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Research Article

The relationship between preoperative nutritional status with postoperative mortality and morbidity in congenital heart patients

Konjenital kalp hastalarında ameliyat öncesi beslenme durumunun ameliyat sonrası mortalite ve morbidite ile ilişkisi

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ABSTRACT

Aim: This study aimed to determine the relationship between preoperative nutritional status and postoperative mortality and morbidity in pediatric patients undergoing congenital heart surgery.

Material and Methods: The study enrolled 36 pediatric patients, aged between 3 and 60 months, who were hospitalized for congenital heart surgery. Nutritional status assessment involved measuring the triceps skinfold thickness (TSFT) prior to surgery. The investigation focused on establishing associations between the provided preoperative data and various postoperative outcomes, including duration of Intensive Care Unit (ICU) stay, mechanical ventilator requirements, inotrope usage, and 30-day mortality."

Results: In the preoperative period, 8.3% of the patients were below <-1 SD; 66.7% of them were found to be between -1 and +1 SD according to TSFT Z-score charts. There was no statistically significant correlation between preoperative triceps skinfold thickness Z score and extubation time (p=0.523), intensive care unit stay (p=0.551), inotrope intake duration (p=0.889) and 30-day mortality (p>0.05).

Conclusion: No significant correlation was found between preoperative nutritional status and postoperative morbidity and mortality in pediatric patients.

Keywords: Triceps skinfold thickness, Nutritional status, Congenital heart disease

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ÖZ

Amaç: Bu çalışma konjenital kalp hastalığı nedeniyle ameliyat edilecek çocuk hastaların preoperatif beslenme durumu ile postoperatif morbidite ve mortalite arasındaki ilişkisini saptamak amacıyla planlanmıştır.

Gereç ve Yöntemler: Çalışmaya konjenital kalp hastalığı nedeniyle ameliyat edilmek üzere hastaneye yatırılan 36 çocuk (3-60 ay) hasta dahil edilmiştir. Ameliyat öncesi hastaların beslenme durum değerlendirmesinde triseps deri kıvrım kalınlığı (TDKK) ölçümleri kullanılmıştır. Operasyon sonrası hastaların yoğun bakımda kalış süreleri, mekanik ventilatörde kalış süreleri, inotrop gereksinimleri ve süreleri ile 30 günlük mortalite kaydedilmiştir.

Bulgular: Preoperatif dönemde hastaların %8.3'ünün TDKK Z-skor değerleri <-1 SD altında; %66.7'sinin ise -1 ile +1 SD arasında saptanmıştır. Preoperatif dönemde ölçülen triseps deri kıvrım kalınlığı ile ekstübasyon süresi ($p=0.523$), yoğun bakım kalış süresi ($p=0.551$), inotrop alma süresi ($p=0.889$) ve 30 günlük mortalite ($p>0.05$) arasında istatistiksel açıdan anlamlı fark bulunmamıştır.

Sonuçlar: Konjenital kalp hastalığı olan çocuk hastalarda preoperatif beslenme durum ile postoperatif morbidite ve mortalite arasında anlamlı bir ilişki saptanmamıştır.

Anahtar Kelimeler: Triseps deri kıvrım kalınlığı, Beslenme durumu, Konjenital kalp hastalığı

Introduction

Critical illnesses and surgical operations increase energy and nutrient requirements, affecting energy homeostasis [1]. Pediatric patients are at a higher risk of inadequate nutrition compared to adults in these situations. This is due to the increased metabolic demand resulting from surgeries and illnesses, as well as the increased energy requirement for growth and neurological development in pediatric patients. Malnutrition is one of the most significant morbidities in pediatric intensive care units [2]. Some studies indicate that assessing the preoperative nutritional status in children before surgery contributes to preventing commonly encountered postoperative comorbidities [2,3].

In the United States, malnutrition is known to be one of the most common comorbidities in pediatric intensive care units [4]. Observations in adult patients indicate that outcomes are unfavorable in disease processes accompanied by malnutrition [5]. Inadequate nutrition leads to the development of additional factors such as myocardial dysfunction, vascular endothelial dysfunction, skeletal muscle atrophy, immunosuppression, and lipolysis [6]. These conditions have greater consequences in pediatric patients due to their incomplete somatic growth and neurodevelopmental processes [7].

Malnutrition is commonly observed in congenital heart diseases and is strongly linked to postoperative outcomes [5]. Therefore, evaluating the nutritional status during the preoperative period in pediatric patients undergoing congenital heart surgery is crucial for reducing postoperative morbidity and mortality. Especially in cases where there is excess pulmonary blood flow, severe cyanosis, and accompanying pulmonary arterial hypertension, the metabolic needs secondary to heart failure change [8]. These conditions affect nutritional homeostasis by leading to increased respiratory requirements, malabsorption secondary to low cardiac output, gastrointestinal dysfunction, and low energy intake with excessive energy expenditure in the development of right heart failure [9]. Despite all these known adverse characteristics, the effects of preoperative nutritional status on clinical outcomes in children undergoing congenital heart surgery have not been investigated in detailed [5].

Nutritional status assessment can be done using various anthropometric measurements. One of these measurements includes the assessment of triceps skinfold thickness (TSFT). Using this method, measurement of peripheral fat mass is performed from the triceps region of the upper arm. It is known that about 50% of total body fat is stored in subcutaneous fat depots and that this is associated with the total body fat amount. With this method, nutritional status assessment can be performed in patients of all age groups, including infants and newborns, and chronic malnutrition conditions can be determined [10].

This study aims to assess the nutritional condition of pediatric patients with congenital heart disease scheduled for surgery using TSFT and to examine the correlation between these findings and postoperative mortality and morbidity.

Material and Methods

The study had retrospective and observational design and involving 36 pediatric patients (18 females, 18 males) aged between 3 months and 5 years. These patients admitted to the

Department of Cardiovascular Surgery at Hacettepe University Faculty of Medicine for elective heart surgery between March 2014 and April 2014. The patients had no additional diseases apart from congenital heart disease.

The RACHS (Risk Adjustment in Congenital Heart Surgery) score is a well-validated method for predicting hospital mortality in pediatric patients undergoing surgery due to congenital heart disease [11]. In this study, only patients with RACHS scores ≤ 3 were included to ensure no differences in mortality and morbidity related to the surgical procedure itself. Due to the possibility of increased extravascular fluid volume (edema) in children with congenital heart disease, Triceps Skinfold Thickness (TSFT) was used for assessing nutritional status. After hospital admission, patients' TSFT was measured with a caliper. The relationship between TSFT and morbidity factors such as duration of ICU stay, mechanical ventilator requirement, inotrope requirement, and 30-day mortality was investigated.

Patients with any additional disease that could cause chronic malnutrition, preterm infants, those with a history of hospitalization for any reason within the last month, and pediatric patients with a RACHS score above 3 were excluded from the study.

During the preoperative admission process, TSFT measurements were taken from the patients. After identifying the midpoint of the upper arm, TSFT measurement was taken from this point. TSFT was measured using a caliper by compressing the skin between two fingers on the non-dominant arm. Measurements were taken three times consecutively, and the average value was recorded. Patients were classified according to their nutritional status using the World Health Organization (WHO) TSFT Z-score values [12].

According to the WHO, TSFT Z-score classification ranges from -3 SD to +3 SD. Severe malnutrition is considered to be -3 SD or below, while those above +3 SD are defined as morbid obese [12]. In this study, patients with Z scores between -2 SD and -1 SD were grouped together and considered mildly malnourished due to not observing patients with Z scores below -2 SD, and because they fell within the 3rd to 15th percentile range on the percentile curves. Patients with Z scores between -1 and +1 SD were grouped together and considered to have a normal nutritional status due to falling within the 15th to 85th percentile range on the percentile curves. As the study did not investigate the effect of obesity on postoperative morbidity and mortality, all patients with Z scores above +1 SD were evaluated together as a single group, and differences between these two subgroups were neglected.

Following the achievement of hemodynamic stability postoperatively, patients were extubated. Inotropes were gradually discontinued as part of routine monitoring, and patients were transferred to the ward for further observation at the earliest possible time.

During the intensive care unit (ICU) stay, morbidity indicators such as extubation duration, duration of inotrope use, and length of ICU stay were prospectively recorded. Additionally, in this study, the relationship between preoperatively measured TSFT Z scores and 30-day mortality in patients was investigated.

This research was conducted in accordance with the principles outlined in the Helsinki Declaration, and informed consent was obtained from the first-degree relatives of the patients. The study was approved by the Hacettepe University Clinical Research Ethics Committee under the protocol number GO 14/223-090.

Statistical analyses were conducted using the SPSS (SPSS Statistics 14) software package. Frequency tables and descriptive statistics were used for interpreting the findings. For measurement values that did not follow a normal distribution, non-parametric methods were employed. Accordingly, the "Mann-Whitney U" test (Z-table value) was used to compare measurement values between two independent groups, while the "Kruskal-Wallis H" test (χ^2-table value) was used for comparing measurement values among three or more independent groups. Cross-tabulation tables using the "Pearson-χ^2" method were utilized to examine the relationships between two categorical variables.

Results

Patients consisted of 18 (50%) males and 18 (50%) females, with a mean age of 11.50 ± 16.06 months. The mean body weight was 8500 ± 3623 g. The diagnoses of the patients are summarized in Table 1.

Table 1. Diagnoses of the Patients

Diagnosis	n	%
ASD	2	5.6
VSD	10	27.7
VSD (Pulmonary Artery Banded)	4	11.2
VSD, ASD	3	8.2
VSD, PDA	1	2.8
Tricuspid Atresia	4	11.2
PAPVD, ASD	1	2.8
TOF	11	9.5
Total	36	100

ASD; Atrial Septal Defect , VSD; Ventricular Septal Defect, PDA; Patent Ductus Arteriosus, PAPVD; Partial Anomalous Pulmonary Venous Drainage , TOF; Tetralogy of Fallot

During the preoperative period, it was determined that 8.3% of patients had TSFT Z-score values below -1 SD, while 66.7% were between -1 and +1 SD.

All patients included in the study underwent complete correction under cardiopulmonary bypass (CPB), except for those diagnosed with tricuspid atresia. Among these patients, 3 underwent a Glenn shunt procedure, and 1 received total cavopulmonary anastomosis.

Of the patients included in the study, 34 (94.4%) were discharged, while 2 patients (5.6%) had fatal outcomes. The diagnoses of the patients with fatal outcomes were VSD-ASD and TOF, respectively. The mean pulmonary artery pressure of the VSD-ASD patient was determined to be 45 mmHg. The McGoon ratio for the TOF patient was 1.7. Both patients underwent complete correction surgery.

In Tables 2 and 3, the relationship between patients' preoperatively determined TSFT Z scores and 30-day mortality, as well as postoperative morbidity, is demonstrated.

Table 2. Relationship between TSFT Z Score and Postoperative Morbidity

TSFT Z Score		Duration of Mechanical Ventilation (h)	Duration of Intensive Care Unite Stay (h)	Duration of Inotropic Agent Requirement (h)
-2-<-1	Mean±SD	12.0±2.3	42.0±14.7	-
-1 - +1	Mean±SD	10.0±27.2	46.0±76.7	46.5±157.7
>+1	Mean±SD	12.0±4.7	42.5±63.8	140.0±148.4
Total		11.5	44.5	46.5
		p=0.523	p=0.551	p=0.889

TSFT; Triceps Skinfold Thickness

Table 3. Relationship between TSFT Z Score and 30-Day Mortality

		30-Day Mortality			
		Alive	Dead	Total	
TSFT Z Score	< -2	0 (%0)	0 (%0)	0	p > 0.05
	-2 - <-1	3 (%100)	0 (%0)	3	
	-1 - +1	19 (%90.5)	2 (%9.5)	21	
	>+1	12 (%100)	0 (%0)	12	
Total		34 (%94.4)	2 (%5.6)	36	

TSFT; Triceps Skinfold Thickness

A relationship between patients' TSFT Z scores and postoperative morbidity parameters was investigated. In the statistical analysis, the mean extubation time was found to be 11.5 ± 20.5 hours, ICU stay was 44.5 ± 67.8 hours, and duration of inotrope requirement was 46.5 ± 148.9 hours. However, no significant relationship was found between the preoperative nutritional status indicator, TSFT Z score, and postoperative morbidity parameters such as extubation time (p=0.523), ICU stay (p=0.551), and duration of inotrope requirement (p=0.889).

Similarly, the TSFT Z score was compared with 30-day mortality rates. However, no statistically significant relationship was found in this comparison (p > 0.05).

Discussion

Malnutrition is commonly observed during the preoperative period in children with congenital heart disease. Various studies conducted on these patients have reported a prevalence of preoperative chronic malnutrition ranging from 42% to 52% [8,13]. Achieving nutritional homeostasis is essential for maintaining an individual's health status. However, maintaining optimal nutritional status in pediatric patients is much more challenging. This is due to the fact that these patients continue to undergo growth processes while also experiencing additional metabolic stress due to their underlying congenital heart diseases [6].

In general, these patients exhibit increased energy demand, decreased energy intake, gastrointestinal system dysfunctions, and certain prenatal factors that may lead to malnutrition [14].

In the study conducted by Varan et al., they noted that only 12% of cyanotic heart patients without pulmonary hypertension had moderate to severe malnutrition. However, they reported that growth was affected in 48% of these patients, with growth being completely halted in 40% of cases [8].

Patients with cyanotic heart disease and large left-to-right shunts (such as patent ductus arteriosus, ventricular septal defect, atrioventricular septal defect, etc.) are at risk of inadequate weight gain and malnutrition. In contrast, malnutrition is generally not observed in pre-tricuspid lesions (such as atrial septal defect, partial anomalous pulmonary venous return, etc.). These patients tend to have minimal effects on growth during infancy[13]. However, when pulmonary hypertension is added to the picture, severe growth and developmental retardation have been reported [15]. Despite normal ventricular systolic functions, severe left-to-right shunts lead to congestive heart failure. After birth, fetal cardiac muscle cells begin to take on adult forms. The lengths of muscle fibers increase, and ventricular compliance increases. Following the decrease in pulmonary vascular resistance within the first 3 months after birth, the increased left-to-right shunt flow during systole is attempted to be compensated. Thus, the left ventricle begins to contract more forcefully to maintain systemic cardiac output. This situation leads to an increase in energy demand [13-15]. Ultimately, heart failure leads to malnutrition and, in the later stages, myocardial atrophy. Myocardial atrophy, in turn, leads to more severe heart failure, creating a vicious cycle [16].

Especially in cyanotic heart patients with excessive left-to-right shunting or accompanying severe hypoxia, cardiac hyperdynamism, increased respiratory demand, and an increase in basal metabolic energy requirements are observed [8]. Additionally, frequent upper respiratory tract infections and hospitalizations negatively affect the energy balance. Furthermore, intestinal edema develops in some patients, leading to insufficient absorption of energy and nutrients along with malabsorption [14,17,18].

The relationship between the preoperative nutritional status of pediatric patients undergoing congenital heart surgery and postoperative morbidity and mortality has been well established [19-21]. Inadequate nutrition during the preoperative period affects postoperative processes; the increase in energy demand, emergence of complex inflammatory responses, and development of protein catabolism during the postoperative period lead to disturbances in patients' metabolic responses. Due to the catabolic processes secondary to surgery, malnourished patients are more susceptible to infections and experience delayed wound healing [2,3]. Preoperative malnutrition affects the mortality and morbidity of hemodynamically unstable patients after cardiopulmonary bypass and cardiac surgery due to all these effects [2,3].

Anthropometric measurements are used to assess nutritional status. While nutritional status can be determined using body weight and height measurements, skinfold thickness measurements can also be used to assess total body fat mass[10]. Although weight-for-age, weight-for-height, and body mass index (BMI) can be used to assess nutritional status, obtaining sufficient information about lean body mass and soft tissue edema is challenging with these measurements [22]. Especially in severe heart failure patients, the presence of edema and a decrease in total body muscle mass make it difficult to obtain reliable data with these measurements. Malnutrition can be masked in this patient group, and it may be overlooked with weight-for-age, weight-for-height, and BMI measurements. It has been reported that inadequate differentiation of these major components of body composition may lead to insufficient information about whether postoperative outcomes are affected by body edema, cachexia, subcutaneous, and visceral fat mass [5].

Skinfold thickness measurements provide information about the body's main energy store, which is fat tissue. Skinfold thickness measurements, especially those taken from the triceps, are considered the best indicators of short-term nutritional status and are not affected by acute fluctuations in nutritional status [23,24]. Additionally, this measurement provides information only about peripheral fat mass, thus preventing errors in determining nutritional status due to body edema secondary to heart failure [5]. In our study, using this method helped minimize the impact of patients' body edema on postoperative outcomes. While some studies suggest that triceps skinfold thickness measurement is effective only in the obese patient group in revealing total body fat tissue, other clinical studies indicate that this measurement provides effective results in healthy and underweight pediatric patients as well [25,26]. For these reasons, in this study, the triceps skinfold thickness measurement was used as an anthropometric measurement method.

In this research sample, the percentage of pediatric patients with TSFT values below -1 SD is 8.3%. This indicates that only a very small percentage of patients are inadequately nourished. In our study, no statistically significant conclusions were reached regarding the mechanical ventilation duration, length of stay in the intensive care unit, inotropic requirement, and duration in relation to the preoperative TSFT Z score classification of patients' nutritional status. Possible reasons for this could be that the patients in the sample had congenital heart diseases with low RACHS scores, indicating low perioperative mortality risk, and therefore they did not exhibit severe heart failure and malnutrition symptoms. Additionally, in our clinical setting, extubation is routinely performed at least 6 hours after ICU admission, and it depends on the attending physician, which may have contributed to the lack of significant findings in extubation durations. The lack of statistical significance in postoperative inotropic requirement and duration may be attributed to the small number of patients classified as mildly malnourished (TSFT Z score between -2 and -1 SD), with only three patients falling into this category, and none of them requiring inotropes during or after surgery.

In this study, two patients in the sample experienced mortality during the postoperative period. Both of these patients were within normal nutritional limits, and the reasons for their mortality were interpreted independently of their nutritional status. Therefore, no relationship was found between preoperative nutritional status and postoperative 30-day mortality in this study.

In the literature, it has been demonstrated that congenital heart patients with malnutrition in the preoperative period have higher postoperative mortality and morbidity rates. However, there are not enough studies directly questioning the relationship between preoperatively determined nutritional status using TSFT Z score and postoperative outcomes. In a comparative prospective study conducted by Radman et al. in two centers, a significant relationship was found between preoperatively determined low body fat mass using TSFT Z score and intensive care unit stay duration, duration of inotrope usage, plasma brain natriuretic peptide levels, and mechanical ventilation duration [5]. Similar results were obtained in this research as well. The effect of preoperative nutritional inadequacy on postoperative morbidity is not clear-cut. The reason for not finding a relationship in this study may be the low percentage of malnutrition among patients in the preoperative period, low RACHS scores, and a heterogeneous group in terms of diagnosis. Additionally, using different anthropometric measurement methods unaffected by edema and more complex methods (such as whole-body analysis) along with biochemical parameters to determine malnutrition may be more effective.

Conclusion

In this study, it was found that the preoperative nutritional status in children undergoing elective heart surgery does not affect postoperative morbidity. There is a need for further research with increased sample size and comparative new and larger-scale studies using different anthropometric measurements.

Production from the Thesis: The current study was produced from the master's thesis of the responsible author.

Ethical Aspect of the Research: The study was produced from the master's thesis of the responsible author and received approval from the non-invasive clinical research ethics committee of Hacettepe University, where the study was conducted, on 02.05.2014 with the number GO 14/223-09.

Author Contribution: Idea/Concept: MY,IP; Design: MY,IP, Supervision/Consultancy: IP,MD,RD, ; Analysis and/or Comment; MY,IP; Literature Review: MY ; Writing of the Article: MY,IP; Critical Review: MY*

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Conflict of Interest

There is no conflict of interest between the authors.

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