Assessment of nutritional status of children with end-stage renal disease on regular hemodialysis

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Introduction
Chronic kidney disease (CKD) refers to a condition related to irreversible kidney damage that can further progress to end-stage renal disease (ESRD). Malnutrition is an ongoing problem among children with ESRD. Children are at greater risk due to accelerated growth velocity and brain development. The provision of adequate nutrition and regular evaluation of nutritional status are key points in the management of children with CKD.

Objectives
To assess the nutritional status of ESRD children on regular hemodialysis attending the Nephrology Unit at Assiut University Children's Hospital (AUCH).

Patient and methods
A descriptive study included children with ESRD on regular hemodialysis, who attended Assiut University Children's Hospital during the 1-year period from 1st Jan 2020 to 31st December 2020. The patients were assessed after 6 months from enrollment in the study. The patients were carefully assessed for signs of growth failure and malnutrition by measuring weight, height, and BMI putting them on percentile using clinical growth charts according to their genders and ages. There was growth failure if weight and height were less than equal to third percentile and BMI less than fifth percentile.

Results
This study included 60 patients with ESRD on regular hemodialysis. Their ages ranged from 6months to 18 years old with mean ± SD (9.7 ± 5.2); 40 patients were males and 20 patients were females. Congenital anomalies of the urinary tract system were the most common cause of ESRD in the studied patients. Body weight in 55% of the studied patients was less than the 3rd percentile, height in 62% of them was less than the third percentile, and BMI was less than the 5th percentile in 65% of the patients; 35% of the patients were within normal BMI (5th–84th), all those cases had limitations in nutrients supplementation.

Conclusion
Children with ESRD on hemodialysis are at risk of developing malnutrition and growth failure.

Keywords:
chronic kidney disease, end-stage renal disease, malnutrition and BMI

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Introduction

Chronic kidney disease (CKD) refers to a condition related to irreversible kidney damage that can further progress to end-stage renal disease (ESRD). ESRD is a devastating disorder associated with excessive mortality and cardiovascular morbidity, and specific problems occur in children, such as impaired growth and psychosocial adjustment, all of which severely impact one's quality of life [1].

Malnutrition (undernutrition) is an ongoing problem in children with ESRD. Children are at greater risk due to accelerated growth velocity and brain development. In children, the assessment of malnutrition is much more complex and involves assessing not only anthropometrics but also poor growth or stagnant growth. Therefore, identification and treatment of malnutrition are important from not only an acute standpoint but also long term as the child should be at an anabolic state consistently to achieve optimal final height and development [2].

In children with CKD, growth failure has multifactorial origins including malnutrition, mineral and bone disease secondary to CKD, metabolic acidosis, electrolyte disturbances, and changes of hypothalamic-pituitary-somatotropic and gonadal axes [3]. The evaluation of growth retardation and protein-energy malnutrition, common clinical features in children with CKD, plays an essential role within routine pediatric nephrology care [4]. Growth failure is associated with increased mortality, hospitalizations, and infections [5].

One major challenge for pediatricians is balancing the nutritional requirements of patients with CKD to promote normal growth and development. Anthropometric values (weigh, length, and BMI) are used worldwide to determine the nutritional status. Thus, the provision of adequate nutrition and regular evaluation of nutritional status are key points in the management of children with CKD and ESRD with hemodialysis [6].

Aim of work

To assess the nutritional status of children with ESRD on regular hemodialysis, who attend the Nephrology Unit at Assiut University Children's Hospital (AUCH). Assessment of growth parameters (weight, length and BMI), manifestations of vitamin and mineral deficiency, and manifestations of renal osteodystrophy.

Patients and methods

This prospective descriptive study included children attending Assiut University Children's Hospital with clinical manifestations of ESRD on regular hemodialysis during the 1-year period from 1st Jan 2020 to 31st December 2020.

(1) *Clinical trial number:* NCT04177368
(2) *Inclusion criteria for patients:*
    (a) Patients aged from 6 months up to 18 years.
    (b) Patients with ESRD on regular hemodialysis.
    (c) Estimated GFR of less than 15 ml/min.
(3) *Exclusion criteria for cases:*
    (a) Patients with acute kidney injury.
    (b) Patients who are not on regular hemodialysis.
    (c)Clinically unstable patients.

Methodology

The following data were collected and recorded for each patient in the reviewing sheets (the descriptive sheet of the study):

(1) History taking (age, sex, duration of illness, number of hospital admission, and etiology of renal impairment.
(2) Full examination (anthropometric measurement (wt, Ht, BMI), blood pressure on admission).
(3) Manifestations of renal osteodystrophy:
    (a) Bone pain.
    (b) Delayed physical development.
    (c) Joint deformity.
    (d) Inability to walk.
    (e) Itching.
(4) Manifestations of vitamin and mineral deficiency
    (a) Pallor.
    (b) Numbness.
    (c) Bleeding per lips and gums.
    (d) Tremors.
    (e) Diarrhea.
    (f) Abdominal cramps.
    (g) Glossitis.
    (h) Investigations:
    (i) CBC
    (j) Urine analysis
    (k) Kidney function test
    (l) Serum electrolytes
    (m) Total serum protein and serum albumin
    (n)Serum parathormone level.

The patients were reviewed after 6 months from enrollment in the study. On each review, the patients were carefully examined for signs of growth failure and malnutrition including growth, which was assessed by measuring weight, height, and BMI putting on percentile using clinical growth charts according to their genders and ages and there was growth failure if weight and height were less than equal to third percentile, BMI less than fifth percentile.

Increased caloric intake and limitation of protein, sodium, phosphorous, and potassium in diet should be considered in children with ESRD on regular hemodialysis. So, we asked about the history of nutrition in our studied patients, types of food that are rich in protein like animal proteins (meat, fish, poultry, eggs, and dairy products), and plant proteins (bread, grains, dried beans, and peas). Foods that are rich in sodium such as bread, cured meats, soups, cheese, chips, and eggs. Foods high in phosphorous like dairy products, meat, fish, nuts, seeds, and all grains. Food that are rich in potassium such as chips, potato crisps, chocolate, and fresh fruit juices.

Statistical analysis

The data were tested for normality using the Anderson–Darling test and for homogeneity variances before further statistical analysis. Categorical variables were described by number and percent (N, %), where continuous variables were described by mean and standard deviation (mean, SD) for parametric data and (median (IQ)) for non-parametric data. All analyses were performed with the IBM SPSS 20.0 software.

Ethical considerations

The study proposal was approved by the ethics committee of Assiut Faculty of Medicine. Before participation of any patient in this study the aim of the study was explained either to the patient or patient caregiver, and a written consent was obtained from those who were welcome to participate in the study.

IRB. No: 17100601

Results

Regarding the sex, about 33.3% of the studied children were females and 66.7% were males. The mean age of children was: 9.7 ± 5.2; it ranges from 6m to 18y. The mean duration of illness was 5.29 ± 4.73, ranges from 3 months to 16 years. The number of hospital admission was <3 times/year (20%) and ≥3 which was 80% of patients. Measurement of SBP in the studied children range from 80 to 180 mmHg with msn ± SD 113.5 ± 20.3 and the DBP ranged from 55 to 120 mmHg with a mean ± SD of 72.08 ± 14.09 as shown in Table 1 and Fig. 1.

The most common cause of ESRD in our studied patients was congenital anomalies, which represent 42% of all cases, followed by steroid-resistant nephrotic syndrome (SRNS), hemolytic uremic syndrome (HUS), lupus nephritis, cystinosis, and urolithiasis accounting for 25%, 18%, 8%, 5%, and 3% of cases, respectively.

Figs. 2 and 3 show clinical manifestations as regards growth failure; body weight in 55% of the studied patients was less than the third percentile, height in 62% of them was less than the third percentile, and BMI was less than fifth percentile in 65% of the patients; 35% of the patients were within the normal BMI (5^{th}–84^{th}).

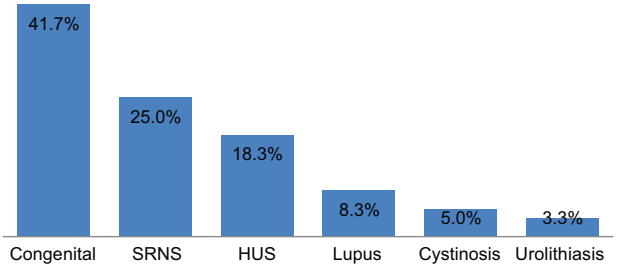
As regards clinical manifestation of renal osteodystrophy, 37 patients (73%) had variable manifestations of ROD as follows: bone pain, inability to walk, itching, delayed physical development, and joint deformity presented in 30 (50%), 27 (45%), 25 (42%), 25 (42%), and 11 patients (18%), respectively.

There were some clinical manifestations of vitamin and mineral deficiency such as pallor, glossitis, numbness, bleeding per lips and gums, diarrhea, abdominal cramps, and tremors, which were found in 38 (63%), 35 (58%), 30 (50%), 23 (38%), 19 (32%), 15 (25%), and 10 patients (17%), respectively Table 2.

There was a limitation of some nutrients in the diet such as protein, K, Na, and ph, which represents 11 (18.3%), 6 (10%), 6 (10%), and 5 (8.3%) of the studied cases, respectively, while 36 (60%) had increased their caloric intake. About 28 (47%) received iron supplementation and 23 (38%) received vitamin supplementation Table 3.

There was a significant difference between children with weight (>3^{th} percentile) when compared with

Figure 1

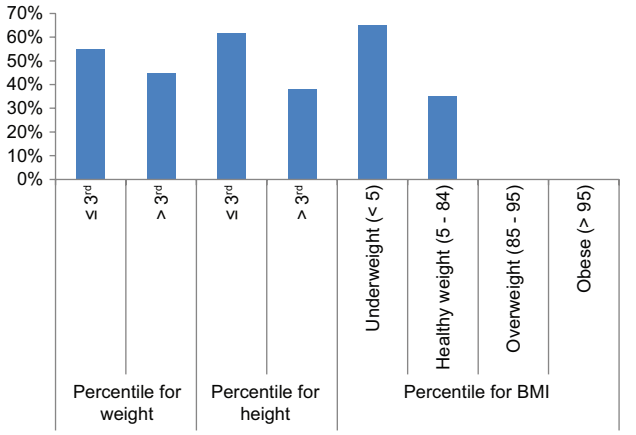


Etiology of end-stage renal disease (ESRD) in the studied patients.

Table 1: Demographic and clinical characteristics of the studied patients

	Frequency (no.)	Percent (%)
Sex		
Male	40	66.7
Female	20	33.3
Age (in years)		
6-12 months	5	8.3
1-3 years	3	5.0
3-6 years	10	16.7
6-12 years	23	38.3
>12 years	19	31.7
Range	6 m -18yrs	
Mean±SD	9.74±5.16	
Duration of illness (in years)		
Range	3m-16yrs	
Mean±SD	5.29±4.73	
Number of hospital admissions (times/years)		
<3 per year	12	20.0
≥3 per year	48	80.0
Range	0–6	
Mean±SD	3.61±1.43	
Blood pressure		
Data	Range	Mean±SD
SBP (mm Hg)	80–180	113.58±20.38
DBP (mm Hg)	55–120	72.08±14.09

Figure 2



Clinical manifestations of ESRD in the studied patients (growth failure manifestations).

those with weight (≤3th percentile), regarding limitation of protein in the diet, increased caloric intake, and vitamin supplement, with (P < 0.001), (P = 0.011), and (P < 0.001), respectively Table 4.

There was significant difference between patients with height (>3th percentile) when compared with patients with height (≤3th percentile), regarding limitation of protein in the diet, increased caloric intake, and vitamin supplement, with (P < 0.001), (P = 0.023), (P < 0.001), respectively.

Discussion

The mean age of the studied patient was 9.7 ± 5.2 years and ranged from 6 months to 18 years. There was a higher prevalence of ESRD among boys than among girls. These results were in opposition to the previous literature which reports that the incidence and prevalence rates of CKD are universally greater for boys than for girls [7].

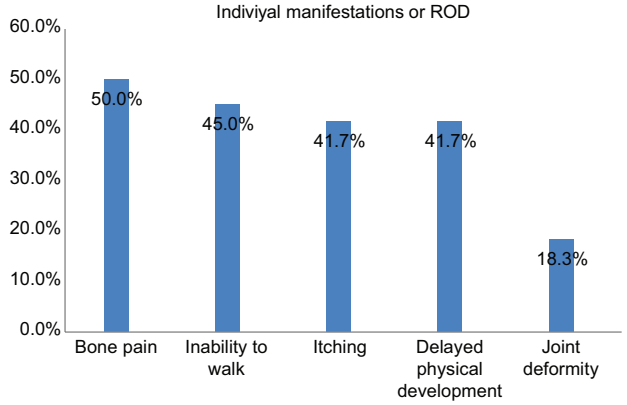
The current study showed that the mean disease duration was 5.29 ± 4.73 and ranged from 3 months to 16 years. This is consistent with the Kidney Disease Improving Global Outcomes (KDIGO) guidelines [8].

The mean number of hospital admissions was 3.61 ± 1.43 and ranged from 0 to 6 times per year. In line with our results, Molnar and Amber [9] *reported* that in all cases the hospitalization rate was higher for chronic dialysis pediatric patients (1.67, 2.48, and 2.47 admissions PPY at 7 days, 30 days, and 6 months, respectively.

The most common cause of ESRD in our studied patients was congenital anomalies, which represent 42% of all cases, followed by steroid-resistant nephrotic syndrome (SRNS), hemolytic uremic syndrome (HUS), lupus nephritis, cystinosis, and urolithiasis that accounted for 25%, 18%, 8%, 5%, and 3% of cases, respectively. These data agreed with the USRDS Annual Data Report, which reported that the leading causes of incident ESRD in children during 2012–2016 were primary glomerular disease (22.3%), CAKUT (congenital anomalies of the kidney and the urinary tract; 21.9%), cystic/hereditary/congenital disorders (11.7%), and secondary glomerular disease/vasculitis (10.7%) [10] Masalskienė *et al.* [11] reported that the most common cause of CKD among children is congenital anomalies of the kidney and the urinary tract (CAKUT).

Growth failure in this study was manifested as follows: body weight in 55% of the studied patients was less than the 3rd percentile, height in 62% of them was less than the 3rd percentile, and BMI was less than the 5th percentile in 65% of cases; 35% of the patients were within the normal BMI (5th–84th). These results are supported by the North American Pediatric Renal Trials and Collaborative Studies (NAPRTCS),

Figure 3



Clinical manifestations of renal osteodystrophy and vitamin deficiency.<CE: Pls checck whether the incorrect spelling (indiviyal instead of individual?)in the figure below can.

Table 2: Nutritional data in the studied patients

Data	Frequency (no.)	Percentage (%)
Limitation of protein in the diet	11	18.3
Limitation of K in the diet	6	10.0
Limitation of Na in the diet	6	10.0
Limitation of Ph. in the diet	5	8.3
Increased caloric intake	36	60.0
Iron supplementation	28	46.67
Vitamin supplementation	23	38.3

Table 3 Relation between weight and nutritional data

	Percentile weight				*P*
	<=3rd (*n*=33)		>3rd (*n*=27)		
Duration of illness (year)					
Range	6m-16yrs		6m-15yrs		0.280
Mean±SD	4.9±4.37		6.19±4.79		
Number of hospital admission per year					
Range	0–6		1–6		0.583
Mean±SD	3.71±1.39		3.5±1.49		
Limitation of protein in the diet					
No	33	100.0	16	59.3	**<0.001****
Yes	0	0.0	11	40.7	
Increased caloric intake					
No	18	54.5	6	22.2	**0.011***
Yes	15	45.5	21	77.8	
Iron supplementation					
No	19	57.6	13	48.1	0.466
Yes	14	42.4	14	51.9	
Vitamins supplementation					
No	28	84.8	9	33.3	**<0.001****
Yes	5	15.2	18	66.7	

**Means, statistically significant difference (p < 0.05)

Table 4: Relation between height and nutritional data

	Percentile height				*P*
	<=3rd (*n*=37)		>3rd (*n*=23)		
Duration of illness(year)					
Range	6m-16yrs		9m-15yrs		0.172
Mean±SD	4.84±4.27		6.51±4.94		
Number of hospital admissions per year					
Range	0–6		1–6		0.870
Mean±SD	3.59±1.4		3.65±1.51		
Limitation of protein in the diet					
No	37	100.0	12	52.2	**<0.001****
Yes	0	0.0	11	47.8	
Increased caloric intake					
No	19	51.4	5	21.7	**0.023***
Yes	18	48.6	18	78.3	
Iron supplementation					
No	22	59.5	10	43.5	0.228
Yes	15	40.5	13	56.5	
Vitamin supplementation					
No	32	86.5	5	21.7	**<0.001****
Yes	5	13.5	18	78.3	

**Means, statistically significant difference ($p < 0.05$)

which reports that 37%, 47%, and 43% of children with chronic renal insufficiency (CRI), dialysis, and transplantation, respectively, have severe short stature, arbitrarily defined by a SD score of less than −1.88, equivalent to less than the third percentile [12].

Regarding the manifestations of ROD as a complication of ESRD, 73% had variable manifestations of ROD as follows: bone pain, inability to walk, itching, delayed physical development, and joint deformity presented in 30 (50%), 27 (45%), 25 (42%), 25 (42%), and 11 patients (18%), respectively.

Pallor was one of the clinical manifestations of vitamin and mineral deficiency that were noticed in this study as a common complication in children with ESRD. About 38 (63%) patients had pallor. In agreement with our study, Anuradha and colleagues reported mucosal pallor in renal failure patients. This mucosal pallor is secondary to the anemia precipitated by a lack of erythropoietin production, bone marrow depression, and reduced red cell survival times [13].

In this study, a complete blood count was done for all studied patients, and we noticed that 21 patients (35%) had normal HB levels, 38 patients (63%) had anemia, and one patient (2%) had polycythemia. Anemia is one of the most common clinically significant complications in children with ESRD, which is associated with a variety of adverse clinical consequences, including an increased risk for hospitalization and mortality, and the development and progression of cardiovascular disease (CD) risk factors, including left ventricular hypertrophy (LVH) [14].

By contrast, increased hemoglobin values in children with ESRD have been associated with improved health-related quality of life. Thus, anemia management is a core component of clinical pediatric nephrology practice [15].

Growth parameters are the best validated tools for the nutritional assessment of children with kidney diseases. It is well established that children, especially young children, with poor growth experience poorer outcomes. Poor growth is associated with suboptimal neurocognitive development, the potential for a compromised final adult height, and increases in morbidity and mortality. Evaluation of dietary intake is recommended as a first-line assessment before other causes of poor growth are examined [16].

This study shows that pediatric patients with weight and height (>third percentile) have a history of the limitation of protein in the diet, increased caloric intake, and vitamin supplementations when compared with patients with weight and height less than equal to third with statistically significant difference ($P < 0.05$), ($P < 0.01$).When we compared the presence or absence of manifestation of vitamin and mineral deficiency according to the patient's history of taking iron and/or vitamin supplementations, we found that patients who received iron and/or vitamin supplementations seemed to have no manifestation of vitamin and mineral deficiency when compared with patients who did not receive these supplementations with ($P < 0.05$), ($P < 0.01$).

Conclusion

(1) Children with ESRD on hemodialysis are at risk of developing malnutrition and growth failure.
(2) Patients with normal weight and height have a history of the limitation of protein in the diet, increased caloric intake, and vitamin supplementations.
(3) When we compared the presence or absence of manifestation of vitamin and mineral deficiency according to the patient's history of taking iron and/or vitamin supplementations we found that patients who received iron and/or vitamin supplementations seemed to have no manifestation of vitamin and mineral deficiency when compared with patients who did not receive these supplementations

Recommendation

(1) Routine and regular assessment of growth parameters for all children attending the Nephrology Unit at AUCH (including body weight, body height, and BMI).

(2) Parent's education programs on proper nutrition and its importance in preventing growth impairment in CKD.
(3) Giving vitamins and mineral supplementations to all patients with CKD to prevent complications of its deficiency.
(4) Regular assessment of serum calcium, phosphorus, and PTH level to avoid the manifestation of ROD.

List of abbreviations: BMI, Body mass index; CAKUT, Congenital anomalies of the kidney and urinary tract; CKD, Chronic kidney disease; ESRD, End-stage renal disease; GFR, Glomerular filtration rate; HUS, Hemolytic uremic syndrome; KDIGO, The Kidney Disease Improving Global Outcomes; PTH, Parathormone hormone; ROD, Renal osteodystrophy; SRNS, Steroid-resistant nephrotic syndrome

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Nil.

Conflicts of interest
There are no conflicts of interest.

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