The effect of albumin transfusion on the CRP/albumin ratio in gastrointestinal surgery

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Abstract

***Background*: The incidence of sepsis following gastrointestinal surgery remains high, despite advancements in treatment over recent decades. One significant factor contributing to this condition is preoperative albumin levels. Hypoalbuminemia can impair the immune response, potentially increasing susceptibility to postoperative complications. C-reactive protein (CRP) is an acute-phase protein released in response to cytokine stimulation during infection, ischemia, trauma, and other inflammatory conditions. This study aimed to evaluate the impact of preoperative albumin transfusion on the postoperative CRP-to-albumin ratio in patients undergoing gastrointestinal surgery.**

***Methods*: This cross-sectional analytical observational study included patients aged 20-60 years who underwent elective gastrointestinal surgery, had preoperative albumin levels of 2.0-2.7 g/dl, and surgeries lasting 2-4 hours. Exclusion criteria included patients with liver disease, sepsis, or blood loss exceeding 20% of estimated blood volume (EBV). Participants were divided into two groups: Group A, which received 25% albumin transfusion, and Group B, which did not. Albumin and CRP levels were measured 24 hours postoperatively.**

***Results*: A total of 51 patients were included: 26 in Group A and 25 in Group B. Preoperative albumin levels were significantly higher in Group A compared to Group B ($p<0.05$). No significant differences were observed in other baseline characteristics between the groups. Postoperative CRP/albumin ratios showed no significant differences between the two groups.**

***Conclusion*: Preoperative albumin transfusion in patients with hypoalbuminemia may increase preoperative albumin levels; however, its effect on reducing the postoperative CRP/albumin ratio remains uncertain.**

Key words: Hypoalbumin, C-reactive protein (CRP), gastrointestinal surgery.

Introduction

Gastrointestinal postoperative sepsis is associated with a high risk of complications following surgical procedures. Approximately 33% of patients undergoing gastrointestinal surgery may develop postoperative complications, including a 14.6% incidence of gastrointestinal infections. Managing patients with intra-abdominal sepsis is challenging, with a postoperative mortality rate of 17% following major gastrointestinal surgeries due to infection. (1) Several factors contribute to the risk of infection, including: 1) disease-related factors (severity of illness), 2) patient-related factors (preoperative condition), and 3) surgical factors (technique and surgeon expertise). (2)

Nutritional status is a critical patient-related factor influencing postoperative outcomes. Albumin, a single polypeptide protein, is a quantitative marker of nutritional status. Albumin plays vital roles in maintaining oncotic pressure, binding and transporting drugs and solutes, scavenging free radicals, exerting antithrombotic effects, and preserving vascular permeability, particularly in septic shock pa-

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tients. Hypoalbuminemia is categorized into three grades: mild (3.0-3.49 g/dl), moderate (2.5-2.99 g/dl), and severe (<2.5 g/dl). (3-5)

Patients with severe hypoalbuminemia are at increased risk of postoperative complications, with a mortality rate of approximately 14%. (6) Measuring serum albumin is a routine test for surgical patients, particularly those undergoing major surgeries and those with multiple comorbidities, malnutrition, or severe chronic illnesses. Garg et al. (2014) demonstrated that low preoperative albumin levels significantly increase the risk of postoperative complications and mortality. Their study identified preoperative albumin levels as a strong predictor of postoperative outcomes, including complications and mortality risk. (7)

Patients with gastrointestinal disorders often present with moderate to severe hypoalbuminemia. One strategy to optimize albumin levels preoperatively within a short period is albumin transfusion. However, the cost of albumin transfusion is considerable, leading many hospitals to implement policies restricting transfusions to patients with albumin levels below 2.5 g/dl.

C-reactive protein (CRP) is an acute-phase reactant released in response to cytokine stimulation during infection, ischemia, trauma, and other inflammatory conditions. CRP is a well-established biomarker for predicting patient prognosis. Studies suggest that the CRP/albumin ratio is a more reliable predictor of mortality than CRP alone, and it has gained widespread use as a prognostic indicator. (8,9)

The aim of this study was to evaluate the effect of preoperative albumin transfusion on the postoperative CRP/albumin ratio. The findings are expected to provide evidence-based guidance to improve outcomes for hypoalbuminemic patients undergoing gastrointestinal surgery.

Methods

This study was conducted in the Intensive Care Unit (ICU) of Prof. Dr. Margono Soekarjo Hospital. Its design was a cross-sectional analytical observational study. Sampling was performed after obtaining ethical approval and research permission from the Ethics Committee of Prof. Dr. Margono Soekarjo Hospital (No. 420/11010/2024), and written informed consent was obtained from each participant's family members. The study subjects were postoperative gastrointestinal patients admitted to the ICU who met the inclusion and exclusion criteria.

The inclusion criteria were adult patients aged 20-60 who underwent elective gastrointestinal surgery, had preoperative albumin levels between 2.0 and 2.7 g/dl, and underwent surgery lasting 2-4 hours. Patients with liver dysfunction, sepsis, or blood loss exceeding 20% of the estimated blood volume (EBV) were excluded from the study. In accordance with hospital protocol, albumin transfusion was administered to patients with albumin levels below 2.5 g/dl.

The subjects were divided into two groups. Group A consisted of subjects who received a 25% albumin transfusion, where the pre-transfusion albumin level was less than 2.5 g/dl, while Group B included subjects who did not receive albumin transfusion because their albumin levels were above 2.5 g/dl.

After obtaining family consent, data on sample characteristics, including age, gender, comorbidities, type of surgery, preoperative leukocyte count, preoperative neutrophil-to-lymphocyte ratio (NLR), pre-transfusion albumin levels, and duration of surgery, were recorded. Albumin and CRP levels were measured 24 hours after surgery by obtaining a 5 ml blood sample from the right antecubital vein.

All data underwent a distribution test using the Kolmogorov-Smirnov method before analysis. Since the data distribution was found to be abnormal, statistical analysis was performed using Fisher's exact test for age, gender, comorbidities, and type of surgery. The preoperative leukocyte count, preoperative NLR, pre-transfusion albumin levels, duration of surgery, postoperative albumin levels, postoperative CRP levels, and the albumin/CRP ratio were analyzed using the Mann-Whitney U test. Statistical significance was defined as $p \leq 0.05$.

Result

The total sample obtained for this study consisted of 51 patients, with 26 patients in Group A and 25 in Group B. The sample characteristics are presented in **Table 1**. Statistical analysis of the variables, including age, gender, comorbid conditions (hypertension, diabetes mellitus, pulmonary disease, and renal impairment), duration of surgery, preoperative leukocyte count, NLR, and type of surgery, revealed no statistically significant differences between the two groups ($p>0.05$). However, a significant difference was observed in pretransfusion albumin levels between the two groups. Specifically, Group A had a mean albumin level of 2.37±0.13 g/dl, whereas Group B had a mean level of 2.54±0.14 g/dl. This difference was statistically significant ($p<0.05$).

The variables of preoperative albumin levels, postoperative CRP, and the postoperative albumin/CRP ratio for the two groups are presented in **Table 2** and illustrated in **Figure 1**. Statistical analysis revealed a significant difference in preoperative albumin levels between the two groups ($p < 0.01$). However, the

CRP/albumin ratio graph (**Figure 2**) indicates no significant difference in the postoperative CRP/albumin ratio between the two groups ($p > 0.05$).

Discussion

Gastrointestinal surgery is considered one of the major surgical procedures associated with a high risk of postoperative infection. In his study, Po-Yi Chen (2019) reported that the incidence of sepsis was higher in gastrointestinal surgeries, including gastric, gallbladder, and colorectal procedures. (10) The disruption of the intestinal mucosal barrier caused by gastrointestinal manipulation has been identified as a key factor in bacterial translocation from the intestine to the vascular bed. The intestinal mucosa also functions as an immune barrier, with mucosal epithelial cells forming tight junctions supported by proteins that maintain mucosal permeability. Additionally, the luminal surface contains secretory immunoglobulin A (IgA), which prevents pathogenic bacteria from adhering to the epithelial cells. The role of proteins in maintaining intestinal barrier function is critical to this process. (11)

Gastrointestinal surgery induces significant tissue trauma, which can lead to a marked decrease in postoperative albumin levels. Other contributing factors include the duration of surgery, intraoperative bleeding, surgical technique, and fluid management. The precise mechanisms underlying perioperative albumin metabolism remain incompletely understood. However, from a pathophysiological perspective, the postoperative decline in albumin may be attributed to an inflammatory response, leading to capillary leakage, reduced hepatic synthesis, and dilutional effects. (12)

A rapid and significant decline in postoperative albumin levels has been correlated with an increased incidence of postoperative complications. (13) Albumin plays a pivotal role in the perioperative period, enhancing vascular endothelial function and modulating the inflammatory response. Gastrointestinal surgeries often elicit significant inflammation, releasing large quantities of cytokines that contribute to increased vascular permeability and bacterial translocation, elevating the risk of sepsis. Additional consequences include impaired wound healing, edema, and fluid retention. Intestinal edema may impair organ perfusion, hinder wound healing, and facilitate microbial translocation into the systemic circulation. Albumin mitigates these effects by binding pro-inflammatory cytokines, reducing the impact of excessive inflammation, and enhancing vascular integrity by minimizing capillary permeability.

The predictive value of albumin in postoperative outcomes is well-documented. Labgaa (2016) demonstrated that a decrease in albumin levels exceeding 10 g/l tripled the risk of postoperative complications. (13) Similarly, Issangya (2020) reported that preoperative albumin levels below 3.4 g/dl were associated with an increased risk of postoperative complications. (14) Galata (2020) identified pre- and postoperative delta-albumin as predictors of complication risk and morbidity in bowel surgery. (15) Furthermore, Arun (2020) concluded that preoperative albumin levels serve as prognostic indicators of surgical outcomes. (16) Preoperative albumin has also been identified as a predictor of prolonged postoperative ileus in gastrointestinal surgery. (17)

This study demonstrates that albumin transfusion significantly increases serum albumin levels before surgery. Pretransfusion albumin levels were significantly lower in Group A compared to Group B. However, following transfusion, Group A exhibited a marked increase in albumin levels relative to Group B. CRP is a well-established inflammation biomarker. In the acute postoperative phase, albumin levels exhibited an inverse correlation with CRP. The postoperative decline in albumin may be attributable to an elevated inflammatory response, as evidenced by increased postoperative CRP levels. (9,15)

Kyungtae (2018) identified CRP levels exceeding 125 mg/l as significant predictors of anastomotic leak and sepsis in gastrointestinal surgery. The CRP/albumin ratio is increasingly utilized as an inflammatory biomarker, often preferred over CRP alone. Elevated CRP levels reflect heightened inflammation, leading to hypoalbuminemia and an elevated CRP/albumin ratio. (18,19)

Elevated CRP levels may result from systemic inflammation, including sepsis. Kim's study reported a CRP/albumin ratio cutoff of 5.09 as a predictor of mortality in septic patients. (8) In this study, the postoperative CRP/albumin ratio did not differ significantly between the two groups. However, preoperative albumin levels were significantly higher in the transfusion group compared to the control group, suggesting a potentially heightened inflammatory response in the transfusion group. Confounding factors influencing postoperative CRP levels include tissue damage during surgery and intraoperative hemodynamics. For example, hypotension has been shown to decrease albumin levels and increase the CRP/albumin ratio.

A high CRP/albumin ratio indicates elevated CRP and reduced albumin levels due to inflammation and surgical manipulation. Zhang (2023) demonstrated the utility of the CRP/albumin ratio as a predictive

marker for inflammation. Shibutani (2021) reported that elevated postoperative CRP levels were closely related to the extent of tissue damage and the duration of surgery. (8,17) Gaetan (2022) found that decreased postoperative albumin levels in gastrointestinal surgery increased the risk of postoperative complications. (12)

The administration of albumin infusions has been shown to mitigate immunosuppression and restore phagocyte function, promoting bacterial clearance. Albumin reduces prostaglandin E2-mediated immunosuppression, (13) thereby supporting the immune response against infection. In patients with renal failure, albumin infusions have been associated with a reduced risk of spontaneous bacterial peritonitis. (20)

The findings of this study also indicate that factors such as age, gender, and body mass index (BMI) do not influence the postoperative CRP/albumin ratio. (21) A decline in the CRP/albumin ratio during intensive care unit (ICU) treatment can guide decisions regarding ICU discharge timing. (22) However, the study's limitations include the exclusion of patients with albumin levels greater than 2.5 g/dl, resulting in persistent hypoalbuminemia despite albumin infusion and a high CRP/albumin ratio.

Conclusion

The administration of albumin transfusions in patients diagnosed with hypoalbuminemia has been shown to elevate serum albumin levels prior to surgical intervention. However, the efficacy of this treatment in reducing the postoperative CRP/albumin ratio remains uncertain. Further research is necessary to elucidate the impact of preoperative albumin transfusions on postoperative inflammatory markers and overall patient outcomes.

Table 1. Characteristic of sample

Variable	Group A (transfusion)	Group B (control)	p
Gender, n (%) - Male - Female	 15 (57%) 11 (42%)	 14 (56%) 11 (44%)	
Age (years), mean±SD	48.56±9.95	46±10.29	0.52
DM, n (%)	3 (11.5%)	3 (12%)	0.647
HT, n (%)	4 (15.4%)	4 (16%)	0.626
Renal insufficiency, n (%)	3 (11.5%)	3 (12%)	
Lung diseases, n (%)	1 (3%)	0 (0%)	
Leucocyte preoperative (cells/µl), mean±SD	10.67±1.817	9.67±1.65	0.54
NLR, mean±SD	10.9±8.9	8.22±7.74	0.35
Albumin pre transfusion (g/dl), mean±SD	2.37±0.13	2.54±0.14	0.0012
Length of surgery (hours), mean±SD	1.5±0.58	1.5±0.79	0.51
Type of surgery, n (%) - Infection(appendicitis, cholecystitis, etc) - Tumors	 14 (53.8%) 12 (46.2%)	 11 (44%) 14 (56%)	 0.406 0.782

Legend: SD=standard deviation; DM=diabetes mellitus; HT=hypertension; NLR=neutrophil-to-lymphocyte ratio.

Table 2. Comparison of albumin levels, CRP, and CRP/albumin ratio between two groups

	Group A (transfusion)	Group B (control)	p
Albumin preoperative (mg/dl)	2.64±0.13	2.54±0.14	0.0012
Albumin postoperative (mg/dl)	2.1±0.3	1.94±0.36	0.13
CRP postoperative (mg/l)	200±11.23	200±53.6	0.45
CRP/albumin ratio postoperative	0.917±0.067	0.974±0.163	0.423

Legend: CRP=C-reactive protein.
All data are in mean±SD

Figure 1. Preoperative albumin levels

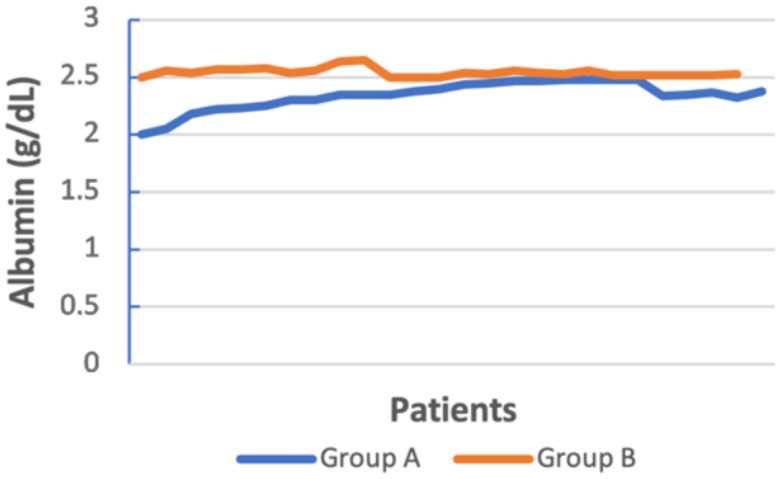
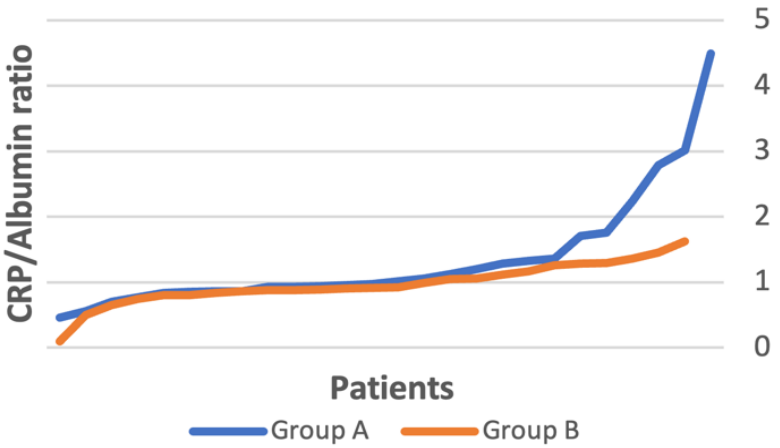


Figure 2. Postoperative CRP/albumin ratio



Legend: CRP=C-reactive protein.

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