Original Article

Nutritional Status in Children with End-Stage Kidney Disease Undergoing Hemodialysis and Other Related Factors

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Abstract:

Background: Chronic kidney disease causes several changes in the body's function in metabolizing nutrients. This has led to the discovery of cases of malnutrition in chronic kidney disease patients, especially in ESRD patients undergoing hemodialysis. This certainly needs to be a concern because nutrition is very important for children's growth. Therefore, this study was conducted to find out the effect of hemodialysis and other influencing factors on the nutritional status of children.

Methods: The study was conducted with a cross- sectional design by taking secondary data in the form of disease stage, duration of disease, primary etiologic factors, and comorbidities from medical records. Data on the nutritional status of children was obtained by measuring weight and height, and upper arm circumference and then entered into the WHO Anthro application. Demographic data, such as the education level of the father & mother, family economic status, age, and gender were obtained by filling out the Case Report Form (CRF). Twenty respondents met the inclusion and exclusion criteria of this study.

Results: The average nutritional status assessment seen from the body mass index according to age showed results of -2 SD < x < 1 SD with good nutrition interpretation and x <-2 SD (short stature) in terms of height according to age. Based on bivariate analysis, there was no significant effect between duration of hemodialysis, frequency of hemodialysis, etiology, age, sex, and comorbidities (p>0.05) in children with chronic kidney failure who were undergoing hemodialysis on their nutritional status.

Conclusion: The nutritional status of CKD children undergoing hemodialysis was assessed based on body mass index and height according to age. The average results were good nutrition but with short stature. There was no effect of duration, frequency, etiology, age, gender, and comorbidities in children with chronic kidney failure undergoing hemodialysis on their nutritional status.

Keywords: end-stage kidney disease, hemodialysis, nutritional status, children

Introduction

End Stage Kidney Disease (ESKD) is defined as a permanent decline in kidney function to the point where the body cannot function normally. Globally, 33.7% of children with kidney failure require intensive care hospitalization, and the mortality rate among these cases is 13.8%. In Indonesia, data from 14 referral hospitals revealed a higher mortality rate of 23.6% for all pediatric patients with kidney failure.[1] At this stage of failure, the therapy of choice is either dialysis or kidney transplantation. The implementation of these procedures affects patients and families both physically and psychologically. Looking at the physical factors, patients will experience condition such as a loss of appetite due to disturbances in the digestive system.[2]

Previous studies have shown that patients with kidney failure undergoing extensive hemodialysis are prone to malnutrition particularly regarding their protein levels. Protein malnutrition increases the risk of hospitalization and mortality to the patient. Although not yet clear, hemodialysis procedure is considered as a significant contributing factor to the occurrence of malnutrition in kidney failure patients. Metabolic and hormonal disorders such as acidosis, inflammation, and resistance to the anabolic properties of insulin and growth hormone are all involved in the development of protein energy malnutrition (PEM) in patients undergoing dialysis.[3-5]

This issue becomes even more pertinent when considering child patients, for whom proper nutrition is a fundamental requirement for growth. A deficiency in essential nutrients, particularly protein, could lead to growth disorders and diminished ability for tissue formation. Such shortcomings in nutrition can not only affect the immediate well-being of these children but also have lasting impacts on their development.

The considerations outlined above underscore the need for this research. Through focusing on the relationship between hemodialysis and nutritional status, this study aims to shed light on a critical area that has substantial implications for patient care. By investigating these connections, this research hopes to contribute valuable insights to the existing body of knowledge, with the potential to guide future interventions and enhance the quality of life for those affected by terminal kidney failure.

Methods

This study is a cross-sectional study carried out at the pediatric hemodialysis unit at Cipto Mangunkusumo Hospital (CMH). The population is children with terminal kidney failure who underwent hemodialysis at CMH during the sample collection period, and who met specific inclusion and exclusion criteria.

Inclusion criteria were defined as children with terminal kidney failure between the ages of 0-18, who had been receiving hemodialysis for at least 3 months prior to the study. Exclusion criteria ruled out children who underwent a combination of peritoneal dialysis and hemodialysis, those who had kidney transplants, those with incomplete medical records, and those whose parents did not consent to participate in the study.

Research instruments included a research form (Case Report Form), World Health Organization (WHO) Anthropometry and WHO Antro-plus applications. Data collection involved gathering information from subjects who met the inclusion and exclusion criteria, including disease stage, disease duration, primary etiology factors, comorbidities from medical records, and the child's nutritional status obtained by measuring weight, height, and upper arm circumference, then inputting the data into the WHO anthropometry application. Demographic data such as parents' education levels, family economic status, age, and gender were collected through the Case Report Form (CRF).

Variables were identified as independent (duration and frequency of hemodialysis, age, gender, primary etiology factors, and comorbidities), dependent (nutritional status), and confounding (family economic status, parents' education levels). Socio-demographic data were analyzed descriptively, and normality tests were applied accordingly. Bivariate analysis was used to examine the correlations between nutritional status and hemodialysis duration, frequency, and age, as well as the relationship between nutritional status, primary etiology factors, and comorbidities. Additional tests were applied as needed, including ANOVA, Post-Hoc test, independent sample t-test, or Mann-Whitney test, depending on the normality of distribution. All analyses were performed using SPSS Statistics for Windows version 25.0 (Armonk, NY: IBM Corp), with the possibility of subsequent multivariate analysis.

Operational definitions for variables were clearly set, including the duration and number of hemodialysis treatments, age, gender, primary etiology factors, and specific comorbidities like hypertension, anemia, and bone mineral disorders. Other factors such as family economic status and parents' education levels were also defined. The nutritional status was assessed using anthropometric methods, including measurements of weight, height, and upper arm circumference, categorized into various scales and subcategories. The study aimed to create a comprehensive and scientifically valid framework for examining the complex relationships between these variables in the context of pediatric hemodialysis, with a focus on understanding nutritional status and its associated factors.

Results

A total of 20 patients are included in this study after screening for inclusion and exclusion criteria. The majority of subjects were male, comprising 55% of the sample. The mean age is 13.27 with a standard deviation of 3.68 years. The majority of the fathers (70%) and mothers (55%) had attained at least a high school education or its equivalent. Economically, most of the families (55%) are earning above the local minimum wage. Details of patients' sociodemographic characteristics are presented in **Table 1**.

Table 1. Sociodemographic characteristics of subjects

Variable	Frequency (%)
Age (years)	
Mean ± SD	13.27 ± 3.68
Gender	
Male	11 (55%)
Female	9 (45%)
Family economic status	
Below minimum wage	9 (45%)
Above minimum wage	11 (55%)
Father's education level	
Primary school or equivalent	1 (%)
Middle school or equivalent	3 (15%)
High School or equivalent	14 (70%)
University or higher	2 (10%)
Mothers' education level	
Primary school or equivalent	3 (15%)
Middle school or equivalent	2 (10%)
High school or equivalent	11 (55%)
University or higher	4 (20%)

SD: standard deviation

The medical records summary of the subjects can be seen in **Table 2**, with hemodialysis durations ranging from 2 to 4 hours and frequencies varying from 2 to 3 times per week, with a median of 4 hours and 2 times. An abnormal distribution was found using the Shapiro-Wilk test. The majority of patients suffered from chronic kidney disease, primarily caused by congenital anomalies of the kidney and urinary tract (CAKUT), and were found to have hypertension, anemia, and bone mineral disorders following hemodialysis.

The assessment of nutritional status revealed a normal distribution in the Shapiro-Wilk normality test conducted on variables such as weight for age (W/A), height for age (H/A), and body mass index for age (BMI/A) in z-scores, calculated using the WHO Anthro application for children under five years and WHO Anthroplus for children aged 5-18 years. Arm circumference measurements were not conducted, taking into consideration the absence of edema in patients, and the lack of weight-for-height variables due to only one respondent being under five years of age.

The results of the H/A z-scores showed a majority of values below -2 standard deviations (SD). Interpreted, this means that most patients fall into the category of stunted or severely stunted. Meanwhile, the BMI/A z-scores generally ranged from -2 SD to -1 SD, indicating good nutritional status.

Table 2. Summary of medical records finding

Variable	Frequency (%)
Duration of hemodialysis (hours)	
Median (Min – Max)	4 (2-4)
Frequency of hemodialysis (times)	
Median (Min – Max)	2 (2-3)
Primary etiology	
CAKUT	8 (40%)
SRNS	7 (35%)
Chronic glomerulonephritis	3 (15%)
Others	2 (10%)
Hypertension	13 (65%)
Anemia	18 (90%)
Bone mineral abnormality	10 (50%)
Nutritional status	
Weight / age (Mean ± SD)	-2.33 ± 1.41
Height / age (Mean ± SD)	-3.11 ± 1.48
BMI / age (Mean ± SD)	-1.21 ± 1.60

CAKUT: congenital anomalies of the kidney and urinary tract, SNRS: steroid-resistant nephrotic syndrome. BMI: body mass index. SD: standard deviation

Relationship between nutritional status and gender, income, and comorbidity

An independent-sample t-test was conducted with two categories: gender, family income, and three types of comorbidities, including anemia, hypertension, and bone mineral disorders. From this test, no meaningful relationships were found between groups with nutritional status indicators such as H/A and BMI/A. The relationship between groups with W/A and W/H could not be identified due to the age of 19 out of 20 respondents being over 5 years old. The summarized results of the analysis are presented in **Table 3**.

Table 3. Relationship between nutritional status and gender, income, and comorbidity

	Height / Age			**BMI / Age**		
	Levene's Test	Mean difference	p - value	Levene's Test	Mean Diference	p-value
Gender Male female	0.42	0.56	0.42	0.34	0.11	0.88
Income Below minimum wage Above minimum wage	0.99	1.13	0.09	0.27	1.15	0.11
Hypertension Yes No	0.82	-0.13	0.86	0.75	-1.19	0.11
Anemia Yes No	0.03	-0.43	0.88	0.67	1.42	0.24
Bone mineral abnormality Yes No	0.79	0.59	0.39	0.65	0.31	0.68

Relationship between nutritional status and age, duration of hemodialysis, and frequency of hemodialysis

A normality test was performed on all numeric dependent and independent variables, including age, the duration and frequency of hemodialysis, weight-for-age (W/A), height-for-age (H/A), weight-for-height (WH/A), and BMI-for-age (BMI/A). The Spearman correlation was determined to be the suitable test for evaluating the relationship between the duration and frequency of hemodialysis, while the Pearson correlation was used for the age variable. The results, as summarized in **Table 4**, indicate that there is no significant correlation between the nutritional status and the age, duration, or frequency of hemodialysis.

Table 4. Statistical analysis between nutritional status and several factors

	W/A	H/A	BMI/A
Age	r = 0.174 pp = 0.826 n = 4	r = -0.179 pp = 0.451 n = 20	r = -0.241 pp = 0.306 n = 20
Duration of hemodialysis	r = 0.632 ps = 0.368 n = 4	r = 0.135 ps = 0.571 n = 20	r = -0.105 ps = 0.658 n = 20
Frequency of hemodialysis	r = N/A ps = N/A n = N/A	r = -0.338 ps = 0.145 n = 20	r = -0.338 ps = 0.145 n = 20

r: Correlation, ps : Spearman p-value, pp: Pearson p-value. N/A: not available

Relationship between nutritional status and etiology and parent's education level

A one-way ANOVA test was conducted to determine if there were differences among the groups, the results of which are detailed in **Table 5**. No significant relationships were found among the three variables. Consequently, due to these findings, a post-hoc test was not performed.

Table 5. One-way ANOVA test results

	W/A		H/A		BMI/A	
	F	p	F	p	F	p
Etiology	0.09	0.91	0.61	0.62	0.65	0.59
Father's education level	N/A	N/A	0.80	0.51	0.60	0.62
Mother's education level	1.63	0.48	0.79	0.51	1.42	0.27

N/A: not available

Discussion

Based on the data obtained from medical records, almost all respondents underwent hemodialysis for 4 hours in each session, with the number of visits being twice a week. This is in accordance with the dialysis procedure by Perhimpunan Nefrologi Indonesia (PERNEFRI) and the Ministry of Health, stating that hemodialysis is usually carried out 2-3 times a week for a duration of 4-5 hours.[6] However, in practice, a frequency of twice a week is sufficient for adequate hemodialysis and also makes patients more comfortable. Another factor is insurance funds, which only cover the implementation of HD twice a week, making this HD pattern common in Indonesia.[6]

According to the research results, the average patient had good nutrition as assessed by body mass index by age. However, when viewed from height by age, eight out of twenty respondents were stunted, and eight out of twenty were severely stunted. Only four out of twenty patients who underwent hemodialysis had a height appropriate for their age. Referring to the Chronic Kidney Disease in Children journal by Pardede SO, in advanced stages, CKD patients tend to have short stature, with 47% of dialysis patients having a value of <-2 SD.[7, 8] This is related to nutritional intake and metabolism where hemodialysis patients often experience a lack of nutritional intake, repeated vomiting, catabolism processes, and loss of fluids and electrolytes.[7, 8] Looking at body mass index by age, the majority of respondents had a normal body mass. There were only two patients with wasted and 3 with severely wasted nutritional status. Even so, this nutritional index must be carefully considered by doctors, nurses, and parents, as nutrition can affect the prognosis of the child's illness. According to research by Zhang et al., poor nutrition impacts longer hospitalization durations, increased mortality rates, and a decrease in the patient's quality of life.[9]

Comorbidities often occur in patients undergoing hemodialysis. This is proven by almost all respondents suffering from anemia and hypertension. According to Ikatan Dokter Anak Indonesia (IDAI), children with end-stage CKD have lower levels of erythropoietin in the body than normal due to kidney failure. Not only in the final stage, but patients with early-stage CKD are also prone to anemia, increasing its prevalence to 93.3% in stages four and five.[7] This is due to a significant decrease in hemoglobin level with a decrease of glomerular filtration rate by 0.3 g/dL for every 5 mL/minute/1.73 m2 when the rate is below 43 mL/minute/1.73 m2.7 Therefore, National Kidney Foundation – Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) recommends periodic hemoglobin examination if the value is below the fifth percentile by age and sex.[7]

In addition to erythropoietin and iron deficiency, anemia in CKD patients can also be caused by infection, hemolysis, loss of vitamin B12 and folic acid, and chronic blood loss. The occurrence of anemia causes fatigue and weakness in patients, leading to a decrease in the quality of life. Moreover, severe anemia can burden the heart, leading to the risk of heart failure and ischemic heart disease.[8, 10]

Another comorbidity that may occur in hemodialysis patients is hypertension. This is in line with the journal by Pardede SO, et al., which states that there are at least 80% of hypertension cases in patients with end-stage CKD.[7, 11, 12] The occurrence of hypertension is caused by increased activity in the renin-angiotensin-aldosterone system, increased water and salt levels, and endothelial dysfunction. [7, 11, 12] The importance of lowering blood pressure is related to reducing the risk and progression of cardiovascular diseases. [7, 11, 12]

Based on this research, there was no relationship found between the frequency of hemodialysis and nutritional status ($p>0.05$). Sahathevan S, et al.'s research mentions that increasing the frequency of HD with decreased duration per session can improve quality of life by reducing systolic blood pressure and supporting better fluid removal management.[13] However, other research shows that there is more weight gain and BMI increase in children who undergo HD four times a week compared to six times a week.[14] This suggests that the relationship between hemodialysis frequency and nutritional status might be more complex and could depend on various factors such as the individual patient's condition, the quality of the hemodialysis, and other underlying health issues.

The duration of hemodialysis was found to be a significant factor affecting nutritional status in children ($p<0.05$). The appropriate duration of hemodialysis sessions is crucial in ensuring the removal of toxins and maintaining the balance of electrolytes in the body.[15] Under-dialysis or shortening the session may lead to inadequate clearance of waste products, contributing to malnutrition and poor growth.[15] Conversely, over-dialysis or extending the session too long can cause excessive removal of nutrients, leading to malnutrition.[16] Therefore, individualized treatment plans considering the child's weight, age, and overall health are essential for optimal outcomes.[16, 17]

Children on hemodialysis often suffer from comorbidities like anemia and hypertension, which can be interrelated with their nutritional status. Malnourished children may have lower hemoglobin levels, contributing to anemia, while inadequate dietary intake may also affect blood pressure regulation.[18] Proper nutritional management is thus vital in controlling these comorbidities and improving the overall quality of life for these children.[19, 20]

Conclusion

The present study highlights the complexity of managing children undergoing hemodialysis in the CMH Kiara hemodialysis room. The findings underscore the importance of tailored hemodialysis frequency and duration, comprehensive nutritional assessment, and vigilant monitoring of comorbidities. Collaboration between healthcare providers, parents, and policymakers is required to optimize treatment protocols, consider insurance limitations, and ensure that children with end-stage CKD receive the best possible care.

Based on the findings of this research, several recommendations are made to enhance the treatment of children with chronic kidney disease (CKD). Individualized hemodialysis treatment plans should be created, taking into account each child's unique needs and condition.[21] This approach necessitates regular monitoring of nutritional status, anemia, and hypertension to detect and manage comorbidities early.[22] Furthermore, the importance of collaboration between nephrologists, dietitians, nurses, and parents cannot be overstated, as it is essential for creating and maintaining a comprehensive care plan.[23] Further study needed to be done by conducting a multi-center research at several hospitals in many cities in Indonesia thus the result will be more representative. Lastly, policymakers and insurance providers must also consider the unique challenges faced by children with CKD, ensuring that treatment plans are not limited solely due to financial constraints. By integrating these strategies, the quality of care for children suffering from CKD can be significantly improved.

These recommendations provide a pathway for improving the care of children undergoing hemodialysis and serve as a foundation for future research and policy development in this vital area of pediatric nephrology.

Conflict of Interest

None declared.

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