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Research paper

Malnutrition on admission to the paediatric cardiac intensive care unit increases the risk of mortality and adverse outcomes following paediatric congenital heart surgery: A prospective cohort study

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ABSTRACT

Background: Malnutrition is a common problem in children with congenital heart disease, and it increases the risk of adverse outcomes in the postoperative period.
Objectives: We aimed to assess the association between malnutrition and cardiac surgery outcomes in paediatric patients aged 0–36 months.
Methods: This prospective cohort study was performed in a hospital specialising in paediatric cardiothoracic surgery. Children aged 0–36 months admitted to the paediatric cardiac intensive care unit after elective cardiac surgery between January 2018 and July 2018 were included in the study. We evaluated the patients' demographics and clinical variables, nutritional status, adverse outcomes, and 30-day mortality rates.
Results: A total of 124 cases met the inclusion criteria. Results showed that the Risk Adjustment for Congenital Heart Surgery score ≥5, underweight status (weight-for-age Z score ≤−2), and stunting (length-for-age Z score ≤−2) were all indicators for increased mortality following congenital heart surgery. Underweight children also spent a prolonged stay in the intensive care unit. Stunting (length-for-age Z score ≤−2) was the most strongly associated variable with mortality.
Conclusion: The results confirm the impact of malnutrition on mortality, postoperative infection, and length of hospitalisation in children undergoing surgery for congenital heart disease.

1. Introduction

Malnutrition is defined as an imbalance between the consumption of nutrients and the cumulative energy/protein demand for maintenance and growth,[1] and it remains a significant health problem among children worldwide. Globally, one-third of children younger than 5 y are undernourished. In 2018, the United Nations Children's Fund reported that 155 million children younger than 5 y old were stunted and 52 million were underweight.[2]

Congenital heart disease (CHD) is one of the most frequent congenital defects present at birth, with an incidence rate of 8–11 per 1000 live births,[3] and has a high impact on neonatal morbidity and mortality.[4] Numerous studies have reported malnutrition to be a recognised cause of morbidity in children with CHD.[5,6] Newborns and infants with CHD requiring surgical treatment face many obstacles in achieving good short- and long-term outcomes and ideal growth.[7] The existence of additional chromosomal anomalies, cyanosis, and cardiac failure heightens the challenges after surgery.[8]

Newborns/infants with cyanotic CHD are especially susceptible to acute or chronic starvation. Possible aetiologies involve insufficient intake (due to fatigue, oral aversion, dyspnoea, and/or early satiety), increased energy expenditure (including tachypnoea, and tachycardia), malabsorption (due to increased right-side heart pressure, lower cardiac output, and/or altered gastrointestinal function), and/or ineffective use of energy.[9] Thus, sufficient energy and protein intake are crucial for achieving normal growth and a

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strong immune system. Surgical trauma increases the metabolic/caloric need and increases metabolic stress in the malnourished newborn/infant as surgery drains their already-insufficient metabolic reserves.[10] As such, the probability of adverse outcomes and mortality after surgery increases. Optimal nutritional intake in the preoperative and postoperative phases can improve the metabolic stores of children with CHD, which is vital to prevent the adverse outcomes of surgical trauma.[11]

1.1. Aim

We aimed to explore the association between malnutrition and adverse outcomes in children aged 0–36 months undergoing surgery for CHD.

2. Materials and methods

2.1. Design

This is a prospective cohort study.

2.2. Setting

This study was conducted in a 17-bed paediatric cardiac intensive care unit (PICU) in Turkey.

2.3. Ethical approval

All procedures performed in this study involving human participants follow the ethical standards of the institutional and/or national research committee and comply with the 1964 Helsinki Declaration and its later amendments. The institutional board approved the study protocol (28001928.501.01/25.05.2018), and written consent was obtained from the guardians of the children included in the study protocol.

2.4. Recruitment and eligibility

Children aged 0–36 months admitted to the PICU after elective cardiac surgery between January 2018 and July 2018 were included. Cases undergoing emergency cardiac surgery or subsequent surgeries during their hospitalisation were excluded.

2.5. Assessed variables

2.5.1. Demographic and clinical variables

Age (days), gender, weight (grams), length (centimetres), prematurity (neonate at less than 37 weeks gestational age),[12] cyanotic heart disease,[13] operative characteristics (cardiopulmonary bypass, duration on bypass, length of operation), mechanical circulation support[14] (extracorporeal membrane oxygenation), sternal closure time (delayed due to myocardial oedema and/or bleeding or non-delayed),[15] and Risk Adjustment for Congenital Heart Surgery (RACHS) scores[16] (utilised to assess in-hospital mortality risk adjustment for paediatric cases undergoing cardiac surgery) were evaluated.

Child development stages are as follows – *Newborn*: 0–1 months; *Infant*: 1–12 months; *Toddler*: 12–36 months.[17–19]

2.5.2. Nutritional assessment

The World Health Organization (WHO) growth standard charts were used for nutritional assessment. Length-for-age, weight-for-age, and weight-for-length Z scores were determined for every case using WHO standard charts (http://www.who.int/childgrowth/en/). *Underweight* was defined as weight-for-age Z score ≤ -2, *Stunting* was defined as length-for-age Z score ≤ -2, and *Wasting* was defined as weight-for-length Z score ≤ -2.

2.5.3. Nutritional support

Enteral nutrition is preferred as the method of nutrition support in our PICU, and we start enteral nutrition as soon as possible following PICU admission (except significant upper gastrointestinal bleeding, presence or high risk of necrotising enterocolitis, postoperative ileus, intestinal obstruction).

The nutritional plan is decided for each patient according to age, medical history, and nutritional status with a dietitian. We prepared a nutritional support program based on the Baylor College of Medicine Guidelines for Neonatal Nutrition,[20] the Schofield prediction equation,[21] and the 2017 American Society for Parenteral and Enteral Nutrition guidelines.[22] Because a significant proportion of the patients were malnourished and there was a prediction of requirement for long-time mechanical ventilation support, high energy and protein intake were planned as 90 kcal/kg/day and 3 g/kg/day, respectively. At the same time, stress factors were considered while calculating energy and protein intake. Enteral nutrition was delivered through a nasogastric tube by continuous infusion, starting at a low rate (5–10 ml/h according to the weight of the child), and gradually increased until entire requirements were delivered. Following any interruption other than feeding intolerance, feeding is restarted according to previously established feeding schedules and advanced as tolerated. We initiated parenteral nutrition in patients with malnutrition, low birth weight, or hypermetabolism if fasting is anticipated for 3 days or more.

A separate wing of the hospital was made available for breastfeeding mothers to stay. Thus, mothers could feed their babies, aged 0–24 months, either directly breastfeeding or via expressing milk. Mother's milk was given enterally for mechanical ventilated patients. Patients aged 24–36 months with spontaneous breathing were fed orally, while those on a mechanical ventilator were fed through a nasogastric tube.

2.5.4. Patient follow-up

All patients were followed up for 30 days following surgery. If patients were discharged before this time, outpatient clinic visits were scheduled for the 30th day after the operation. In each case, the duration of mechanical ventilation, the instance of postoperative infection, length of PICU stay, hospitalisation time, and 30-day mortality were evaluated. Urinary tract infection, ventilator-associated pneumonia (developing 48–72 h after endotracheal intubation),[23] mediastinitis (deep sternal wound infection), and sepsis[24] were deemed postoperative infections.

2.6. Statistical analysis

The NCSS 2007 (Utah, USA) program for statistical analysis was used. Descriptive statistical methods (mean, standard deviation, median, first quarter, third quarter, frequency, percentage, minimum, maximum) were used to evaluate the study data. The Shapiro–Wilk test and graphical examinations were applied to test the suitability of quantitative data for normal distribution. Binary logistic regression analysis was used for univariable and multivariable evaluations of factors affecting mortality, cardiac arrest, and infection. Generalised linear models were used for univariable and multivariable assessments of factors affecting mechanical ventilation, length of PICU stay, and hospitalisation time. Statistical significance was accepted as $p < 0.05$.

3. Results

A total of 124 children met the inclusion criteria for the study. The gender distribution was 46/124 (37%) female and 78/124 (63%) male, with ages ranging between 0 and 36 months. Underweight and wasting were seen more frequently in infants (35/51 [68.6%] and 20/51 [39.2%], respectively), while stunting was observed most commonly in newborns (30/41 [73.2%]). Demographics and operational characteristics are shown in Table 1.

3.1. Factors affecting mortality

Increased age and weight were associated with decreased mortality rates ($p = 0.02$ and $p = 0.01$, respectively). On the other hand, prematurity, longer cardiopulmonary bypass duration, RACHS score ≥5, underweight (weight-for-age Z score ≤−2), and stunting (length-for-age Z score ≤−2) were all associated with increased mortality rates ($p = 0.04$; $p = 0.03$; $p = 0.01$; $p = 0.04$; $p = 0.04$, respectively). Details of factors affecting mortality are shown in Table 2.

3.2. Factors affecting the duration of mechanical ventilation

There was an inverse association between decrease in weight and length and longer duration of mechanical ventilation (Beta [95% confidence interval {Cl}]: −0.178 [−0.327, −0.028], $p = 0.012$; Beta [95% Cl]: −0.001 [−0.002, −0.001], $p = 0.02$, respectively). The duration of mechanical ventilation was longer in patients who were underweight and short.

Other factors related to extended mechanical ventilation were underweight, stunting, wasting, low weight-for-age Z score, and shorter length-for-age Z score (Table 2). Additionally, increase in length-for-age Z score in the Toddler group was associated with a decrease in mechanical ventilation time (Beta [95% Cl]: −7.127 [−12.763, −1.491], $p = 0.017$).

Table 1
Patient and operative characteristics.

Characteristics	Mean ± SD, median (IQR) or n*(%)*
Age (months), mean ± SD, median (Q1, Q3)	9.08 ± 10.4, 5 (0.66, 16)
Female/male, n *(%)*	46/78 *(37/63)*
Weight (grams), mean ± SD, median (Q1, Q3)	6145.06 ± 3344.42, 4700 (3250, 8200)
Length (centimetres), mean ± SD, median (Q1, Q3)	62.72 ± 14.52, 59 (50, 71)
Prematurity, n *(%)*	20 *(16.1)*
Cyanotic hearth disease, n *(%)*	14 *(11.2)*
Major noncardiac anomaly, n *(%)*	5 *(4)*
Preoperative mechanical ventilation, n *(%)*	24 *(19.3)*
Cardiopulmonary bypass, n *(%)*	109 *(87.9)*
Duration on bypass (minutes), mean ± SD, median (Q1, Q3)	148.22 ± 127.07, 130 (90, 1080)
Delayed sternal closure, n *(%)*	
Yes	50 *(40.3)*
No	74 *(59.7)*
Cardiac arrest, n *(%)*	5 *(4)*
[b]**ECMO,** n *(%)*	19 *(15.3)*
Mortality (with in 30 days of surgery), n *(%)*	10 *(8)*
Postoperative infection	15 *(12.1)*
Duration of mechanical ventilation (postoperative) (days), mean ± SD, median (Q1, Q3)	9.2 ± 10.2, 7 (3,12)
Duration of PICU[a] (days), mean ± SD, median (Q1, Q3)	14.2 ± 13.2, 10 (5, 18)
Hospital stay (days), mean ± SD, median (Q1, Q3)	19.8 ± 14.7, 16 (10,24)
[a]**RACHS score,** n *(%)*	
1	15 *(12.1)*
2	25 *(20)*
3	43 *(34.6)*
4	19 *(15.3)*
5	10 *(8)*
6	12 *(9.7)*
Growth and development indices, n *(%)*	
Weight-for-age, Z score ≤−2	
All patients (n = 124)	85 *(59.7)*
Newborn (n = 41)	24 *(58.5)*
Infant (n = 51)	35 *(68.6)*
Toddler (n = 32)	14 *(43.7)*
***Length*-for-age, Z score ≤−2**	
All patients (n = 124)	88 *(70.9)*
Newborn (n = 41)	30 *(73.2)*
Infant (n = 51)	29 *(56.8)*
Toddler (n = 32)	15 *(46.8)*
Weight-for-length, Z score ≤−2	
All patients (n = 124)	*43 (34.6)*
Newborn (n = 41)	*14 (34.1)*
Infant (n = 51)	*20 (39.2)*
Toddler (n = 32)	*9 (28.1)*

PICU: paediatric cardiac intensive care unit; SD: standard deviation.
[a] RACHS: Risk Adjustment for Congenital Heart Surgery.
[b] ECMO: extracorporeal membrane oxygenation.

Table 2
Determination of factors affecting mortality, ICU LOS, hospital LOS, duration of mechanic ventilation, and postoperative infection.

	Mortality[a]		ICU LOS[b]		Hospital LOS[b]		Duration of mechanical ventilation[b]		Postoperative infection[a]	
	OR (95% CI)	*p*	Beta (95% CI)	*p*	Beta (95% CI)	*p*	Beta (95% CI)	*p*	OR (95% CI)	*p*
Age (days)	0.908 (0.995,1.001)	0.02[c]	−0.005 (−0.014, 0.003)	0.221	−0.002 (−0.012, 0.009)	0.766	−0.003 (−0.01, 0.004)	0.375	−0.997 (0.001,- 0.004)	0.004[c]
Gender (male)	1.480 (0.351, 6.239)	0.594	−2.30 (−9.255, 4.639)	0.510	−3.59 (−11.476, 4.296)	0.367	0.103 (−4.393, 4.6)	0.964	1.045 (0.413,2.642)	0.926
Weight (gr)	0.802 (1.001, 1.004)	0.01[c]	−0.002 (−0.003,-0.001)	0.011[c]	23.424 (15.918,30.93)	0.137	−0.001 (−0.002,-0.001)	0.012[c]	−1.002 (−0.003,-0.001)	<0.001[c]
Length (cm)	0.949 (0.892, 1.009)	0.096	−0.228 (−0.429,-0.027)	0.027[c]	−0.137 (−0.374, 0.099)	0.252	−0.178 (−0.327,-0.028)	0.020[c]	−0.928 (−0.108,-0.045)	<0.001[c]
Prematurity	1.909 (0.059, 4.408)	0.04[c]	3.668 (−2.084, 9.42)	0.208	2.794 (−3.106, 8.695)	0.348	1.623 (−3.255, 6.501)	0.509	3.131 (0.788,12.44)	0.105
Cyanotic hearth disease	2.143 (0.378, 12.16)	0.390	−1.464 (−9.327, 6.399)	0.712	3.211 (−8.782, 15.204)	0.595	7.885 (−4.556, 20.326)	0.211	1.676 (0.387, 7.257)	0.490
CBP[e]	0.467 (0.082, 2.648)	0.390	0.08 (−8.242, 8.402)	0.985	0.815 (−6.429, 8.06)	0.823	−2.124 (−9.736, 5.489)	0.580	1.013 (0.25, 4.106)	0.985
Duration of CPB[e] (min)	1.999 (0.993, 1.006)	0.03[c]	−0.006 (−0.019, 0.008)	0.385	−0.005 (−0.019, 0.009)	0.491	−0.009 (−0.02, 0.001)	0.082	0.999 (0.995, 1.003)	0.570
Noncardiac anomaly	[d]—	0.999	−6.779 (−12.496, −1.063)	0.021[c]	−10.23 (−17.636, −2.824)	0.07	6.354 (−9.697, −3.01)	<0.001[c]	0.381 (0.033, 4.389)	0.439
Preoperative Mec.Vent.[e]	1.964 (0.443, 8.713)	0.374	1.016 (−5.034, 7.066)	0.739	2.776 (−5.595, 11.148)	0.511	7.879 (−0.15, 15.907)	0.054	4 (1.027,15.57)	0.046[c]
RACHS[e] (5–6)	5.750 (1.248, 36.522)	0.01[c]	2.629 (−8.075, 13.332)	0.026[c]	2.229 (−8.293, 12.751)	0.674	12.049 (−3.629, 27.727)	0.130	1.06 (0.221, 5.092)	0.942
Weight-for-age, Z score ≤−2	1.675 (0.398,7.049)	0.04[c]	2.587 (−4.697, 9.87)	0.043[c]	1.811 (−6.057, 9.68)	0.048[c]	5.887 (1.658, 10.115)	0.007[c]	3.712 (1.398, 9.86)	0.008[c]
Length-for-age, Z score ≤−2	6.075 (0.727, 50.757)	0.04[c]	3.22 (−3.523, 9.963)	0.044[c]	−0.067 (−7.64, 7.506)	0.986	4.452 (0.066, 8.839)	0.047[c]	4.156 (1.58, 10.934)	0.004[c]
Weight-for length, Z score ≤−2	3.286 (0.838,12.884)	0.088	2.8 (−2.541, 8.141)	0.300	0.887 (−5.224, 6.999)	0.773	5.298 (0.089, 10.507)	0.046[c]	3.354 (1.204, 9.346)	0.021[c]
Weight-for-age	0.787 (0.465, 1.33)	0.371	−1.737 (−3.42, −0.054)	0.043[c]	−1.063 (−2.984, 0.859)	0.024[c]	−1.875 (−3.019, −0.732)	0.002[c]	0.540 (0.365, 0.801)	0.245
Length-for-age	0.849 (0.503, 1.435)	0.542	−1.574 (−3.452, 0.303)	0.099	−0.538 (−2.557, 1.482)	0.047[c]	−1.499 (−2.896, −0.101)	0.036[c]	0.534 (0.357, 0.799)	0.062
Weight-for- length	0.667 (0.4, 1.111)	0.120	0.386 (−1.862, 2.633)	0.733	1.088 (−1.407, 3.583)	0.388	−0.94 (−3.158, 1.278)	0.401	0.668 (0.456, 0.979)	0.090
Delayed sternal closure	[d]—		−9.199 (−15.584, −2.815)	0.005[c]	−10.002 (−17.174, −2.83)	0.007[c]	[d]—		[d]—	
ECMO[e]	[d]—		6.892 (−7.021, 20.806)	0.327	12.244 (−3.528, 28.016)	0.126	[d]—		[d]—	
Postop infection	[d]—		7.172 (1.724, 12.621)	0.011[c]	9.283 (3.316, 15.251)	0.003[c]	[d]—		[d]—	

CI: confidence interval; ICU: intensive care unit; LOS: length of stay; OR: odds ratio.
[a] Logistic regression analysis.
[b] Linear regression analysis.
[c] $p < 0.05$.
[d] The OR or beta value could not be calculated because the affecting determinant was not observed.
[e] CPB: cardiopulmonary bypass; Mec.Vent.: mechanical ventilation; RACHS: Risk adjustment for congenital heart surgery; ECMO: extracorporeal membrane oxygenation.

3.3. Factors affecting postoperative infection

There was an inverse association between age, length, weight, and postoperative infection rates (odds ratio [OR] [95% CI]: −0.997 [0.001, −0.004], $p = 0.004$; OR [95% CI]: −0.928 [−0.108, −0.045], $p < 0.001$; OR [95% CI]: −1.002 [−0.003, −0.001], $p < 0.001$, respectively). Postoperative infection rates were higher in younger, shorter, and less weighted patients. Additionally, underweight (weight-for-age Z score ≤−2), stunting (length-for-age Z score ≤−2), and wasting (weight-for-length Z score≤−2) were other factors related to postoperative infection rates ($p = 0.008$; $p = 0.004$; $p = 0.001$, respectively) (Table 2).

3.4. Factors affecting the length of stay in the PICU

Being shorter, of less weight, and underweight had an inverse association with prolonged ICU stay ($p = 0.011$; $p = 0.027$; $p = 0.043$, respectively). Other factors associated to prolonged PICU stay were the RACHS score ≥5, underweight (weight-for-age Z score ≤−2), delayed sternal closure, and postoperative infection (Table 2).

3.5. Factors affecting the length of stay in hospital

There was a relationship between underweight patients and an increased length of hospital stay ($p = 0.048$).

4. Discussion

The study highlights the negative impact of malnutrition on mortality in patients aged 0–36 months who undergo cardiac surgery, and stunting has the most noticeable effect.

Hypercatabolism, following cardiac surgery, consumes the limited amounts of hepatic glycogen and adipose tissue reserves that are present in newborns, infants, or toddlers. Therefore, deficiency in these metabolic stores is associated with an increased risk of mortality among the youngest children undergoing cardiac surgery.[8,25] In the study, more than half of the children were underweight, a sign of acute malnutrition, and more than 70% had stunting, considered an indication of chronic malnutrition. This supports previous studies that indicate a particularly high rate of malnutrition in children with CHD who live in developing countries. The malnutrition rates reported in the literature for children who undergo surgery for CHD range from 27% to 90.4%.[26,27] The 1962 study by Mehrizi and Dash described a 27% rate,[26] while more recent research from Turkey puts this number at a much higher to 85%;[27] and in Nigeria, the rate is reported to be 90.4%.[28] When investigating mortality rates of children undergoing cardiac surgery, the link between age/weight/length and mortality is a well-documented concept.[8,11,16,29] Inevitably, paediatric candidates for cardiac surgery often have complicated comorbidities and severe physiological variations. There may be difficulties related to immature organ development and the immune system, while cardiopulmonary bypass can cause severe pathophysiological outcomes in patients with such a small volume of intravascular blood. In the study, *stunting*, a marker for foetal undernutrition, had a substantial impact on mortality, increasing the risk by 6.075 times. This result was in line with previous studies.[30–32] Although the results did not show any relation between stunting and length of hospital stay, associations were seen between stunting and an increase in the length of PICU stay, duration of mechanical ventilation, and risk of postoperative infection.

Recent studies have shown that, in cases where the Glenn procedure is used, a higher *weight-for-age Z score* correlates to a shorter hospitalisation time.[33] Also, in patients awaiting the Norwood procedure, successful preoperative enteral nutrition is associated with a shorter transition to full enteral feeding.[34]

Institutions have varying approaches to dealing with malnourished infants, such as which to treat with nasogastric feeding, which can be breastfed, and the exact time to start enteral nutrition via gastric tube.[16] Although many institutions discharge patients with a nasogastric feeding tube in place, some prefer to use a surgically placed percutaneous gastric tube, which is the most reliable way of delivering nutrients to maintain nutritional support.[30] According to the protocol we followed, malnourished newborns/infants who have undergone cardiac surgery are fed with formula via a nasogastric tube, while those with a healthy sucking reflex are assigned formula + breastfeeding.

Feeding difficulties in newborns and infants undergoing cardiac surgery are a common problem, although the actual mechanism causing this remains unclear.[35] Some newborns completely resist sucking, whereas others lose their sucking reflex shortly after surgery.[36] In fact, swallowing begins in the 16th gestational week and is expected to be a normal functioning reflex at birth in healthy newborns.[37] However, laryngopharyngeal dysfunction, which inescapably leads to problematic feeding, is often seen in newborns undergoing major cardiac surgery. Despite optimal medical care, weight gain is less than expected in these children.[38,39] The percentage of patients with *stunting*, which indicates chronic undernutrition, was 70.9% in our study group. It is likely that chronic malnutrition, which begins in the intrauterine period and continues into the extrauterine period, has a negative impact on mortality after major cardiac surgery. Our results showed that mortality rate, duration in the PICU, duration of mechanical ventilation, and postoperative infection were higher in stunted patients.

The delay of sternal closure is also of importance. Delaying sternal closure helps the patient to settle down haemodynamically by providing space for the dilated, dysfunctional ventricle or poorly compliant lungs to expand.[40] The advantages of delayed sternal closure are more significant in paediatric cardiac surgery because of a larger cardiac size relative to the thoracic cavity. Besides this, postsurgery cardiac oedema causes diastolic restriction and leads to a tamponade-like condition of the right ventricle.[41] We observed that children who underwent delayed sternal closure had prolonged PICU stay and hospitalisation. The haemodynamically unstable condition of children undergoing cardiac surgery explains the longer PICU and hospital stays.

The interrelation between undernutrition and adverse postoperative outcomes demonstrated may force our institution as well as other paediatric cardiac surgery centres to place more emphasis on preoperative nutritional support before complex cardiac surgery. Despite the extraordinary efforts taken in most paediatric cardiac surgery institutions, a standardised nutritional care protocol for neonates or infants with CHD, which could lead to improved nutritional status, is lacking. Further investigations are needed to assess the possible impact of an optimised preoperative enteral nutrition program on postoperative outcomes.

5. Limitations

There are several limitations to consider. The primary constraint is that the cohort was from a single institution with a relatively small number of cases. The short follow-up period is a second limitation. Unlike many previous studies,[15,42,43] children with a high RACHS score (RACHS score: 4-5-6) were included in this study, and this may have influenced the resulting rate of prolonged PICU hospitalisation. This issue was not investigated further as the focus of the study was the link between the children's preoperative nutritional status and its postoperative effects.

Indeed, evaluating the association between the RACHS score and hospital/PICU stay is a separate topic. We recommend that multicentre studies conducted with larger sample sizes and provision for long-term follow-up are needed to confirm our findings.

Data about daily nutritional plan were not used in the study. We think that these data would not contribute to the purpose of our study but may clarify the nutrition of critically ill patients in the intensive care unit. Thus, it would be better if these data could be included the study.

6. Conclusions

We assessed the association between malnutrition present on admission to the PICU and postoperative outcomes in patients who underwent surgery for CHD. Our research confirms the impact of malnutrition on mortality in children having surgery for CHD and poor postoperative outcomes, including postoperative infection and extended length of hospital stay. We believe international guidelines on the identification, management, and treatment of malnourished paediatric cases should be established with the aim of reducing mortality rates and preventing adverse surgical outcomes. In addition, in the light of these international guidelines, each paediatric cardiac surgery institution should determine their own strategies for managing newborns/infants who are malnourished before surgery.

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Conflict of Interest

The authors declare no conflict of interest.

CRediT authorship contribution statement

Sibel Yilmaz Ferhatoglu: Conceptualisation, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualisation, Project administration; **Okan Yurdakok:** Resources; **Nurgul Yurtseven:** Supervision.

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