GLOMERULAR FILTRATION RATE IN MALNOURISHED CHILDREN

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ABSTRACT

BACKGROUND
Glomerular function or kidney function can be affected because of infection or wrong diet (imbalanced nutrients) which is most of the times seen in under nourished or obese children. Like many other organs, kidney also develops in early childhood, especially up to eighteen to twenty four months of life. Malnutrition also is common in six months to two years of life. So, glomerular filtration rate can be affected in this period of life. Malnutrition mostly occurs in low-and middle-income countries. Malnutrition refers to deficiencies, excesses or imbalance in a person's energy and nutrient intake. Nutrition is one of the most important factors that determines growth and size of the human body in childhood. Malnutrition has effect both on renal growth and function of the kidneys. Kidneys serve the excretory and synthetic functions and are important for maintaining the normal homeostasis. We wanted to study the GFR in malnourished children especially who are under nourished as per World Health Organization (WHO) criteria.

METHODS
72 malnourished children (WHO classification) who met the inclusion criteria were included in this study from June 2017 to May 2018 after taking approval from institutional ethics committee in the department of Paediatrics, Assam Medical College & Hospital. Detailed anthropometric measurements were taken and grading of malnutrition was done according to WHO classification. Serum creatinine was measured for each case.

RESULTS
Majority of children (68.06%) had severe malnutrition. GFR was normal in 35 (48.61%) cases, decreased in 33 (45.83%) cases, increases in 4 (5.56 %) cases.

CONCLUSIONS
From the study, we can say that approximately 45 % patients having low glomerular filtration rate are malnourished-children, who are under nourished as per World Health Organization (WHO) criteria; but differences in GFR between male and female, and between moderate and severe malnutrition were insignificant (p>0.05).

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BACKGROUND

Glomerular function most of the time is affected by infection or imbalanced nutrition which are commonly seen in malnourished children. Kidney functions is best measured as glomerular filtration rate (GFR). As the blood passes through the glomerular capillaries, the plasma is filtered through the glomerular capillary walls. The ultrafiltrate, which is cell free, contains all of the substances in plasma (Electrolytes, glucose, phosphate, urea, creatinine, peptides, low-molecular-weight proteins) except proteins having a molecular weight of 268 kDa (Such as albumin and globulins). The filtrate is collected in Bowman's space and enters the tubules. There its composition is modified by tightly regulated secretion and absorption of solute and fluid by the multiple tubular segments of the nephron and the ductal system, until it exits the kidney, via the ureter, as urine.

Glomerular filtration is the net result of opposing forces applied across the capillary wall. The force for ultrafiltration (Glomerular capillary hydrostatic pressure) is a result of systemic arterial pressure, modified by the tone of the afferent and efferent arterioles. The major force opposing ultrafiltration is glomerular capillary oncotic pressure, created by the gradient between the high concentration of plasma Proteins within the capillary and the almost protein-free ultrafiltrate in Bowman's space. Filtration may be modified by the rate of glomerular plasma flow, the hydrostatic pressure within Bowman's space, and/or the permeability of the glomerular capillary wall. Although glomerular filtration begins at approximately the 6th week of fetal life, kidney function is not necessary for normal intrauterine homeostasis because the placenta serves as the major fetal excretory organ. After birth, the GFR increases until renal growth ceases (by age ~18-20 yr in most people). To compare GFRs of children and adults the GFR is standardized to the body surface area (1.73 M^2) of an "ideal" 70-kg adult. Even after correction for surface area, the GFR of a child does not approximate adult values until the 3rd year of life. The GFR may be estimated by measurement of the serum creatinine level. Creatinine is derived from muscle metabolism. Its production is relatively constant, and its excretion is primarily through glomerular filtration, although tubular secretion can become important as serum creatinine rises in renal insufficiency. In contrast to the concentration of blood urea nitrogen, which is affected by state of hydration and nitrogen balance, the serum creatinine level is primarily

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influenced by muscle mass and the level of glomerular function. The serum creatinine is of value only in estimating the GFR under steady-state conditions. A patient can have a normal serum creatinine level without effective renal function very shortly after the onset of acute renal failure with anuria. In this clinical setting, serum creatinine is an insensitive measure of decreased renal function because its level does not rise above normal until GFR falls by 30-40% The precise measurement of the GFR is accomplished by quantitating the clearance of a substance that is freely filtered across the capillary wall and is neither reabsorbed nor secreted by the tubules. The clearance (Cs) of such a substance is the volume of plasma that, when completely cleared of the contained substance, would yield an equal quantity of that substance excreted in the urine over specified time. Renal clearance is calculated by the following formula: C_s (mL/min) = Us (mg/mL) × V (mL/min)/P_s (mg/mL) where C, equals the clearance of substance s, U_s reflects the urinary concentration of s, V represents the urinary flow rate, and P_s equals the plasma concentration of s. To correct the clearance for individual body surface area, the formula is-

$$\text{Corrected clearance (mL/min/1.73 m}^2\text{)} = C_s \text{ (mL/min)} \times \frac{1.73}{\text{Surface area (m2)}}$$

The GFR is optimally measured by the clearance of inulin, a fructose polymer having a molecular weight of approximately 5 kDa. Because the inulin clearance technique is cumbersome for use in clinical practice, the GFR is commonly estimated by the clearance of endogenous creatinine. Formulas that estimate creatinine clearance accurately in clinical settings have been useful tools in patient care. The "bedside" Schwartz formula is the most widely used pediatric formula and is based on the serum creatinine, patient height, and an empirical constant. The accuracy of this equation is further improved utilizing an additional endogenous marker, cystatin C, in addition to serum creatinine. Cystatin C is a 13.6 kDa protease inhibitor produced by nucleated cells. It continues to be tested as a clinical tool to completely replace creatinine-based formulas, as it has distinct advantages in estimating GFR unlike creatinine, cystatin C is unaffected by sex, height, muscle mass, bilirubin or red blood cell hemolysis, and is not secreted by the renal tubules under any conditions Malnutrition is a big health problem, involving hundreds of millions of children in the developing world.[1] They mostly occur in low-and middle-income countries.[2] Malnutrition refers to deficiencies, excesses or imbalance in a person's energy or nutrients intake. WHO defines malnutrition as "the cellular imbalance between supply of nutrients and energy and the body's demand for them to ensure growth, maintenance and specific functions."[2]

Protein-calorie malnutrition is a widespread public health problem contributing considerably to mortality and morbidity in areas where it is prevalent. Approximately 45% children in India and in many other developing countries are undernourished.[2]

Malnutrition has effect on maximum organs especially vital organs like brain, kidney and heart of the body. Kidneys serve the excretory and synthetic function and are important for maintaining the normal homeostasis. Although the formation of nephron is completed by 35-36 weeks of gestation, glomerular and tubular growth continues in the first eighteen months of postnatal life [3]. If protein energy malnutrition (PEM) develop during this period, which may have impact on kidney function either acute or chronic (later development to hypertension, chronic kidney disease, decreased lifespan). GFR is most useful measure of kidney function. It refers to the volume of the glomerular filtrate formed each minute by all the nephrons in both the kidneys. GFR is a test used to check how well the kidneys are doing. Specifically, it estimates how much blood passes through the glomeruli each minute.

Malnutrition has effect both on renal growth and function of the kidney. Though clinical manifestations of malnutrition may be evident on physical examination but alterations in renal functions may not be found at the initial exam.

Malnourished children have decreased G.F.R and renal plasma flow (R.P.F) and impaired tubular function [4-6]. As G.F.R. decreases ammonia, urea, creatinine, potassium increases and as a result, later on it may lead to uremic or metabolic encephalopathy. Decreased G.F.R. may also lead to chronic kidney disease (CKD) and end stage renal disease (ESRD).

METHODS

This cross-sectional study was conducted at the department of paediatrics from June 2017 to May 2018 after obtaining approval from the institute ethics committee. 72 children who met the inclusion criteria were included in this study. Written informed consent was taken from parents/ guardians for enrolment of their children in the study. Through history particularly the nutritional history of the subject and other systemic examination was done. Detailed anthropometric measurements were done and grading of malnutrition was done according to WHO classification. Length/ height of child was measured to the nearest millimeter (mm). Weight was recorded to the nearest 100 gm. Mid arm circumference was measured to the nearest millimeter. Body mass index (BMI) in Kg/m2 was calculated from weight and height using the formula - BMI=Weight (Kg)/ (Height/length in m)^2. BSA was measured by the equation of, BSA =√ [Wt (Kg) x Ht/ length (cm)/3600].All cases were subjected to serum creatinine measurement. GFR was measured by Schwartz formula.[7]

Schwartz formula for GFR= (0.413 x Height in cm)/serum creatinine (mg/dl).

Normal Value of GFR (ml/min/1.73m^2)[8]

Neonates > 34 Weeks of Gestation

- 1 week : 26 to 56 ml/min/1.73 m^2
- 2-8 weeks : 41 to 91 ml/min/1.73 m^2
- >8 weeks : 74 to 118 ml/min/1.73 m^2

Children and Adolescents

- 2-12 years (males & females): 106-160ml/min/1.73m^2

Statistical Analysis

Statistical analysis were performed using SPSS version 20. Results were expressed as mean ± standard deviation for continuous variables and as number (%) for categorical data. chi-square test was applied where it was applicable. A p value<0.05 was considered significant.

RESULTS

72 cases were enrolled in the study which met inclusion criteria.

GFR	Number (n)	Percentage (%)
Decreased	33	45.83
Normal	35	48.61
Increased	4	5.56
Total	**72**	**100.00**

Table 1. Distribution of GFR

In this study increased GFR was found in 4 (5.56%) cases, normal in 35 (48.61%) cases and decreased GFR in 33 (45.83%) cases (Table-1).

GFR	Moderate		Severe		p Value
	N	%	N	%	
Decreased	8	34.78	25	51.02	0.37997
Normal	13	56.52	22	44.90	
Increased	2	8.70	2	4.08	
Total	**23**	**100.00**	**49**	**100.00**	

Table 2. GFR Among Moderate and Severe Malnutrition

The chi-square statistic is 1.9353. The p-value is 0.379967. The result is not significant at $p < .05$.

In this study, among moderate malnutrition, GFR decreases in 8 (34.78%) cases, normal in 13 (56.52%) cases and increased in 2 (8.70%) cases; among severe malnutrition, GFR decreases in 25 (51.02%) cases, normal in 22 (44.90%) cases and increased in 2 (4.08%) cases (Table-2).

GFR	Male		Female		Total		p Value
	N	%	N	%	n	%	
Increased	3	6.38	1	4.00	4	5.56	0.64363
Normal	21	44.68	14	56.00	35	48.61	
Decreased	23	48.94	10	40.00	33	45.83	

Table 3. GFR Among Sex (Male and Female)

The chi-square statistic is 0.8813. The p-value is 0.643628. The result is not significant at $p < .05$.

Decreased GFR was found among male 23 (48.94%) cases out of 47 and among female 10 (40 %) cases out of 25 cases. GFR was normal in 21 (44.68 %) male cases and in female 14 (56 %) cases. Increased GFR was found among male 3 (6.38%) cases and among female 1 case (4 %) (Table-3). Differences in GFR between male and female was insignificant.

Variables	Mean	± S.D.
Serum Creatinine (mg/dl)	0.36	0.09
GFR (mL/min/1.73 m^2)	94.55	27.80

Table 4. Mean Value of Serum Creatinine and GFR

Serum creatinine mean value was 0.36 ± 0.09 mg/dl and mean GFR was 94.55**±** 27.80 mL/min/1.73 m^2.

DISCUSSION

In the present study, conducted between age group 6-60 months with majority (26.39%) of the study population were 13-24 months of age. In the present study the mean ± SD age of malnourished children was 27.96 ± 16.75 months that is comparable with the study done by Panigua R,[12] et al.

In this study GFR was normal in 35 (48.61%) cases, decreases in 33 (45.83%) cases, increases in 4 (5.56 %) cases. Decreased GFR was found among male 23 (31.94%) cases out of 47 and among female 10 (40 %) cases out of 25. GFR was normal in 21 male cases (44.68 %) and in female 14 cases out of 25 (56 %). Increased GFR was found among male 3 cases out of 47 (6.38%) and among female 1 case out of 25 (4 %). Differences in GFR between male and female were insignificant.

Among moderate malnutrition GFR decreased in 8 (34.78%) out of 23 cases, increased in 2 cases (8.70%). Among severe malnutrition GFR decreased in 25 (51.02%) out of 49 cases, increased in 2 cases (8.70%).Though in severe malnutrition, GFR reduced in maximum percentage cases than moderate malnutrition but it had no statistical significance ($p > 0.05$).

Other study done by G.A.O. Alleye[9] et al, Benabe JE et al.[10],they found reduced GFR and RPF in malnourished children. Arrotave G. et al.[11]also found reduced GFR and RPF in malnourished children. So our study had similarity with above mentioned study.

Panigua R [12], et al. (1980) did a study of a total 16 malnourished patient (8 marasmic infant and 8 kwashiorkor). They found that GFR and RPF was normal in all malnourished children.

In malnourished children there may be less number of functioning nephron as malnutrition has effects on various vital organs like kidney. So it is expected that they may have low GFR.

CONCLUSIONS

Kidney functions like serum creatinine or GFR are affected in malnourished children. They should be properly investigated when a child presents with malnutrition. GFR decreases in malnourished children. In our study 4 malnourished children had increased GFR. No previous study found increased GFR in malnourished children. This finding can be clarified with further cohort studies. Most of the time we are giving more importance to nutritional deficiency, vitamin A deficiency, or infection; but from the study, we can say that monitoring of GFR or renal function can be a predictor for chronic kidney diseases if these children are developing any form of end stage renal disease or any other form of chronic kidney in future.

REFERENCES

[1] Ece A, Gozu A, Bukte Y, et al. The effect of malnutrition on kidney size in children. Paediatric Nephrology 2007;22(6):857-63.

[2] www.who.int/news-room/fact-sheets/detail/malnutrition

[3] Effmann EL, Ablow RC, Siegel NJ. Renal growth. Radiol Clin North Am 1977;15(1):3-17.

[4] Klahr S, Alleyne GA. Effects of chronic protein calorie malnutrition on kidney. Kidney Interntional 1973;3(3):129-41.

[5] Rao A, Cherian A. Renal tubular function in protein energy malnutrition. Indian J Pediatr 1990;57(3):405-9.

[6] Gordillo G, Soto RA, Metcoff J, et al. Intracellular composition and homeostatic mechanisms in severe chronic infantile malnutrition. III. Renal adjustments. Paediatrics 1957;20(2):303-16.

[7] Schwartz GJ, Muñoz A, Schneider MF, et al. New equations to estimate GFR in children with CKD. J Am Soc Nephrol 2009;20(3):629-37.

[8] Srivastava RN, Bagga A, Paediatric Nephrology. 6th edn. Jaypee Brothers Medical Publishers (P) Ltd., 2016: p. 618.
[9] Alleyne GA. The effect of severe protein caloric malnutrition on the renal function of Jamaican children. Paediatrics 1967;39(3):400-11.
[10] Benabe JE, Martinez-Maldonado M. The impact of malnutrition on kidney function. Miner Electrolye Metab 1998;24(1):20-6.
[11] Arroyave G, Wilson D, Behar M, et al. Serum and urinary creatinine in children with severe protein malnutrition. Am J Clin Nutr 1961;9(2):176-9.
[12] Paniagua R, Santos D, Munoz R, et al. Renal function in protein-energy malnutrition. Pediatr Res 1980;14(11):1260-2.