

Factors affecting perioperative Δ ALB and short term complications in pediatric patients undergoing major gastroenterology surgery

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Research article

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Abstract

Background: Albumin is considered a negative acute-phase protein because its concentration decreases during injury and sepsis. The decrease in serum albumin might be important for perioperative morbidity, even in patients with normal preoperative levels in pediatric population. We here intend to determine the perioperative factors associated with the reduction in serum albumin within 2 postoperative days compared with the preoperative level (Δ ALB) and its influence on the perioperative outcome in a pediatric general surgical cohort.

Methods: This single-center retrospective review included 939 patients who underwent Roux-en-Y hepaticojejunostomy between August 2010 and Aug 2019. Based on the median Δ ALB (14.6%), patients were separated into two groups, including a high Δ ALB group ($\geq 14.6\%$) and a low Δ ALB group ($< 14.6\%$). Multivariable logistic regression analyses were performed to determine the independent risk factors for the reduction in serum albumin. Propensity score matching was performed to adjust for any potential selection bias for the two groups. In 366 matched patients, influences of operating time on perioperative outcomes, including postoperative recovery, complications measurement, length of hospital stay between the two groups were analyzed.

Results: For all 996 patients reviewed, 939 patient records were enrolled into the final analysis. Controlling for other factors, multivariate analysis showed that the high CRP on POD 3 or 4 (OR =2.36 [95% CI, 1.51-3.86]; $p = 0.007$), presence of Charcot's triad (OR=1.73[95% CI, 1.05-2.83]; $p = 0.031$), the longer operating time (OR=1.18[95% CI, 1.00 -1.53]; $p=0.014$) were factors that predicted the high Δ ALB level. The high Δ ALB level was associated with postoperative gastrointestinal functional recovery, reflected by the first defecation ($p= 0.013$) and first bowel movement ($p=0.019$) and the high occurrence of postoperative complications (16.1% vs 10.9%, RR, 1.57; 95 %CI, 1.02-2.41, $P=0.0026$). The mean length of postoperative stay was longer than that of patients with Δ ALB < 14.0% group, although no statistic significant was stained ($p=0.057$).

Conclusions: We showed that change in albumins was associated with postoperative outcomes. The risk factors for Δ ALB could be intervened in the perioperative period to permit patients gain a safe recovery and discharge after major abdominal operations

Background

As a acute-phase protein, albumin is usually negatively response to surgical stress, injury or sepsis, etc [1, 2]. The decrease of plasma albumin concentration is considered one of the features of the systemic inflammatory, due to loss of albumin to the tissue spaces [3]. The C-reactive protein (CRP) had been considered as acute-phase protein to predict the postoperative infectious complication [4]. The preoperative hypoalbuminemia was also confirmed as an indicator for mortality and postoperative complications and poor nutritional status, like surgical site infections (SSI) after spine surgery [5], GI surgery [6], acute kidney injury after living donor liver transplantation[7], which prolonged intensive care

unit stays and inpatient stay. Because albumin (ALB) has quick kinetics after surgery, the response of albumin to surgical stress even occur earlier than CRP, so has been focused intensively during perioperative management [8, 9].

An sharp decrease by 33% of serum ALB within 2 days was observed after major abdominal surgery, which occurred earlier than the another acute-phase protein, CRP[2, 10]. The transcapillary leakage of albumin could elevated more than 300% in the systemic inflammatory pathogenesis [11, 12]. Few studies have examined which factors could be used to predict future hypoalbuminemia and the outcome of pediatric patients in the perioperative period of major gastroenterology surgery. There are many factors that may potentially impact upon the reduction of ALB level (Δ ALB) including the pathology being treated, and the actual procedure undertaken, which is common among all types of surgical approaches [13]. A clear evaluation these factors, accounting for the the reduction of ALB level might optimize the perioperative care protocol in regard to serum ALB. Furthermore, although the Δ ALB had been evaluated previously, especially in adult patients, the Δ ALB level remains poorly defined for practice among pediatric patients. It remains unclear whether the adverse outcomes mentioned were driven more by the reduction of ALB level.

This study aimed to investigate the risk factors for reduction of ALB by retrospectively reviewing data on pediatric patients undergone major gastroenterological surgery. We further sought to clarify the association between Δ ALB and postoperative recovery and outcomes and its diagnostic accuracy.

Methods

Population selection

The Ethics Committee of the Chongqing Medical University gave expedited approval of this protocol. This retrospective study included 996 consecutive patients who underwent elective Roux-en-Y hepaticojejunostomy between August 2010 and Aug 2019 at the department of general surgery of the affiliated chongqing children's Hospital, Chongqing medical university. Exclusion criteria included patients with ALB infusion preoperatively or within postoperative day (POD 1), or incomplete laboratory data.

Data collection and definitions

Electronic medical records were individually reviewed and collected by two well trained clinical investigators who collected the relevant data. Data extraction included three aspects: (1) Preoperative data, including demographic data, clinical details, like preoperative neutrophils, lymphocytes, hemoglobin, preoperative CRP and ALB, and pre-existing comorbidities; (2) Intraoperative variables, including surgical procedures (surgical approach, type of resection), American Society of Anesthesiology (ASA) classification, operation time, duration of operation, estimated blood loss (EBL), intraoperative blood transfusion, intraoperative hemoglobin levels; (3) The postoperative outcomes, included CRP on POD 3 or 4, ALB on POD 1, the prompt postoperative biochemical profiles (hemoglobin, blood glucose, creatinine, serum electrolytes, albumin, retinol binding protein, WBC, CRP, etc), gastrointestinal function recovery

features and postoperative complications. The following laboratory data were determined preoperatively and on PODs 3 and 7: serum albumin, CRP, aspartate aminotransferase (AST), alanine aminotransferase (ALT), gamma-glutamyl transpeptidase (γ -GTP), lactate dehydrogenase (LDH), alkaline phosphatase (ALP), serum creatinine (Scr), blood urea nitrogen (BUN), hemoglobin (Hb), and white blood cell (WBC) count. Gastrointestinal symptoms were recorded for the first 5 days postoperatively, including the first postoperative flatus or defecation, gastric retention, nausea or vomiting, time to normal diet, abdominal bloating and/or cramps. All postoperative complications were recorded and ranked according to the Clavien-Dindo classification system, such as postoperative hemorrhage, anastomotic fistula, anastomotic stenosis and wound infection, intra-abdominal abscesses, pneumonia, bacteremia, renal failure and respiratory failure.

Relative change of the serum albumin (Δ ALB) was calculated as follows: (preoperative albumin level – nadir albumin level within POD 2)/albumin level before surgery \times 100% [17]. For the purposes of analysis, the patients were dichotomized into low ($< 14.6\%$) and high ($\geq 14.6\%$) groups based on the cutoff value.

Propensity scores and matching

To minimize the biases in baseline characteristics between hypertonic saline patients and controls, propensity score matching was accomplished using a multivariable logistic regression model using SPSS 20.0 (IBM, Armonk, NY) or R 3.1.2 (The R Foundation for Statistical Computing). A 1:1 Propensity scores matching with a caliper distance of 0.2 without replacement, was accomplished using nearest-neighbor analysis, which included the demographic and clinical variables. We further measured the interaction among all pre-test covariates. The linear assumption was checked using the generalized additive model. The generalized additive model was used to check linear assumption in PS model, thus matching 366 patients with high Δ ALB $\geq 14.6\%$ and 366 patients with Δ ALB $< 14.6\%$. The perioperative outcomes between the two groups were compared after propensity score matching.

Statistical analysis

Statistical analyses were performed using SPSS version 19.0 (SPSS Inc., Chicago, IL, United States). Categorical data were expressed as counts with percentages and were analyzed using the Fisher's exact test or Pearson's χ^2 test when appropriate. Continuous data were expressed as the means \pm (standard deviations) for normally distributed data and medians (interquartile ranges) for non-normally distributed data, which were tested with the Student's t-test or Mann-Whitney U test and the Wilcoxon rank-sum test, respectively. To verify independent predictors for postoperative complications, multivariate analysis was performed using multivariate logistic regression analysis after univariate analysis to identify those with a significance level of $P < 0.30$. The results of the multivariate logistic regression analysis were expressed using P value, odds ratio (OR), and 95% confidence interval (CI). The SPSS 20.0 (IBM, Armonk, NY, USA) software was used to perform all statistical analyses. In all cases, $P < 0.05$ was considered significant.

Results

Patient population characteristics

Among the initial 996 pediatric patients in our department underwent colorectal resection, 41 of them did not fulfill inclusion criteria and were initially excluded, sixteen patients were excluded because notes were unobtainable for data extraction. Finally, A total of 939 patient records were enrolled into the final analysis (Table 1).

Table 1
Univariate analyses of perioperative factors on Δ ALB

	Total Population		p Values
	Δ ALB \geq 14.6% (471)	Δ ALB < 14.6% (468)	
Age (yrs), mean \pm SD	2.13 \pm 1.02	2.16 \pm 1.07	0.21
Female: Male	183(37.5)	191(39.9)	0.31
Weight (kg), mean \pm SD	11.38 \pm 2.96	11.52 \pm 3.68	0.22
BMI, median (range)	24(20–30)	25 (21–31)	0.13
Laboratory findings			
hypertransaminasemia, n (%)	325	334	0.47
hyperbilirubinemia, n (%)	186	173	0.39
Preoperative ALB(g/L), mean \pm SD	39.28 \pm 4.72	41.41 \pm 5.39	0.016
Preoperative CRP(g/L), mean \pm SD	11.24 \pm 3.26	12.56 \pm 4.17	0.15
Preoperative WBC(10 ⁹ /L), mean \pm SD	7.9 \pm 2.8	8.2 \pm 3.1	0.52
Ultrasound presentation			
Mean CBD(cm), mean \pm SD	1.53 \pm 0.58	2.34 \pm 0.97	0.042
Charcot's triad, n (%)	142	109	0.011
Nadir ALB within POD 2(g/L), mean \pm SD	34.94 \pm 8.92	30.22 \pm 7.83	0.0012
CRP on POD 3 or 4(mg/L), mean \pm SD	41.45 \pm 13.65	29.8 \pm 7.69	< 0.001
Postoperative WBC(10 ⁹ /L), mean \pm SD	15.8 \pm 4.9	14.9 \pm 4.8	0.350
Mode of surgical approach, n(%)			
Laparoscopic	168	139	
Open	303	329	0.03
Operation time, median (range), min	175 (132–418)	143 (115–367)	0.0024
Nadir of hemoglobin(g/L)	9.18 \pm 1.32	9.64 \pm 1.68	0.28
Operative blood loss (mL), mean \pm SD	36.78 \pm 16.84	33.86 \pm 15.88	0.26
Intraoperative fluid utilization(mL/kg*h), mean \pm SD	16.74 \pm 6.88	14.26 \pm 6.72	0.017
Intraoperative transfusion, n (%)	131 ()	115()	0.15

	Total Population		
ASA classification			
ASA1-2	338(72.6)	319(67.7)	0.13
ASA3-4	133(27.4)	149(22.3)	

The factors associated with Δ ALB

Based on the cutoff value of Δ ALB, we dichotomized the patients into two groups, the Δ ALB \geq 14.6% and Δ ALB < 14.6% group. The baseline features of the two groups are summarized in Table 1. There were no significant differences in the demographic features of patients, ASA classification, preoperative CRP between the two groups (Table 1). Furthermore, the nadir of hemoglobin and operative blood loss was similar between the two groups ($P > 0.05$). A larger choledochal cyst size ($p = 0.042$), and worse comorbidity (Charcot's triad) ($p = 0.011$), lower preoperative ALB ($p = 0.016$), CRP on POD 3 or 4 ($p < 0.001$), and long surgery duration ($p = 0.0024$), were often associated with a greater Δ ALB ($P < 0.05$) in the univariate analysis. Multivariate analysis revealed three independent risk factors. As shown in Table 2, the CRP on POD 3 or 4 (OR = 2.36 [95% CI, 1.51–3.86]; $p = 0.007$), presence of Charcot's triad (OR = 1.73[95% CI, 1.05–2.83]; $p = 0.031$), the longer operating time (OR = 1.18[95% CI, 1.00 -1.53]; $p = 0.014$) were the independent risk factors associated with Δ ALB.

Table 2
Multivariate analysis of related factors for Δ ALB.

	OR	95%CI	p
CRP on POD 3 or 4 (> 135 mg/L)	2.36	(1.51–3.86)	0.007
Charcot's triad	1.73	(1.05–2.83)	0.031
Operation time(> 165 m)	1.18	(1.01–1.53)	0.014

The influences of Δ ALB on postoperative outcomes

To explore the association of Δ ALB and the perioperative outcomes, we performed PS-matching between the patients with the Δ ALB \geq 14.6% and Δ ALB < 14.6% groups to adjust for potential confounding factors and exclude the effects of correlation between factors. Under PS-matching, 366 patients with Δ ALB \geq 14.6% group were matched to 366 patients with Δ ALB < 14.6% group. The absolute standardized mean differences reduced the values, indicating that the continuous and categorical variables were very similar and comparable between the two groups (Table 3).

Table 3

	Total Population		p Values
	Δ ALB \geq 14.6% (366)	Δ ALB < 14.6% (366)	
Age (yrs)	2.14 \pm 1.01	2.15 \pm 1.03	0.45
Female: Male	135(36.9)	136(37.2)	0.50
Weight (kg)	11.44 \pm 2.76	11.46 \pm 3.11	0.34
BMI, median (range)	25(21–28)	25 (21–29)	0.28
Laboratory findings			
hypertransaminasemia, n (%)	252(68.9)	251(68.6)	0.50
hyperbilirubinemia, n (%)	146(39.9)	143(39.1)	0.44
Preoperative ALB(g/L), mean \pm SD	39.83 \pm 4.26	40.63 \pm 4.96	0.18
Preoperative CRP(g/L), mean \pm SD	11.87 \pm 3.16	12.04 \pm 3.88	0.35
Preoperative WBC(10 ⁹ /L), mean \pm SD	8.01 \pm 2.62	8.14 \pm 2.69	0.39
Ultrasound presentation			
Mean CBD(cm), mean \pm SD	1.75 \pm 0.53	2.07 \pm 0.86	0.18
Nadir ALB within POD 2 (g/L), mean \pm SD	33.13 \pm 8.56	32.34 \pm 7.69	0.23
Postoperative WBC(10 ⁹ /L), mean \pm SD	15.56 \pm 4.64	15.12 \pm 4.63	0.46
Mode of surgical approach, n(%)			
Laparoscopic	131(35.8)	126(34.4)	
Open	235(64.2)	240(65.6)	0.38
Nadir of hemoglobin(g/L)	9.35 \pm 1.25	9.48 \pm 1.52	0.33
Operative blood loss (mL)	35.16 \pm 14.69	34.47 \pm 13.53	0.29
Intraoperative fluid utilization(mL/kg*h), mean \pm SD	15.59 \pm 6.54	14.93 \pm 6.18	0.27
Intraoperative transfusion, n (%)	102 (27.9)	98(26.8)	0.40
ASA classification			
ASA1-2	262(71.6)	257(70.2)	0.37
ASA3-4	104(28.4)	109(29.8)	

Overall, there were no differences in the vasopressor support, diuresis usage and the number of intraoperative hypotensive events, hypokalemic episodes, metabolic acidosis (defined by low bicarbonate) or other laboratory and hemodynamic parameters throughout the perioperative period between the $\Delta\text{ALB} \geq 14.6\%$ and $\Delta\text{ALB} < 14.6\%$ groups (Table 4).

Table 4
Outcome characteristics in the matched population

	$\Delta\text{ALB} > 14.6\%$ (366)	$\Delta\text{ALB} < 14.6\%$ (366)	p Values	Odds ratio (95% CI)
Hypotensive events, n(%)	42(10.47)	38(11.88)	0.36	
Norepinephrine usage, n(%)	45(13.95)	40(12.17)	0.32	
Furosemidum, n(%)	36(9.88)	34(11.30)	0.50	
Metabolic acidosis, n(%)	18(3.20)	13(4.93)	0.23	
hypokalemic episodes, n(%)	24	25	0.50	
Serum albumin				
First defecation (days)	3.13 ± 1.32	2.88 ± 1.27	0.12	
First flatus	3.56 ± 0.88	3.07 ± 0.90	0.013	
First bowel movement(days), Mean ± SD	2.75 ± 0.82	2.14 ± 0.78	0.019	
Stool within 72 hours, n (%)	123(32.75)	147(40.12)	0.039	1.33(0.98– 1.79)
Abdominal distension, n (%)	36(13.5)	28(19.8)	0.18	
Diarrhea, n (%)	23 (6.8)	21(10.9)	0.50	
Vomiting, n (%)	35(13.0)	31(16.1)	0.38	
No. of patients with mild complications, n(%)	45(11.7)	29(9.0)	0.033	1.63(1.00– 2.66)
No. of patients with major complications, n(%)	28(7.7)	21	0.19	
Total number of complications, n(%)	59(16.1)	40(10.9)	0.026	1.57(1.02– 2.41)
Length of stay (d), mean ± SD	8.19 ± 3.16	7.69 ± 2.67	0.057	

In the propensity matched cohort, patients with $\Delta\text{ALB} < 14.6\%$ had reduced the time for first flatus ($p = 0.013$) and first bowel movement ($p = 0.019$) (Table 2). In the $\Delta\text{ALB} < 14.6\%$ group, 40.2% (147/366) of patients spontaneously passed stool within 72 hours, whereas only 33.6% (123/366) cases in the high

urine output passed stool within the same period (RR, 1.33; 95%CI, 0.98–1.79, $p = 0.039$). The incidences of Diarrhea ($p = 0.50$), Vomiting ($p = 0.38$) and abdominal distention ($p = 0.18$) within 5 PODs in patients with $\Delta\text{ALB} < 14.6\%$ were similar with patients with $\Delta\text{ALB} \geq 14.6\%$.

According to Clavien-Dindo classification, 74 patients (20.2%) had mild complications (Grade I or II), and 49 (13.4%) had major complications (Grade III or greater). As shown in Table 4, patients with $\Delta\text{ALB} \geq 14.0\%$ were found to have more total complications than those with $\Delta\text{ALB} < 14.0\%$ (16.1% vs 10.9%, RR, 1.57; 95%CI, 1.02–2.41, $P = 0.0026$), including anastomotic leakage, infectious complications of pneumonia, incision dehiscence, intraperitoneal abscess, sepsis, and surgical site infections, etc. In addition, The mean length of postoperative stay was 8.19 ± 3.16 days in patients with $\Delta\text{ALB} \geq 14.0\%$ group, which was longer than that of patients with $\Delta\text{ALB} < 14.0\%$ group (7.69 ± 2.67 days), although no statistic significant was stained ($p = 0.057$).

Discussion

We conducted the present analysis to focus on serum albumin as an acute phase protein for a pediatric surgical cohort following the same surgical procedure. This study revealed that several factors were associated with the high ΔALB , like the operative duration, disease comorbidities, the mean CBD, etc. Furthermore, patients with a greater relative decrease in serum albumin were at a higher risk of postoperative gastrointestinal function recovery, postoperative complications, prolonged postoperative hospital stays after major gastroenterology surgery.

The serum ALB maintain important physiological functions, including anticoagulant, sustaining the colloid osmotic pressure, and scavenging superoxide ion, transportation of important physiological materials, and so on [14, 15]. The factors led to hypoalbuminemia were often complicated and involved in operative case type, ALB loss, redistribution, catabolism, and so on [17, 18]. In patients with sepsis and surgical trauma, systemic inflammatory response is recognized as a common reason for albumin fractional synthesis and capillary leakage, whereas the synthesis rate was unaltered, which account for the reduction in ALB level [11, 16]. Numerous studies have focused the preoperative and postoperative hypoalbuminemia as risk factors for postoperative complications [5, 19], while few have specifically stressed the perioperative factors related to the ΔALB , which may be clinically significant for postoperative care. During surgery, manipulation of the intestine is proved to initiate the gastrointestinal edema and activation of inflammatory cells including mast cells, macrophages and neutrophils infiltrate [20, 21]. The postoperative edema might attribute to the low colloid osmotic pressure and fluid accumulation, which resulted from the low postoperative ΔALB level [11]. In present study, several clinical factors related to the decrease in postoperative albumin were presented, including longer operating time, severe comorbidities, like Charcot's triad, and high CRP, etc. All these factors might be associated with an inflammatory response caused by surgical stress. Consistent with the current findings, previous reports focused primarily on adult patients with various co-morbidities, higher ASA scores, and a wide variety of serious conditions, ranging from major trauma to extensive pancreatic surgery. Norberg Å[2] reported the stress response led to a reduction in postoperative albumin levels, which was consistent with the findings

in our study. We here focus on pediatric population with same operation, intended to explore the perioperative factors related to postoperative albumin.

Another factor was intraoperative and postoperative fluid use, which has not been shown in previous studies to be associated with high Δ ALB after Roux-en-Y hepaticojejunostomy. The reasons for this association may pertain to hemodilution, which might contribute to the decreased albumin level after surgery. In my previous study [22], postoperative complications were related to conventional intraoperative and postoperative fluid usage, it might also affect the albumin level after surgery. In other words, perioperative fluid use should affect serum albumin through sequestration into the interstitial space, which account for the postoperative complications. The excessive fluid should also promote capillary permeability and leakage of serum albumin into the extravascular space [23]. Capillary leakage is especially common in some malnourished patients with surgical trauma followed by an increased transcapillary escape rate of $\geq 100\%$ [24], which was not presented in the current research.

CRP has already been suggested the valuability to predict postoperative complications, early nutritional intervention and ensure a safe and early discharge after abdominal surgery[25]. Furthermore, serum albumin on POD 3 was observed to be correlated with preoperative CRP level [13]. The inflammatory cytokines should be activated during the surgical stress, which account for the increased CRP and prohibited the synthesis of constitutive proteins, such as serum albumin, and increase its degradation. In the current research, we indeed found that high Δ ALB was associated with the CRP on POD 3 or 4. On the country, hypoalbuminemia inhibits the innate immune response by reducing collagen synthesis and promoting granuloma formation. As a result, the systemic immune status with hypoalbuminemia is more sensitive to infection and other postoperative complications.

Prompt postoperative recovery serves as the main focus of all surgical specialties for the postoperative rehabilitation [26]. As indicated in the current study, although uneventful recovery was presented in most patients following choledochal cyst resection, postoperative gastroenterological recovery vary among them. The high Δ ALB was associated with the unfavorable postoperative gastroenterological recovery. In previous biological investigation, it have demonstrated that edema's detrimental effects on intestinal function by directly affecting muscle function and force transmission[27, 28]. The serum ALB is a predictor of both systemic inflammation and nutritional status, which should account for postoperative intestine edema after major operation or severe trauma. Furthermore, tissue oxygenation might decline with fluid accumulation, also unfavorable for the postoperative recovery and complications. In this study, we detected an increased total number of complications, including anastomotic leakage, in patients with high Δ ALB. The possible explanation at the tissue level indicated that the low ALB level decline the collagen deposition for the tissue connections and, therefore, poor structural integrity. The effect of Δ ALB on local inflammatory response and edema recovery is also important, which might also explain the postoperative recovery and complications[29, 30]. This hypothesis on background mechanisms was not investigated in this study. To achieve the goal to reduce the local inflammatory response, exogenous ALB supplementation strategy has been proposed as the optimal therapeutic modality to attenuate the postoperative intestine edema after major operation or severe trauma. However, other reported that

routine ALB infusion was not beneficial to patients in the European intensive care units (ICUs)[31]. Instead, exogenous ALB administration might increase risks of edema, extravasation of albumin, or other postoperative complications[32]. It remains to be established whether ALB supplementation would reduce the postoperative intestine edema and cellular swelling so to benefit patients and promote intestinal function recovery in patients undergoing major upper gastrointestinal surgery, which has not been previously reported in pediatric population. More intensive perioperative care might relieve an early Δ ALB following gastric cancer resection and improve patient outcomes by reducing postoperative generalized inflammation.

There were several limitations to the current study. First, it was a retrospective observational analysis, where unmeasured differences, known selection and treatment bias may contribute to confounding, which could not be entirely excluded. Second, it was a single-center study and the general surgery procedures were performed in our hospital over a long period of time; therefore, there may have been many practice changes within both surgical and the ICU divisions, leading to different care practices between study patients, which may not reflect the outcomes from current treatment algorithms. Another point of emphasis was that although we did not find differences in baseline characteristics after PS matching, the patients with high Δ ALB might have been more surgically challenged than the low Δ ALB. Third, whether the findings in our study could be applied to other operations, such as liver resection or transplantation, is not known for sure. To limit the influence of confounding variables on the actual effects of Δ ALB, large, multicenter prospective studies must be performed to verify the conclusions of the current study.

Conclusions

In the current study, we have characterized some risk factors that may predispose to high Δ ALB, which impacts negatively on the postoperative recovery after pediatric major abdominal operation. The surgeons should be aware of the Δ ALB variation in the early postoperative period to optimize preoperative planning and maximize surgical efficiency.

Abbreviations

Δ ALB: the reduction in serum albumin within 2 postoperative days compared with the preoperative level; CRP:C-reactive protein ALB: albumin POD: postoperative day AST: aspartate aminotransferase ALT: alanine aminotransferase γ -GTP: gamma-glutamyl transpeptidase LDH: lactate dehydrogenase ALP: alkaline phosphatase Scr:serum creatinine BUN: blood urea nitrogen Hb: hemoglobin WBC: white blood cell

Declarations

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Conflict of Interest: All the authors declare that they have no conflict of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: The need for written informed consent was waived because all patients were treated according to routine institutional treatment guidelines.

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