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Original Article

Nutritional Status of Pediatric Intensive Care Patients with Chronic Disease

Kronik Hastalığı Olan Çocuk Yoğun Bakım Hastalarının Beslenme Durumları

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ABSTRACT

Objective: This study aims to evaluate the relationship between enteral nutrition and mortality in children with chronic diseases who need to be hospitalized in the pediatric intensive care unit (PICU).

Method: The data of the patients who were admitted to intensive care between January 2014 and December 2019 were retrospectively supplied from the hospital database. Demographic data, the presence of underlying diseases, the diagnoses during intensive care admission, the history of previous hospitalization, homecare requirement, the presence of gastrostomy, feeding type during homecare before hospitalization, the amount and type of nutrition were recorded.

Results: A total of 186 patients hospitalized in the PICU due to an acute critical illness and with an underlying chronic disease were included in the study. The median age was 49 (17.75-104.5) months, it was observed that 53.8% of the patients were required homecare. The most common chronic disease was central nervous system pathologies accompanied by neurological impairment in swallowing functions (37.3%), while the most common cause of the acute disease was lower respiratory tract infections (48.9%). The overall mortality was 9.7%, and it was found that the majority of the patients who were died were the patients requiring homecare and fed with nasogastric tube at home (p=0.002, p=0.014).

Conclusion: It is observed that patients with percutaneous endoscopic gastrostomy are relatively low, hence feeding tube is frequently preferred in children with dysphagia during homecare. However, it is demonstrated that the feeding tube is an independent risk factor for mortality.

Keywords: Nutrition, home care, pediatric intensive care unit, mortality

ÖZ

Amaç: Çocuk yoğun bakım yatış (ÇYBÜ) ihtiyacı gösteren, kronik hastalığa sahip çocuklarda, nutrisyonel denge ve mortalite arasındaki ilişkinin araştırılması planlamıştır.

Yöntem: Ocak 2014-Aralık 2019 tarihleri arasında yoğun bakımda yatan ve kronik hastalığı olan tüm hastaların verileri geriye dönük olarak tarandı. Yaş, cinsiyet, kilo, boy, büyüme çizelgeleri, vücut kitle indeksleri, altta yatan hastalıkların varlığı, yoğun bakıma yatış sırasındaki tanılar, önceki yatış öyküsü, evde bakım gereksinimi, gastrostomi varlığı, yatış öncesi evde bakım sırasında beslenme şekli, beslenme miktarı ve türü kaydedildi.

Bulgular: Çalışmaya altta yatan hastalığı olan ve akut ciddi hastalık nedeniyle yoğun bakıma yatırılan 186 hasta dahil edildi. Yaş ortancasının 49 (17,75-104,5) ay olduğu çalışmamızda %53,8 hastanın evde bakıma muhtaç olduğu görüldü. Alt solunum yolu enfeksiyonları yatışların en sık akut sebebi iken; santral sinir sitemi patolojilerine eşlik eden yutma disfonksiyonuyla giden nörolojik hastalıklar en sık altta yatan kronik hastalıklar olarak göze çarptı (%48,9, %37,3). Mortalitenin %9,7 olduğu çalışmada, kaybedilenlerin evde bakıma muhtaç, nazogastrik beslenmenin yapıldığı çocuklardan oluştuğu gözlendi (p=0,002, p=0,014).

Sonuç: Kronik hastalığa sahip çocuklarda, günlük nutrisyonel dengenin yetersiz kalması mortalite ile ilişkilidir. Tek tipte sulu gıdalarla beslenme mortalite için bağımsız risk faktörüdür. Multidisipliner yaklaşımla nutrisyon ekiplerinin kurulması ve dengeli nutrisyonun sağlanması sağ kalımı artıracaktır.

Anahtar kelimeler: Beslenme, evde bakım, çocuk yoğun bakım ünitesi, mortalite

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INTRODUCTION

Chronic disease is defined as a condition that deviates from normal status or shows permanent disability, irreversible, as a consequence of pathological changes, special training for rehabilitation, nursing, observation and supervision for a long time [1]. Chronic disease prevalence is ranged from 1 to 2% and affects daily activities [2]. Diseases such as congenital anomalies, congenital heart diseases, chronic pulmonary diseases, hypoxic-ischemic encephalopathy, cerebral palsy, metabolic diseases, trauma-related long-term organ injuries (extremity paralysis, traumatic brain injury, etc.), chronic renal failure affecting various organs are considered as a part of chronic diseases. However, the medical care requirement of the patients might increase after the presence of a neuromotor disease resulted in bed ridden [1,2].

Nutritional problems observed in children with chronic diseases hold an important place in the medical care and treatment of these children as well. Studies have shown that the frequency of feeding problems in children with cerebral palsy is between 30 and 90% and the malnutrition rate is 90% [3]. It is known that malnutrition negatively affects morbidity and mortality by causing growth restriction. The most common feeding problems can be listed as gastroesophageal reflux (GER), oral-motor dysfunction, swallowing disorders and food refusal behaviors. Complications that may develop due to these problems are other negative factors affecting the quality of life [4]. These complications include inadequate food intake, development of malnutrition, immune system suppression secondary to malnutrition leading to infections, and aspiration (oral-motor dysfunction or GER). Life-threatening recurrent respiratory tract infections due to aspiration and rarely apnea requiring resuscitation can be observed. Protein and calorie requirements of children should be regulated depending on the age and activity of the children where growth and development must be followed closely in children with nutritional problems and the presence of chronic disease [5].

It is known that patients with neuromotor retardation frequently require pediatric intensive care unit (PICU) admission due to complications caused by the underlying chronic diseases that disrupt vital functions, severe infections and nutritional disorders. International guidelines recommended that oral or enteral nutrition without the presence of any contraindications should be initiated as soon as possible in critical children [4,5]. It has been determined that early trophic feeding improves the immune system through the lymphoid tissue of the intestinal mucosa and reduces mortality and morbidity. Guidelines suggest that the dietary intake of such children at home should be arranged according to the age, gender and daily activity of the patient after discharge from intensive care unit [6].

As the only tertiary pediatric care center within Sivas provincial borders, medical care is provided to all critically ill children requiring surgical and internal intensive care. Similarly with the literature, our clinical observations indicate that many critical patients whose caloric intake is limited during hospitalization are at risk for entering into a catabolic state and subsequently developing malnutrition that ultimately results in increased morbidity and mortality [7-9]. The primary goal of this study is to evaluate the dietary intake of children with chronic diseases who require intensive care unit admission and of those with growth retardation; providing effective and correct nutrition and taking preventive measures against malnutrition after discharge. The secondary aim of the study is to investigate whether the nutrition is adequate or not during intensive care unit stay and to establish our protocol for the nutrition of critically ill children within the department of our university.

MATERIALS and METHODS

After obtaining Local Ethics Committee approval for the study from the Cumhuriyet University Clinical Research Ethics Committee (decision number: 2019-04/11, date: 17.04.2019), the data of the patients who were admitted to intensive care between January 2014 and December 2019 were retrospectively supplied from the hospital database. The authors anounced 'acute onset of disease' as the acute sickness that resulted in the PICU admission. Both acute onset of disease and chronic underlying conditions were collected from the hospital database. Demographic characteristics including age, gender, weight, height, previous hospitalizations, children in need of home-care or those with technology dependence (enteral nutrition via gastrostomy and home ventilation via tracheostomy) were assessed for analysis.

Antropometric evaluation consisted of the measurements of height-for-age Z score (HAZ), weight-for-age Z score (WAZ), weight-for-height Z-scores (WHZ) to assess the degree of nutritional status in the child [10]. Z score of body mass index (BMI): (calculation of weight in kilograms divided by height in meters squared) was also obtained for children older than five years

of age. Z score classification defined by World Health Organization (WHO) was categorized as normal nutrition: >-1 standart deviation score (SDS), mild undernultrition: SDS between -1 and -2, moderate undernutrition: SDS between -2 and -3, severe undernutrition: <-3 [11]. The group categorization was based on survival.

We got the height of the patients with supine length measurement. The patient was made to lie down supine. Using a flexible measuring tape the length between the vertex of the head and the heel was measured. The measurement was taken up to one decimal point. Although this measure is undereasy to do, it may be unreliable in patients with joint contractures. In those patient who had contractures we got four point method of measurement.

Nutrition data consisted of variables such as the route of nutrition (via nasogastric tubing or gastrostomy), the volume and type of daily nutrition (breast milk, enteral nutrition, aqueusfood, solid food prior to hospitalization. Nutritional status and basal caloric demand at home-care for each gender was calculated by the recommendations of The Food and Agriculture Organization/WHO/United Nations University Expert Consultation for Human Energy Requirements and The Society of Turkish Pediatric Gastroenterology, Hepatology and Nutrition [12]. The children whose daily caloric intake at home-care were below the target dietary caloric requirement were identified.

Due to technical difficulties to monitore resting energy expenditure (REE) using indirect calorimetry at PICU, the investigators used the Schofield-WH method for calculation REE and total enery expenditure (TEE) in the hospitalization period [13-15]. Basal caloric demand during the PICU-stay admssion was calculated from TEE which was considered as REE plus 5% of activity factor and 15% for day-to-day variability [16,17]. Thus the duration to achieve target caloric intake at PICU was extracted from the patient data.

Statistical Analysis

Analysis were performed using Statistical Package for Social Sciences (SPSS Inc., Chi, IL) for Windows version 23 program. The distribution of the data were analyzed by the Kolmogorov-Smirnov test. Student t-test was used for normally distributed data where Mann-Whitney U test for abnormal. Multivariate regression analysis was used to evaluate independent risk factors to predict mortality. Descriptive statistics were used as numbers and percentages for categorical variables, mean ± SD for normally distributed continuous variables, and median (distance between quartiles 25-75%) for abnormally distributed continuous variables.

RESULTS

A total of 186 patients who suffer an underlying chronic disease and hospitalized due to an acute onset of critical illness were included in the study. The median age was 49 (17.75-104.5) months. Of the study group, 53.8% of the children were in need of homecare assistance. The most common chronic disease was central nervous system pathologies accompanied by neurological impairment in swallowing functions (37.3%), while the most common cause of acute onset of disease was lower respiratory tract infections (48.9%; Table 1). The growth stature of the population can be observed at Table 2. The Z score of WHZ was lower than -3 in 14.2% of the children under five years and in 5% of for the ones older than five years. Moreover, an underlying chronic disease resulted in short stature (HAZ <-3) in 42.5% of the patients under five and 25% of the study group who were older than five years (Table 2).

Homecare

The route of nutrition at home-care via nasogastric tubing and gastrostomy was 20.4% and 18.8% respectively. The daily routine of nutrition revealed that the daily caloric intake were below target dietary caloric requirement in 24.7% of the children (Table 3). Nutrition by solid foods remained at 46.2% in the study population.

Nutrition in Pediatric Intensive Care Unit

Due to acute onset of a life-threatining sickness, enteral feeding was initiated to critically-ill child at median 2 days (interquartile range 25-75%: 1-2 days) once the cardiorespiratory balance was achieved. A median duration of five days was recorded to achieve the target caloric intake at PICU stay. However enteral nutrition could not reach the target calories in deceased children due to either gastrointestinal intolerance or high doses of inotropic support (Table 3).

Mortality

The overall mortality was 9.7%. Older children with male gender, lower Z scores of WHZ and BMI were more likely to die due to the acute life-threatining conditions

(p=0.015, p=0.015, p=0.023, p=0.001; Table 4). Moreover, these children required home-care assistance and nutrition with nasogastric feeding more often (p=0.002, p=0.014). Sepsis was significantly associated with mortality (p=0.024).

A multiple regression model was created for mortality risk prediction including four independent variables of Pediatric Risk of Mortality 3 (PRISM 3) score, sepsis, lower daily caloric intake than target caloric requirement at home-care and nutrition by liquid foods. The model predicted the highest odds of mortality for children fed by liquid foods at home-care (OR: 9.149, p=0.002, 95% CI: 1.182 - 16.158; Table 5).

Table 1. Demographic characteristics	
Variables	**(IQR %)**
Age (months)*	49 (17.75-104.5)
Weight (kg)*	13 (7.9-28)
Height (cm)*	92 (70-120)
Variables	Patients total n=186 (n%)
Gender ratio (M/F %)	92/94 (49.5%)
Previous hospitalization	158/186 (84.9%)
In need of homecare	100/186 (53.8%)
Tracheostomized	27/186 (14.5%)
Acute diseases causing pediatric intensive care unit admission	Patients total n=186 (n%)
Seizure	15 (8.1%)
Sepsis	26 (14%)
LRTI	91 (48.9%)
Cardiopulmonary arrest	4 (2.2%)
Dehydration/shock	6 (3.2%)
Bronchiolitis/asthma	28 (15.1%)
Heart failure	4 (2.2%)
Trauma-bleeding	4 (2.2%)
Underlying chronic disease	Patients total n=186 (n%)
Hematologic	8 (4.3%)
Gastrointestinal	4 (2.2%)
Endocrine	18 (9.7%)
Nephrologic	12 (6.5%)
Muscle disorder	23 (12.4%)
Respiratory	11 (5.9%)
Neurologic	69 (37.1%)
Genetic anomaly	25 (13.4%)
Cardiovascular	14 (7.5%)
Immunologic	9 (4.8%)

*Median (IQR: Interquartile range 25-75%), LRTI: Lower respiratory tract infection, n: Number, M: Male, F: Female

Table 2. Growth status of the population										
Age	**<5 years**					**>5 years**				
WHO Z scores	**>-1**	**-1/-2**	**-2/-3**	**>-3**	**SDS median (25-75%)**	**>-1**	**-1/-2**	**-2/-3**	**>-3**	**SDS median (25-75%)**
Weight-for-age										
n (%)	29 (27.4%)	17 (16%)	27 (25.5%)	33 (31.1%)	-2.18 (-4.46)-(-0.61)	45 (56.3%)	12 (15%)	14 (17.5%)	9 (11.3%)	-0.80 (-2.16)-(0.29)
Weight-for-height										
n (%)	68 (64.2%)	15 (14.2%)	8 (7.5%)	15 (14.2%)	-0.47 (-1.43)-(0.77)	55 (68.8%)	10 (12.5%)	11 (13.8%)	4 (5%)	0.30 (-1.62)-(1.23)
Body mass index										
n (%)	67 (63.2%)	14 (13.2%)	10 (9.4%)	15 (14.2%)	-0.3 (-1.51)-(0.80)	57 (71.3%)	10 (12.5%)	9 (11.3%)	4 (5%)	0.19 (-1.20)-(1.53)
Height-for-age										
n (%)	30 (28.3%)	22 (20.8%)	9 (8.5%)	45 (42.5%)	-2.14 (-5.46)-(-0.73)	32 (40%)	13 (16.3%)	15 (18.8%)	20 (25%)	-1.67 (-3.25)-(-0.26)

WHO: World Health Organization, SDS: Standard deviation score

Table 3. The nutritional status of the study population			
Homecare	**Patients n (%)**	**Nutrition at PICU**	**Patients n (%)**
Nutrition via gastrostomy	35/186 (18.8%)	Parenteral nutrition	15 (8.1%)
Nutrition via nasogastric tube	38/186 (20.4%)	Initiation of enteral feeding (days)	2 (1-2)
Enteral feeding product	48 (25.8%)	Duration to achieve target caloric intake (days)	5 (3-5)
Liquid food	53 (28.5%)	PICU stay (days)	9 (9-10)
Solid food	86 (46.2%)	Hospital stay (days)	15 (14-16)
Daily caloric intake below target dietary caloric requirement	46 (24.7%)	Exitus	18 (9.7%)
PICU: Pediatric intensive care unit, n: Number			

DISCUSSION

The present study revealed that nutritional support was inadequate in critically ill children during homecare where approximately one-quarter of the children were taken below ideal daily calorie intake. The overall mortality rate was 9.7% which tends to be higher in children getting homecare compared to PICU. Sepsis was the major cause of death. The age of the deaths was two-fold older than the survivors, where most of the deaths were female. In addition, most of the deaths have been fed on aqueous foods via nasogastric tubes.

The critical illness causes evident endocrine and metabolic alterations associated with autonomic and immune changes. These changes include insulin resistance and catabolism [18,19]. Besides these alterations, critically ill children often encounter feeding problems caused by feeding intolerance, thus leading to malnutrition during the PICU stay period [20]. The rate of malnutrition at the time of admission to PICU is ranged from 15 to 25% even in developing countries. Malnourishment and macronutrient deficits in critically ill children have been related to increased complications including infections, weakness, prolonged mechanical ventilation and delayed recovery.

In contrast, optimal nutrition is essential for the treatment of critically ill children [21]. Various studies have reported that severe malnourishment in children leads to a higher risk of mortality compared to healthy ones in developing countries than in developed countries [22-24]. Similar with the previous studies, sepsis was the major cause of death in the present study [25]. There is a lack of data available where children with malnutrition have poor outcomes than in children with optimal nutritional status. Previous studies demonstrated that the presence of malnourishment elevates the mortality rate of children admitted to PICU [8,9,26]. Moreover Thukral et al. [27] showed that critically ill children with malnutrition and an elevated PRISM score have a trend towards a higher mortality rate.

Furthermore, the present study revealed that patients who died in PICU had a previous history of homecare those already had a higher PRISM score compared to others. Interestingly, it is also showed that mainly aqueous feeding is an independent risk factor for mortality. This finding suggested that aqueous foods may increase the aspiration risk causing aspiration pneumonia, thus requiring PICU admission and leading to severe infection/sepsis with an elevated risk of mortality as well.

However, mortality could not merely be affected by PICU stay but also related to several factors including demographic and clinical features of the population, infrastructure, paramedical conditions, and nutritional status of the patient [26,27]. Elucidating the aspects of malnutrition as an independent factor for the cause of death is of crucial importance, in order to interpret the anthropometric data and prioritization of applications and main strategies. Evaluation of malnutrition is usually used to define the risk of morbidity and mortality.

Study Limitations

This study has some limitations. First, age-specific clinical assessments could not be completed associated with the limited number of patients that would directly affect the nutritional status of the children. Second, the number of patients with severe malnutrition was low to predict a contributing factor for nutrition. Third, samples were collected from a single center which restricts the generalizability of the results of this study.

Table 4. The clinical characteristics of the patients			
	Mortality (n=18)	**Survival (n=168)**	**p**
Growth charts and demographics			
Age (month)*	90 (65.75-151.75)	46 (17-100.75)	**0.015**
Weight (kg)*	17 (8-33.75)	12.25 (7.8-26)	0.334
SDS-WAZ	-2.28 (-5.34)-(-1.83)	-1.39 (-2.47-0.80)	**0.012**
Height (cm)	111 (86-133.75)	88 (69-120)	**0.045**
SDS-BMI	-2.19 (-4.12)-(-0.43)	-0.11 (-1.27-1.23)	**0.001**
SDS-WHZ	-2.26 (-2.71)-(0.72)	-0.05 (-1.27-1.09)	**0.023**
SDS-HAZ	-2.18 (-6.17)-(-0.54)	-1.67 (-4.55)-(-0.41)	0.971
Gender (Female)	14 (77.8%)	80 (47.6%)	**0.015**
Previous hospitalization	14 (77.8%)	144 (85.7%)	0.276
In need of homecare	16 (88.9%)	84 (50.0%)	**0.002**
Tracheostomy	-	27 (16.1%)	-
PRISM-3 score*	35 (16-38)	5 (2-6%)	**<0.001**
Acute onset of disease			
Impaired consciousness	-	19 (11.3%)	-
Seizure	-	15 (8.9%)	-
Sepsis	6 (33.3%)	20 (11.9%)	**0.024**
Cardiac arrest	2 (11.1%)	2 (1.2%)	**0.047**
Dispnea	6 (33.3%)	22 (13.1%)	0.022
Heart Failure	-	4 (2.4%)	-
Dehydrationyon/shock	2 (11.1%)	4 (2.4%)	0.105
Trauma/bleeding	-	4 (2.4%)	-
Underlying chronic conditions			
Hematologic	2 (11.1%)	6 (3.6%)	0.175
Gastrointestinal	-	4 (2.4%)	-
Endocrine	-	18 (10.7%)	-
Nephrologic	-	12 (7.1%)	-
Muscle disorder	2 (11.1%)	21 (12.5%)	0.611
Chronic pulmonary disease	-	11 (6.5%)	-
Genetic	5 (27.8%)	20 (11.9%)	0.073
Cardiac	-	14 (8.3%)	-
Immune defficiency	2 (11.1%)	7 (4.2%)	0.212
Neurologic	8 (44.4%)	61 (36.3%)	0.497
Nutrition at homecare			
Enteral feeding products	-	48 (28.6%)	-
Liquid food	13 (72.2%)	40 (23.8%)	**<0.001**
Solid food	6 (33.3%)	80 (47.6)	0.248
Nutrition via nasogastric tube	8 (44.4%)	30 (17.9%)	**0.014**
Nutrition via gastrostomy	4 (22.7%)	31 (18.5%)	0.450
Daily caloric intake below target dietary caloric requirement	14 (77.8%)	32 (19.0%)	**<0.001**
Nutrition in PICU			
Initiation of enteral feeding (days)*	2 (2-4)	2 (1-2)	0.371
Duration to achieve target caloric intake (days)*	-	5 (4-5)	-
PICU stay (days)*	5 (3.75-7)	10 (9-10)	**<0.001**
Hospital stay (days)*	5 (3.75-7)	17 (16-17)	**<0.001**

Chi-square or Fischer's Exact test (if necessary) was performed. *Median (interquartile range 25-75%);. SDS: Standard deviation score, WAZ: Weight-for-age Z score, BMI: Body mass index, WHZ: Weight for height Z score, HAZ: Height-for-age Z score, PICU: Pediatric intensive care unit, PRISM-3: Pediatric Risk of Mortality 3

Table 5. Multivariate regression analysis for mortality				
	Odds ratio	%95 Confidence interval		
		Lower bound	Upper bound	p
Daily caloric intake below target dietary caloric requirement	0.100	0.009	1,138	0.063
Sepsis	0.127	0.010	1,692	0.118
PRISM-3 score	0.599	0.432	0,830	**0.022***
Liquid feeding at home	9,149	1,182	16,158	**0.002***
*p<0.05; PRISM-3: Pediatric Risk of Mortality 3				

CONCLUSION

In conclusion, this study showed that mortality is closely associated with the lack of recommended daily calorie intake in critically ill children. Supplementing daily calorie intake with a balanced diet in children requiring homecare is of great importance. Since the number of patients with PEG is seen to be relatively low, feeding tube is often preferred during home care in children with swallowing difficulties. However, it is demonstrated that the feeding tube is an independent risk factor for mortality. The establishment of nutrition team consisted of a dietitian, a pediatric gastroenterologist, a pediatrician and family physicians might decrease the mortality rate in in critically ill children requiring medical care. In addition, we think that we will contribute to the quality of home healthcare services by sharing the findings of this study with the provincial health directorate.

Ethics

Ethics Committee Approval: Cumhuriyet University Clinical Research Ethics Committee approval was obtained (decision number: 2019-04/11, date: 17.04.2019).

Informed Consent: Since the study design was retrospective and data were collected anonymously, informed consent was waived.

Peer-review: Externally and internally peer-reviewed.

Author Contributions

Surgical and Medical Practices: Ö.S.S., E.A.O., Concept: Ö.S.S., E.A.O., Design: Ö.S.S., E.A.O., G.C., Data Collection and/or Processing: Ö.S.S., E.A.O., G.C., Analysis and/or Interpretation: Ö.S.S., E.A.O., G.C., Literature Search: Ö.S.S., E.A.O., G.C., Writing: Ö.S.S.

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