Original Article

Albumin Haemoglobin Index: A Novel Pre-operative Marker for Predicting Mortality and Hospital Stay in Patients Under One-Year Undergoing Gastrointestinal Surgeries

Musa Silahli, Mehmet Tekin

Department of Paediatrics, Konya Training and Application Centre, Baskent University Medical Faculty, Baskent University, Konya, Turkey

Abstract

Aim: The aim of this study was to evaluate the mortality and morbidity of infants <1 year of age with intestinal obstruction requiring surgical intervention and to investigate the factors affecting mortality and hospital length of stay in paediatric surgery, including albumin-haemoglobin index. **Patients and Methods:** The records of gastrointestinal paediatric surgeries in the past 10 years of patients who were <1-year-old at Baskent University Konya Hospital were obtained from the hospital and retrospectively studied. Patient characteristics, especially the relationship between albumin haemoglobin index (AHI) and hospital duration and mortality, were examined. According to the surgical areas, it also subjected this relationship to further analysed in subgroups. **Results:** There were 144 cases who fulfilled the inclusion criteria. Pre-operative serum AHI was analysed using receiver operating characteristics (ROC) curve analyzes. In the ROC analysis, AHI had a diagnostic value in predicting case discharge rates (area under the curve: 0.755, $P = 0.001$). When the cut-off point was set at 46.18, the sensitivity of the test was 57.5% and the sensitivity for predicting survival was 84%. In the logistic regression model to estimate survival, the odds ratio of AHI was 1.063 (confidence interval: 1.020–1.108, $P = 0.004$). In subgroup analyzes, AHI positively predicted survival in the NEC group and in the other group. In a linear regression model analysing the effect of AHI on hospital stay of length, AHI explained 10% of the variance in the hospital stay of length variable and significantly and negatively influenced the hospital length variable ($\beta = -0.319$, $P = 0.05$). In the linear regression model for subgroup analyzes, AHI significantly and negatively predicted hospital length of stay in the NEC and pyloric surgery groups, but positively predicted hospital length of stay in the perforation group. **Conclusion:** The AHI can be used as a valuable marker to predict the likelihood of discharge and length of hospital stay in paediatric surgical cases <1-year-old.

Keywords: Albumin haemoglobin index, gastrointestinal surgery, paediatric surgery

Introduction

In the paediatric age group, especially in infancy, abdominal surgery is performed for many reasons. Surgery of the digestive system is an important part of these operations in children under 1 year of age. Mechanical bowel obstruction in children may have congenital or acquired causes such as atresia and stenosis, annular pancreas, malrotation, duplication cysts, meconium ileus, meconium plug syndrome and Hirschsprung's disease, neoplasia, trauma and other rare causes such as intussusception.[1] Predicting postoperative mortality and morbidity in paediatric surgery remains a challenge. To predict both intraoperative and post-operative mortality and morbidity, many markers and predictors have been used in the past, which were got in regression models. To overcome this obstacle, researchers have been searching for a new biomarker or scoring system to help with such prediction. Pre-operative albumin, C-reactive protein (CRP), haemoglobin, neutrophil-to-lymphocyte ratio, platelet-to-lymphocyte ratio, and similar whole blood indices can be mentioned here.

Albumin is a medium-sized protein that accounts for more than half of the total body composition and has a molecular

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Address for correspondence: Dr. Musa Silahli, Saray Cd, Hocacihan Mh, No: 1, Selçuklu, Department of Paediatrics, Baskent University, Konya 42080, Turkey. E-mail: msilahli@gmail.com

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weight of 66–69 kDa.[2] Albumin has been shown to have multiple functions, including regulation of osmotic pressure, antioxidant and anti-inflammatory effects.[3,4] Serum visceral protein synthesis is impaired by malnutrition and inflammation. Therefore, low serum levels of albumin and prealbumin have historically been used as surrogates for malnutrition and to determine the extension of a physiological disorder.[5-7] Serum albumin and prealbumin levels are powerful predictors of post-operative complications when assessing pre-operative risk stratification.[8]

Haemoglobin is an oligometalloprotein that transports oxygen from the lungs to the tissues and carbon dioxide and protons from the tissues to the lungs. Haemoglobin, along with arterial oxygen saturation and arterial partial pressure of oxygen, is the most important factor determining the oxygen-carrying capacity of the blood. We frequently observed anemia in malnutrition and severe disease, especially in digestive system surgery because of intestinal obstruction and feeding problems, as well as in chronic diseases in the perioperative stage.

A desire arose to create a more powerful marker by combining serum albumin and haemoglobin levels, and a need to evaluate the predictive power of this new marker in GIS surgical cases <1 year of age. Therefore, optimal perioperative status is the most important factor in predicting intra-operative and post-operative outcomes.

In this study, we aimed to investigate descriptive factors in the study group and evaluate the impact of pre-operative albumin-haemoglobin index (AHI) as a novel marker on hospital length of stay and mortality rate of infants under 1 year of age who required surgical intervention.

Patients and Methods

We retrospectively reviewed data from all patients <1 year of age who underwent gastrointestinal surgery at our hospital from 2010 to 2020. We excluded inguinal and umbilical hernias and other solid organ surgeries. A total of 144 patients with serious pathologies of the digestive tract involving the esophagus, stomach, small intestine, colon and anorectal area who underwent surgery in the Department of Paediatric Surgery and Neonatology (aged 0–12 months), Baskent University Konya Hospital, between January 2010 and December 2020 were included in our analyzes.

Patient data included age, gestational age, mode of delivery, birth weight, sex, primary surgical diagnosis, ileus status, type of hospitalisation (inpatient or outpatient), type of admission (with or without referral), number of repeat surgeries required, duration of surgery; time before surgery, time after surgery, the total length of hospital stay, duration of invasive mechanical ventilation and oxygenation, exitus associated with complications of surgery in the early or late phase of surgery, discharge, pre-operative whole blood indices and biochemical markers were obtained from medical records. All deaths include deaths caused by the disease itself or its complications and during hospitalisation due to the underlying disease. Thus, a single hospitalisation was recorded. The baseline characteristics and pre-operative blood parameters of the patients and the markers calculated from them were subjected to statistical analysis according to whether or not the patients survived and whether ileus was present. The survival discriminating power of the marker called AHI, obtained by multiplying preoperative haemoglobin and albumin values, was evaluated by receiver operating characteristics (ROC) curve analysis. Cut-off values of AHI were described. Descriptive statistics of scale variables were reported as mean ± standard deviation or median (range). Demographic and clinical continuous variables were compared using the two independent Student *t*-test for normally distributed values and the Mann–Whitney U-test for non-normally distributed values. Categorical variables were compared using Fisher's exact test or the Chi-square test, as appropriate. ROC curves were used to determine sensitivity and specificity, and differences in areas under the curve (AUC) were determined using the (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp). To manage missing data, data mapping for subgroup analyzes was performed using the method Multiple Imputation, which is available in the SPSS package programme. Then, patients were classified into eight surgical categories, including Group 1: Atresia, Group 2: Pyloric surgery, Group 3: Intussusception, Group 4: Megacolon, Group 5: Perforation, Group 6: Ileus, Group 7: Other, Group 8: NEC. To determine whether the AHI values showed significant differences between the subgroups, the one-way statistic analysis of variance was used. Simple linear regression analysis was used to determine if the variable AHI could explain the variation in the dependent variable of total hospital length of stay. Subgroup analyzes by the surgical group were performed. Logistic regression analysis was also used to describe and explain the relationship between AHI and survival rate. The statistical results of the regression model were also analysed for the subgroups. We set the significance level at $P = 0.05$ for all tests. Data were analysed using the SPSS software package, version 25.

Results

Of the paediatric surgical cases under 1 year of age that met the study criteria, 21% (31) had congenital small bowel malformations, 15% (22) had oesophageal atresia, 14% (21) had NEC, 13% (19) had surgery for gastroesophageal reflux, gastrostomy and hypertrophic pyloric stenosis, 9% (13) had anogenital malformations, 7% (11) had congenital megacolon, 4% (6) had intussusception, i.e., the invagination of part of the intestine into itself, 2% (4) exploratory laparotomy due to free air in the abdomen, 2% (4) congenital diaphragmatic hernia and the rest (13%) including malrotation, colonic perforation, brid ileus, i.e., post-operative adhesive bands that do not allow bowel passage, and closure of the colostomy. Sixty-eight percent of patients were referred from other hospitals. Of the paediatric surgery patients who were under 1 year of age, 34.3% required over one surgical procedure. However, this percentage was higher for mechanical ileus cases at 41.6%.

When cases were classified as ex-surviving, with or without mechanical obstruction, gestational week and birth weight were significantly lower in the exitus and ileus groups. The need for reoperation was also significantly higher in the ileus group, while there was no difference between the exitus and surviving groups. There were no differences between the groups in terms of age at diagnosis [Table 1]. While the total length of hospital stay was significantly higher in the exitus group, we found no differences between the ileus or non-ileus groups. The crucial factor that influenced the total length of hospital stay was the preoperative hospital stay. The length of postoperative hospital stay was similar between groups, while pre-operative hospital stay was significantly higher in the exitus group. However, this factor was not influenced by the presence or absence of ileus. As expected, the proportion of intubation for respiratory failure, duration of mechanical ventilation, and oxygen duration was significantly higher in the exitus group. The duration of total parenteral nutrition (TPN) and proven sepsis were significantly higher in the exitus and ileus groups. While there was no difference in major cardiac abnormalities between the groups, minor cardiac abnormalities were significantly higher in the non-ileus group [Table 1]. Platelet count, pre-operative albumin and AHI were significantly higher in the discharge group and the non-ileus group, when the pre-operative whole blood indices and biochemical markers were examined. The pre-operative CRP levels of the patients were significantly higher in the exitus and ileus groups [Table 2].

We constructed the ROC curve using data from 66 cases to evaluate the prognostic performance of AHI for survival. As a result of the ROC curve, the AUC value was found to be 0.759 [Figure 1]. The likelihood ratio was calculated by relating the specificity and sensitivity values obtained in the analysis. Considering this process, we can state that with a cut-off point of 46.18, the specificity of the test is 57.5% and the sensitivity is 83%. The comparison of the predictive power of AHI and other parameters, including preoperative haemoglobin, pre-operative albumin, neutrophil-lymphocyte and platelet-lymphocyte ratio, is shown in Figure 2 with AUC values. AHI proved to be the best predictor of survival among all mentioned parameters. AHI values showed significant differences between surgical groups ($P < 0.001$). AHI values of group 5 (perforation) and group 8 (NEC) were significantly lower than those of the other groups [Figure 3].

A logistic regression analysis was performed to determine the extent of the AHI's ability to predict the survival outcome variable and we presented the results in Table 3. The results of the logistic regression analysis showed that the established model was significant ($\chi^2 = 10.613$, df = 1, $P < 0.01$). The correct classification rate of the model was 71.9%. Cox and SnellR[5] value was 0.15 and NagelkerkeR[5] value 0.21. These findings showed the AHI explained that the variance

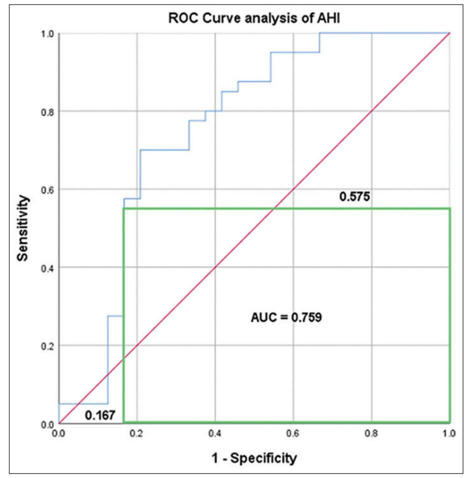

Figure 1: Receiver operating characteristics curve analysis of albumin haemoglobin index

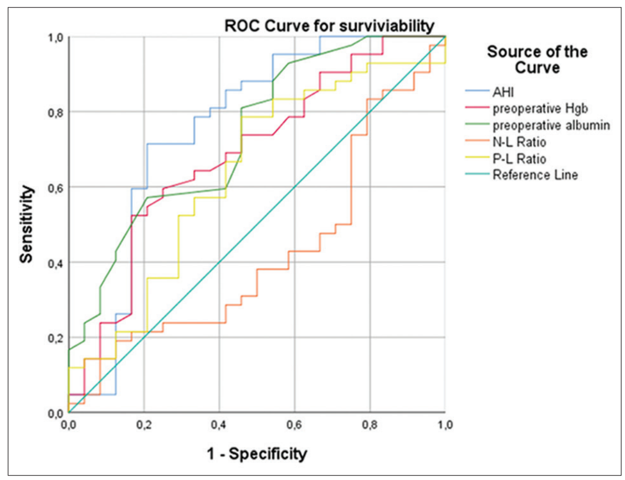

Figure 2: Albumin haemoglobin index is the most valuable marker for survivability among other predictors

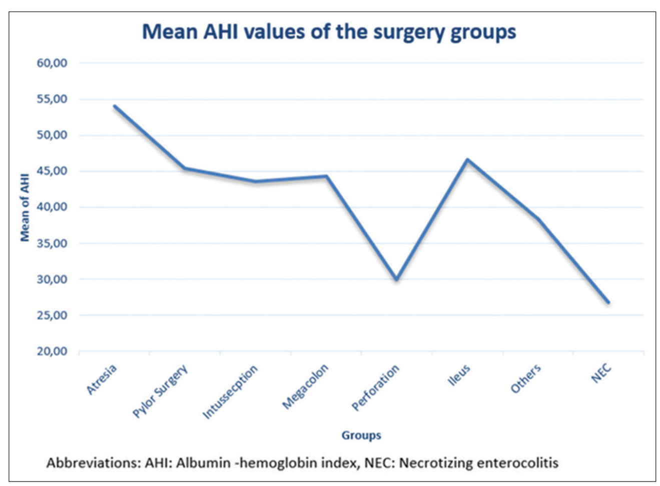

Figure 3: Mean albumin haemoglobin index values between the groups

from 15% to 21% of the survival variable of the patients. The Wald statistics performed to test the significance of the logistic regression coefficients showed that the AHI, which

Table 1: Baseline characteristics of patients

	Total cases (*n*=144)	Exitus (*n*=38)	Discharge (*n*=106)	*P*	Ilues (*n*=78)	Nonileus (*n*=66)	*P*
Birth weight gram;, mean±SD (minimum-maximum)	2335±905 (620-4050)	1830 (620-3300)	2790 (800-4050)	<0.001	2010 (700-3700)	2800 (620-4050)	0.002
Gestational week	34.5±4 (25-40)	34 (25-40)	37 (27-40)	0.013	34 (25-40)	37 (26-40)	0.009
Gender, male, *n* (%)	86 (59.7)	18 (47.4)	68 (64.2)	0.084	44 (56.4)	42 (63.6)	0.399
Age at diagnosis, mean±SD (minimum-maximum)	57.1±90.7 (1-360)	16 (1-210)	18.5 (1-360)	0.146	18.5 (1-330)	17 (1-360)	0.593
Recurrent surgery requirement, median (minimum-maximum)	0 (0-4)	0 (0-3)	1 (0-4)	0.099	1 (0-4)	0 (0-3)	0.047
Hospital duration, median (minimum-maximum)	16.5 (1-301)	29.5 (1-160)	14 (1-301)	0.020	22 (1-287)	14.5 (1-301)	0.062
Preoperative hospital duration, median (minimum-maximum)	2 (0-64)	7 (0-45)	1 (0-64)	<0.001	2 (0-45)	2 (0-64)	0.416
Postoperative hospital duration, median (minimum-maximum)	12 (1-288)	14 (1-157)	12 (1-288)	0.998	14.5 (1-270)	10 (1-288)	0.209
Mechanichal ventilation, *n* (%)	73 (50.7)	37 (97.4)	36 (34.3)	<0.001	55 (43.8)	30 (45.5)	0.243
Duration of mechanical ventilation, median (minimum-maximum)	0.5 (0-265)	8 (0-99)	0 (0-265)	<0.001	1 (0-99)	0 (0-265)	0.689
Oxygen duration, median (minimum-maximum)	4.5 (0-301)	20 (1-150)	1 (0-301)	<0.001	4 (0-287)	5 (0-301)	0.692
TPN, *n* (%)	85 (59)	34 (91.9)	51 (49)	<0.001	56 (73.7)	29 (44.6)	0.001
TPN duration	8 (0-232)	18 (0-159)	0 (0-232)	<0.001	14 (0-232)	0 (0-63)	<0.001
Proven sepsis, *n* (%)	54 (37.5)	27 (73)	27 (26)	<0.001	41 (53.9)	13 (20)	<0.001
Associate any cardiac abnormality, *n* (%)	44 (30.6)	16 (42.1)	28 (26.9)	0.102	17 (22.1)	27 (41.5)	0.018
Associate complex cardiac abnormality	7 (4.9)	4 (10.5)	3 (2.9)	0.083	2 (2.6)	5 (7.7)	0.157
The age at surgery (<1 month old), *n* (%)	91 (63.2)	28 (73.8)	63 (59.4)	0.169	50 (64.1)	41 (62.1)	0.863

SD: Standard deviation, TPN: Total parenteral nutrition

Table 2: Preoperative laboratory findings

	Total cases (*n*=144)	Exitus (*n*=38)	Discharge (*n*=106)	*P*	Ilues (*n*=78)	Nonileus (*n*=66)	*P*
Wbc, mean±SD (minimum-maximum)	12,770±6502 (2130-34,700)	14,700 (2130-32,000)	10,950 (3090-34,700)	0.688	10,800 (2130-32,000)	11,750 (3090-34,700)	0.147
Hgb, mean±SD (minimum-maximum)	13.6±3.6 (7.6-22.4)	12.1 (7.6-21.7)	12.9 (8.2-22.4)	0.154	12.4 (7.96-22.4)	13.4 (7.6-20.4)	0.235
Plt, mean±SD (minimum-maximum)	291,019±167,806 (28,200-856,000)	190,000 (37,000-577,000)	306,500 (28,200-856,000)	0.01	238,000 (28,200-697,000)	317,000 (44,200-856,000)	0.011
AHI, mean±SD	42.07±15.5	33.9±16	46.7±13.4	0.01	37.6±15.1	48.8±18.01	0.04
N/L ratio, median (minimum-maximum)	1.07 (0.06-52.7)	1.31 (0.06-9.84)	0.96 (0.09-52.7)	0.07	1.28 (0.06-6.74)	1.04	0.947
P/L ratio	59 (2.64-2029)	39.2 (8.38-293)	64.9 (2.64-2029)	0.07	54.2 (2.64-571)	63.4 (8.63-2029)	0.321
TMI, mean±SD	2394±1273	2026±1191	2523±1583	0.06	2316±1345	2475±1200	0.507
Albumin, mean±SD	3.08±0.63	2.74±0.57	3.28±0.58	0.001	2.92±0.63	3.33±0.55	0.01
Crp, median (minimum-maximum)	4.28 (0.1-339)	41.5 (0.2-339)	2.8 (0.1-238)	0.001	25.7 (0.2-339)	1.14 (0.1-76.1)	<.001
AHI >46.1, *n* (%)	29 (20.1)	4 (16.7)	25 (59.5)	0.001	12 (30)	17 (65.4)	0.006

SD: Standard deviation, AHI: Albumin-haemoglobin index, Hgb: Haemoglobin, Plt: Platelet, Crp: C-reactive protein, N/L: Netrophile to lymphocyte ratio, P/L: Platelet to lymphocyte ratio, TMI: Thrombocyte mass index

was the independent variable, predicted the survival variable significantly and positively. The odds ratio of AHI was 1.063 (confidence interval [CI] [95%]: 1.020–1.108) which showed that an increase of one unit in the AHI increased the probability of discharge 1.063 times compared to the probability of death [Table 3]. When subgroup analyzes were performed in imputed data, in Group 8 (NEC) and Group 7 (others), AHI values predicted to survival significantly and positively (NEC, *P* value: 0.001, odds ratio [OR]: 1.079 [CI 95%: 1,03–1,130], Others, *P* value: 0.002, OR: 1,052 [CI 95%:1,019–1,086]) [Figure 4a].

Linear regression analysis was performed to determine the ability of AHI to predict the total hospital duration variable and the results are presented in Table 4. Linear regression analysis results showed that the established model was significant (F = 7.035, df = 1, $P < 0.05$). The findings showed the AHI explained 10% of the variance of the hospital duration. The standardised beta coefficient value showed that AHI, which was the independent variable, affected the total hospital duration significantly and negatively ($\beta = -0.319$, $P < 0.05$) [Table 4]. When subgroup analyzes were performed in imputed data, while AHI in Group: 5 (Perforation) had a positive predictor (OR: 5,143, CI 95% [2,776–7,509] P: <0.001), AHI in Group 8 (NEC) (OR: −1,423, CI95% [−2.781–0,065] *P*: 0.04) and Group 2 (Pyloric surgery) (OR: −0,111 CI95% [−0,19––0,032] *P*: 0.006) was negative predictors for hospital stay length [Figure 4b]. Subgroup analyzes were performed by imputed data because the small sample size was far from fulfilling the assumptions of linear regression analysis of the subgroups.

Discussion

Identification of prognostic factors is clinically relevant for paediatric surgery patients and can guide clinical treatment. There are many studies on clinical and laboratory markers to predict post-operative mortality, intensive care admission and other results of patients undergoing surgery, especially in adults. We tried to find risk factors to be determined based on the surgical field. In this study, we assessed the effect of AHI on mortality and the length of hospital stay.

Oesophageal and duodenal atresia make up a major part of congenital lower and upper gastrointestinal system emergencies with an incidence of 1 in 2500–3000[9] and 1 in 10,000,[10] respectively, and jejunoileal atresia in the lower gastrointestinal system is the most common emergency cases with an incidence of 1in 5000.[11] In our study group, most also had oesophageal and small intestinal atresias, which made up approximately one-third of cases.

There are various studies on the relationship between pre-operative haemoglobin level and mortality, especially in the cardiovascular surgery field and adults. The study by Carson *et al*., which investigated the effect of preoperative haemoglobin on mortality, showed that the low preoperative haemoglobin levels and the intra-operative blood loss increased

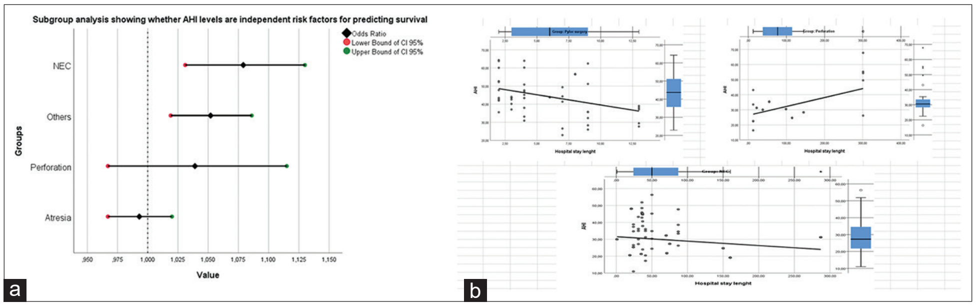

Figure 4: (a) Subgroup analyses regarding surgery type (b) The linear regression plots of the albumin haemoglobin index values of the subgroups that predict significantly for hospital stay length

Table 3: Logistic regression analyse results

Independent variable	β	SE	Wald χ^2	SD	P	Exp (B) (likelihood ratio)	95% CI
AHI	0.061	0.021	8.511	1	0.004	1.063	1.020-1.108
Constant	−1.938	0.848	5.216	1	0.022	0.144	
The general assessment of the model							
Tests			χ^2	**SD**		P	
Wald test statistic			3.914	1		0.04	
Hosmer and Lemeshow test statistic			11.210	8		0.190	
Cox and Snell R^2						0.153	
Nagelkerke R^2						0.208	
Classification ratio (%)						71.9	

Dependent variable 0=exitus, 1=Discharge. AHI: Albumin-haemoglobin index, SE: Standard error, SD: Standard deviation, CI: Confidence interval

Table 4: Linear regression analyse result for the hospital stay length

Independent variable	B	SE	β	t	P
AHI	−1.049	0.395	−0.319	−2.652	0.010
Constant	92.878	17.650	-	5.262	0.000
R^2			0.102		
F			7.035*		

*$P<0.05$ is significantly level. AHI: Albumin-haemoglobin index, SE: Standard error

the risk of morbidity and mortality, and the risk was much higher if the patients had cardiovascular disease.[12]

In their study, in which 216 consecutive adult patients who underwent living donor liver transplantation the primary outcome was survivability for 90 days, Badawy *et al*. found that a preoperative haemoglobin level <10 g/dl was an independent risk factor for increased post-transplant 90-day patient mortality, infection-related mortality, and early graft loss.[13] Contrary to this study, we found no difference in the groups' preoperative haemoglobin levels and no effect on mortality because of the study, which was retrospective. We may relate this to starting the operation as an optimal condition and the propensity of transfusion in the pre-operative days.

In a multicentre study investigating prolonged critical illness and mortality after cardiac surgery in paediatric cardiac surgery patients from 22 hospitals, while premature birth, extracardiac abnormality, and prolonged pre-operative hospital stay, were determined as risk factors for prolonged critical illness in neonatal patients, any chromosomal anomaly or syndrome, patient intubated preoperatively. Age at surgery <6 months, pre-op hospitalisation >1 day and previous cardiac surgery were found as risk factors in non-neonatal period surgery.[14] Similar to this study, we found the duration of preoperative hospital duration, mechanical ventilation time, oxygen exposure times and TPN times to be high in the exitus group, while we found the gestational week and birth weight to be low in the exitus group. Unlike the study, the absence of a difference in mortality in surgeries <1 month seems to be related to lower mortality in GIS surgery compared to cardiac surgery.

Among acutely ill surgical patients, malnourishment cannot explain solely the association between hypoalbuminaemia and adverse outcomes. In a meta-analysis of 90 retrospective studies and 9 prospective studies investigating hypoalbuminaemia among acutely ill patients, the association between hypoalbuminaemia and adverse outcomes was evident even after adjusting for body mass index and other measures of nutrition status, including body weight, body surface area, rate of weight loss, triceps skinfold, mid-arm muscle circumference and cachexia.[15] Despite the significant differences in the pathophysiology of stress-induced hypoalbuminaemia and protein deficiency-induced hypoalbuminaemia, in these patients who will undergo surgery, it seems to be related to systemic inflammation, nutritional problems and catabolic phase, depending on the underlying disease requiring surgery. In our study, we found that mean serum pre-operative values of AHI were significantly lower in the perforation group and NEC group. It made us think that lower AHI values in these groups were associated with both mechanisms simultaneously, although AHI was calculated by haemoglobin and albumin level. The higher AHI values in the atresia group support us which that group had a catabolic stage or undernourishment in the same way. In a prospective observational study that investigated the relationship between pre-operative serum albumin values and post-operative outcomes in non-cardiac surgery patients, the researchers found that pre-operative albumin values were independent predictors of mortality and morbidities, such as sepsis, and major infections.[16] In other studies which investigated pre-operative albumin and mortality association, or the prediction of prognosis in cancer surgery and gastrointestinal emergency surgery patients, they found serum albumin level to be an independent predictor of survival.[8,17-19] In line with these studies, we found that pre-operative serum albumin levels had significant effects on mortality and the length of hospital stay.

Deng *et al*., who assessed the prediction of surgical management of operated adhesive post-operative small bowel obstruction in a paediatric population, found CR*P* value to be a predictor of recurrent surgery.[20] CR*P* values are important inflammation markers. Although the CRP-to-death relationship was not examined in the study by Deng *et al*., pre-operative CRP values were significantly higher in the exitus and ileus groups in the present study. Similar to the study by Deng *et al*., the cases who needed recurrent surgery in our study had higher preoperative CRP values, however, the difference was not significant. In subgroup analyzes, CRP values had significant differences between the subgroups. Especially in perforation and NEC groups, CRP was significantly higher when compared to other subgroups. When the subgroup analyzes according to the recurrent surgery need, while CRP values were higher ileus, other and NEC groups were lower in atresia and intussusception groups. We may relate these findings to adhesions associated with the severity of inflammation in those more observed inflammation groups, such as ileus and NEC groups, similar to the study of Deng *et al*.

Our study had several limitations. First, it represented a retrospective database analysis in which unmeasured differences, known selection and treatment bias may be confounders that limit the generalisability of findings. Data were collected in a single institution, reflected our institution's experience and approach.

In conclusion, we showed AHI may be used as a valuable marker for survival and hospital stay length. Various markers or scoring systems that can predict mortality and length of stay will continue to be a subject of study. Further studies with a prospective nature and which include multiple taking part hospitals and a larger number of patients should be conducted.

Recommendations: AHI values measured in the preoperative period in paediatric surgery cases under the age of one can help surgeons and intensive care professionals to predict which patients may have a worse prognosis, and can provide time to take early precautions for other conditions that may endanger the patient's condition in the post-operative period.

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Conflicts of interest

There are no conflicts of interest.

References

1. Hajivassiliou CA. Intestinal obstruction in neonatal/pediatric surgery. Semin Pediatr Surg 2003;12:241-53.
2. Arques S. Human serum albumin in cardiovascular diseases. Eur J Intern Med 2018;52:8-12.
3. Don BR, Kaysen G. Serum albumin: Relationship to inflammation and nutrition. Semin Dial 2004;17:432-7.
4. Roche M, Rondeau P, Singh NR, Tarnus E, Bourdon E. The antioxidant properties of serum albumin. FEBS Lett 2008;582:1783-7.
5. Friedman AN, Fadem SZ. Reassessment of albumin as a nutritional marker in kidney disease. J Am Soc Nephrol 2010;21:223-30.
6. Gupta D, Lis CG. Pretreatment serum albumin as a predictor of cancer survival: A systematic review of the epidemiological literature. Nutr J 2010;9:69.
7. Kobayashi T, Teruya M, Kishiki T, Endo D, Takenaka Y, Miki K, *et al.* Elevated C-reactive protein and hypoalbuminemia measured before resection of colorectal liver metastases predict postoperative survival. Dig Surg 2010;27:285-90.
8. Loftus TJ, Brown MP, Slish JH, Rosenthal MD. Serum levels of prealbumin and albumin for preoperative risk stratification. Nutr Clin Pract 2019;34:340-8.
9. Spitz L. Esophageal atresia and tracheoesophageal malformations. In: Ashcraft KW, Holcomb G, Murphy JP, editors. Pediatric Surgery. 4th ed. Philadelphia: Elsevier Saunders; 2005. p. 352-70.
10. Latzman JM, Levin TL, Nafday SM. Duodenal atresia: Not always a double bubble. Pediatr Radiol 2014;44:1031-4.
11. Ashcraft KW, Holcomb GW, Murphy JP, Ostlie DJ, St. Peter SD. Ashcraft's pediatric surgery. 6th ed. London: Saunders/Elsevier; 2014.
12. Carson JL, Duff A, Poses RM, Berlin JA, Spence RK, Trout R, *et al.* Effect of anaemia and cardiovascular disease on surgical mortality and morbidity. Lancet 1996;348:1055-60.
13. Badawy A, Kaido T, Hammad A, Yagi S, Kamo N, Yoshizawa A, *et al.* The impact of preoperative hemoglobin level on the short-term outcomes after living donor liver transplantation. World J Surg 2018;42:4081-9.
14. DeWitt AG, Rossano JW, Bailly DK, Bhat PN, Chanani NK, Kirkland BW, *et al*. Predicting and surviving prolonged critical illness after congenital heart surgery. Crit Care Med 2020;48:e557-64.
15. Vincent JL, Dubois MJ, Navickis RJ, Wilkes MM. Hypoalbuminemia in acute illness: Is there a rationale for intervention? A metaanalysis of cohort studies and controlled trials. Ann Surg 2003;237:319-34.
16. Gibbs J, Cull W, Henderson W, Daley J, Hur K, Khuri SF. Preoperative serum albumin level as a predictor of operative mortality and morbidity: Results from the national VA surgical risk study. Arch Surg1999;134:36-42.
17. Han S, Huang Y, Li Z, Hou H, Wu A. The prognostic role of preoperative serum albumin levels in glioblastoma patients. BMC Cancer 2015;15:108.
18. Guo Y, Shi D, Zhang J, Mao S, Wang L, Zhang W, *et al.* The

hemoglobin, albumin, lymphocyte, and platelet (HALP) score is a novel significant prognostic factor for patients with metastatic prostate cancer undergoing cytoreductive radical prostatectomy. J Cancer 2019;10:81-91.
19. Lee JY, Lee SH, Jung MJ, Lee JG. Perioperative risk factors for in-hospital mortality after emergency gastrointestinal surgery. Medicine (Baltimore) 2016;95:e4530.
20. Deng Y, Wang Y, Guo C. Prediction of surgical management for operated adhesive postoperative small bowel obstruction in a pediatric population. Medicine (Baltimore) 2019;98:e14919.