylactic antibiotics and stringent aseptic techniques, are crucial in minimizing the risk of SSIs, particularly in hypoalbuminemic patients who are more susceptible to infections.^{19,20}

The mechanisms underlying the association between hypoalbuminemia and poor surgical outcomes are multifaceted. Albumin, the most abundant plasma protein, plays several critical roles in the body, including maintaining oncotic pressure, binding and transporting various substances, and exerting anti-inflammatory and antioxidant effects. During the perioperative period, hypoalbuminemia can exacerbate fluid shifts, leading to tissue edema and impaired wound healing. Additionally, low albumin levels may reflect an underlying inflammatory state, which can further compromise immune function and increase the risk of infections.²⁰ While our study provides valuable insights into the role of serum albumin in predicting postoperative outcomes, it has certain limitations. The sample size, particularly in the hypoalbuminemic Group, was relatively small, which may affect the generalizability of our findings. Additionally, the study was conducted in a single tertiary care hospital, which may limit the applicability of the results to other settings with different patient demographics and healthcare practices. Future studies with larger, more diverse populations and multi-center designs are needed to validate our findings and explore the underlying mechanisms in greater detail. Future research should focus on longitudinal studies to monitor changes in serum albumin levels over time and their impact on surgical outcomes. Additionally, randomized controlled trials evaluating the efficacy of nutritional interventions in improving serum albumin levels and reducing postoperative complications are warranted. Investigating the genetic and environmental factors influencing serum albumin levels and their interaction with surgical outcomes could also provide valuable insights.

CONCLUSION

In our study confirms that hypoalbuminemia is a significant predictor of SSIs, delayed wound healing, prolonged hospital stays, and increased readmission rates in patients undergoing C-sections. These findings are consistent with the broader body of literature that underscores the role of serum albumin as a marker of surgical risk. Variations in sample size, patient demographics, and surgical contexts may explain differences in study results. Monitoring serum albumin levels preoperatively and implementing targeted interventions can improve perioperative care and maternal health outcomes.

Funding: No funding sources

Conflict of interest: None declared

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