Kidney Size in Malnourished Children

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ABSTRACT

BACKGROUND

Malnourished children can suffer from various problems including sepsis, pneumonia, tuberculosis, gastroenteritis, vitamin A deficiency and very significantly growth failure. Malnutrition is a leading cause of stunting in under five years group of children in developing world. As stunting is visible but other parameters may remain unrecognized because of low importance in a busy paediatric ward or outpatient department (OPD) management activities. It includes growth of many organs including kidney. Under-nutrition affects more than several lakhs of children in the under-developed world like India. Among various factors which determine growth, nutrition is one of the most important factors that determine growth and size of the human body in childhood. Malnutrition can affect both renal growth and function of the kidney especially if it is seen in the first eighteen months of life as growth of nephron continues till two years of life though the formation of nephron is almost complete by term pregnancy. We wanted to study the size of kidney in malnourished children.

METHODS

In the study, 72 under nourished children were included as per inclusion criteria (according to WHO classification of malnutrition) from 01.06.2017 to 31.05.2018. Detailed anthropometric measurements were done and ultrasound kidney, ureter and bladder (KUB) was done for each case.

RESULTS

It has been seen that maximum number of children (68.06%) had severe malnutrition. Decreased kidney size was found in 34 (47.22%) cases. It was found that there was significant difference in kidney size between moderate and severe malnutrition (p=0.003). Significantly, there was no major difference in kidney parameters (length and width) between male and female as p value > 0.05. All measurements of right kidney were found to be lower than those of the left kidney, but no significant difference was found in size between right and left kidney.

CONCLUSIONS

There was no significant difference of kidney size between male and female (p>0.05). But there was significant difference of kidney parameters between severe and moderate malnutrition (p<0.05) and kidney size is best correlated with their length/height (r=0.5686). Hence it is always to be remembered that severity of malnutrition can affect the growth of kidney especially in under-five children which may have a connection to some of the chronic morbid conditions like hypertension, chronic kidney disease and end stage renal disease in later part of life.

KEY WORDS

Kidney Size, Growth Failure, Undernutrition, Ultrasonography

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BACKGROUND

Under nutrition is a major health issue mostly seen in under developed countries. Malnutrition is defined as excesses, deficiencies or imbalances in a person's energy or nutrients intake especially during growing period of life. WHO defines malnutrition as "the cellular imbalance between supply of nutrients and calorie and the body's demand for them to ensure growth, maintenance and specific functions of the cell."[1] The kidneys lie in the retroperitoneal space slightly above the level of the umbilicus. They range in length and weight, respectively, from approximately 6 cm and 24 gm in a full-term newborn to ≥ 12 cm and 150 gm in an adult. The kidney has an outer layer, the cortex, which contains the glomeruli, proximal and distal convoluted tubules, and collecting ducts; and an inner layer, the medulla, that contains the straight portions of the tubules, the loops of Henle, the vasa recta, and the terminal collecting ducts. The blood supply to each kidney usually consists of a main renal artery that arises from the aorta; multiple renal arteries can occur. The main artery divides into segmental branches within the medulla, becoming the interlobar arteries that pass through the medulla to the corticomedullary junction. At this point, the interlobar arteries branch to form the arcuate arteries, which run parallel to the surface of the kidney. Interlobular arteries originate from the arcuate arteries and give rise to the afferent arterioles of the glomeruli. Specialized muscle cells in the wall of the afferent arteriole and specialized distal tubular cells adjacent to the glomerulus (Macula densa) form the juxtaglomerular apparatus that controls the secretion of renin. The afferent arteriole divides into the glomerular capillary network, which then recombine into the efferent arteriole. The juxtamedullary efferent arterioles are larger than those in the outer cortex provide the blood supply, as the vasa recta, to the tubules and medulla. Each kidney contains approximately 1 million nephrons (Each consisting of a glomerulus and associated tubules). There is a large distribution of "normal nephron number" in humans, with the ± 2 SD ranging from 200,000 to 2 million nephrons/kidney. This variation can have major pathophysiologic significance as a risk factor for the later development of hypertension and progressive renal dysfunction. In humans, formation of nephrons is complete at 36-40 weeks of gestation, but functional maturation with tubular growth and elongation continues during the 1st decade of life. Because new nephrons cannot be formed after birth, any disease that results in progressive loss of nephrons can lead to renal insufficiency. A decreased number of nephrons secondary to low birth weight, prematurity, and/or unknown genetic or environmental factors has been implicated as a significant risk factor for the development of primary hypertension and progressive renal dysfunction in adulthood. Low nephron number presumably results in hyperfiltration and eventual sclerosis of "overworked" nephron units.

Under nutrition affecting several lakhs of children especially under five in the developing countries.[2] Under nutrition mainly seen in low-and middle-income countries[1]. In these countries large proportions of population are living under limited social and economic development which have a direct impact on growing children. Protein-energy malnutrition or PEM is a widespread public health problem contributing considerably to mortality mainly because of pneumonia, diarrhoea, measles, tuberculosis and morbidity in areas where it is prevalent[3,4] and also leads to primary education failure. There has been a very slow reduction in under nutrition in the countries like India and now India has the maximum burden of under nourished children in the world.[5,6] Normally growth of visceral organs is affected by various factors like oxygen, nutrition, genetic pattern and environmental situation. Nutrition is one of the most important factors that determine growth and size of the human body in childhood especially from six months to eighteen months of life. Growth retardation due to malnutrition or under nutrition generally occurs in children of post-weaning age, which may be as a result of dietary deficiency[7] or may be a knowledge gap between mother and health care delivery system. Under nutrition has effect on almost every organ especially vital organ like kidney, heart, brain and adrenal gland of the body. Kidneys serve the excretory and synthetic function and are important for maintaining the normal homeostasis if not affected by nutrition during its developmental period. Although the formation of nephron is completed by 35-36 weeks of gestation, glomerular and tubular growth continues in the first eighteen months of post-natal life, therefore it is important that a child should not suffer from nutritional deficiency during this period.[8] If protein energy malnutrition (PEM) develop during this period, which may have impact on kidney function either in acute or chronic (later development of hypertension, chronic kidney disease, end stage kidney disease, decreased life span) form. Theoretically it is often stated that kidney growth parallels somatic growth, this is overly simplistic and at present unsubstantiated. The factors which influence and modify normal kidney growth, function and development remains poorly understood. Among the various factors one of the most important factors identified in the growth of the kidneys is the nutrition of the child during its growth period. Malnutrition or under nutrition has effect both on renal growth and function of the kidney. Though different clinical manifestations of under nutrition may be evident on physical or clinical examination but alterations in kidney functions may not be found at the initial examination of the child. Under nourished children have lowered tubular function, decreased renal plasma flow (R.P.F.) and also decreased Glomerular filtration rate (GFR).[9-11] They have a decreased capacity to concentrate the urine. As G.F.R. decreases ammonia, urea, creatinine, potassium increases and this may lead to, metabolic or uremic encephalopathy if not treated on right time. Decreased G.F.R. may also lead to chronic kidney disease (CKD) and end stage renal disease (ESRD) in long run. During renal growth, deprivation of nutrients has an association of under nutrition and various kidney diseases which may be due to primary deficiency of nutrients or secondary to kidney problem. In developing countries like India, it is mostly due to primary malnutrition, however wide range of prevalence of secondary malnutrition (6%-51%) had been reported in hospitalized children.[12,13]

METHODS

The study was conducted at the department of paediatrics from 01.06.2017 to 31.05. 2018 after obtaining approval from the institutional ethics committee. This was a cross- sectional study and 72 children who met the inclusion criteria were included in this study as per the protocol of the study. Written informed consent was taken from parents or guardians for enrolment of their children in the study. Thorough history particularly the nutritional history of the subject and other systemic examination was done. Various anthropometric measurements were done in the department and grading of malnutrition was done according to WHO classification. Length/height of child was measured to the nearest millimeter (mm) of the length or height. Weight was recorded to the nearest 100 gm of the weight. Mid arm circumference (MUAC) was measured to the nearest millimeter. Body mass index (BMI) in Kg/m^2 was calculated from weight and height using the formula - BMI=Weight (Kg)/ (Height/length in m).[2] Body surface area (BSA) was measured by the equation of, BSA =√ [Wt (Kg) x Ht/ length (cm)/3600].

Ultrasonography (USG) of Kidney, Ureter and Bladder

Investigation to determine sizes of kidney were done by ultrasonography using a 3.5-5 MHz curvilinear probe with an accuracy of 0.1 mm (TOSHIBA APLIO 500 Machine). All the measurements were performed from the same radiology department with the same device. The probe was placed on the back of the child in a supine position turning right and left side. The kidney was identified in the sagittal plane along its longitudinal axis. In this position, longitudinal anterior–posterior measurements of the largest length and width were done. Decreased renal size was defined when the renal length was less than normal value for that particular age based on kidney size.[(14)]

Statistical Analysis

All the data collected for the study for statistical analysis were performed using SPSS version 20. From the findings, results were expressed as mean ± standard deviation for continuous variables and as number in percent for categorical data. Comparison between two quantitative variables between two groups using student's t test. To find out different findings variables Pearson's correlation analysis was done to determine correlation between different variables. The Chi-square test was done wherever it was applicable. A p value <0.05 was considered significant.

RESULTS

The mean ± SD age of malnourished children was 27.96 ± 16.75 months (range 6-60 months). Majority of the children had severe malnutrition (68.06%).

Variables	Mean	± S.D.
Weight (Kg)	7.61	2.20
Length/Height (cm)	78.62	12.08
MAC (cm)	12.48	1.15
BMI (Kg/m^2)	12.16	1.43
BSA (m^2)	0.41	0.09

Table I. Anthropometry

Kidney Size	Moderate		Severe		Total		p Value
	n	%	N	%	n	%	
Normal	18	78.26	20	40.82	38	52.78	0.0030
Decreased	5	21.74	29	59.18	34	47.22	
Total	23	100.00	49	100.00	72	100.00	

Table II. Severe and Moderate Malnutrition and Kidney Size

The chi-square statistic is 8.8058. The result is significant at p<.05.

Kidney Size	Female		Male		Total		p Value
	n	%	n	%	n	%	
Decreased	11	44	23	48.96	34	47.22	0.6896
Normal	14	56	24	51.06	38	52.78	
Total	25	100.00	47	100.00	72	100.00	

Table III. Kidney Size in Male and Female

The chi-square statistic is 0.1595. The p-value is 0.689574. The result is not significant at p <.05.

Kidney Size	Kidney				p Value
	Right		Left		
	Mean	± S.D.	Mean	± S.D.	
Width (cm)	2.44	0.25	2.59	0.32	0.00207
Length (cm)	5.33	0.68	5.48	0.67	0.20061

Table IV. Comparison of Right and Left Kidney Parameters

*Student t test. The result is not significant at p < 0.05.

Kidney Size	Right Kidney				p Value*	Left Kidney				p Value*
	Moderate		Severe			Moderate		Severe		
	Mean	Mean	± S.D.	Mean		± S.D.	± S.D.	Mean	± S.D.	
Length (cm)	5.56	0.59	5.23	0.69	0.04138	5.68	0.59	5.38	0.69	0.04658
Width (cm)	2.55	0.22	2.39	0.24	0.00693	2.73	0.32	2.52	0.30	0.01182

Table V. Moderate and Severe Malnutrition and its Correlation with Kidney Parameters

*Student t test. The result is significant at p < 0.05

Kidney size	Age		Weight (kg)		Length/ Height (cm)		MAC (cm)		BMI (kg/m^2)		BSA (m^2)	
	r Value	p Value	r Value	p Value	r Value	p Value	r Value	p Value	r Value	p Value	r Value	p Value
Width (cm)	0.2690	0.2232	0.2915	0.01297	0.3174	<0.00659	0.1940	0.1025	-0.068	0.2703	0.3074	0.0086
Length (cm)	0.5537	<0.001	0.5262	<0.001	0.5686	<0.001	0.3246	0.0054	-0.123	0.3033	0.5512	<0.001

Table VI. Left Kidney Sizes with Anthropometric Measurements with Pearson's Correlation Coefficient (r)

r value of 0.1- trivial correlation, 0.1-0.3- small correlation, 0.3-0.5- moderate correlation, 0.5-0.7- large correlation, 0.7-0.9- very large correlation, 0.9- 1.0-nearly perfect correlation, 1- perfect correlation.

In this study, the mean (±S.D.) weight was 7.61 ± 2.20 kg (range from 3.30 kg to 12.40 kg). The mean Body Mass Index (B.M.I.) was 12.16 ± 1.43 kg/m^2 (range from 8.4 to 14.72). The mean (±S.D.) body surface area was 0.41 ± 0.09 m^2 (range from 0.22 to 0.59). The mean (±S.D.) length was 78.62 ± 12.08 cm (range from 55 to 104 cm). The mean (±S.D.) of MAC was 12.48 ± 1.15 cm (range from 9 to 14.5 cm) (Table-I).

In moderate malnutrition, normal kidney size was found in 18 (78.26%) cases, decrease in 5 (21.74%) cases in contrast to severe malnutrition where kidney size was normal in 20 cases (40.82%) and decrease in 29 (59.18%) cases. There was significant difference in kidney size between moderate and severe malnutrition (p=0.003) (Table II).

We observed that in male, kidney size was normal in 24 (51.06%) cases, decrease in 23 (48.96%) cases and among female, kidney size was normal in 14 (56%) cases, decrease in 11 (44%) cases. There was no significant variation of kidney size between male and female (Table III).

In this study, right kidney parameters (length, width) were lower than left kidney parameters but from the findings it was seen that there was significant differences of width between right and left kidney (p <0.05) but as such there was no significant differences of length between right and left kidney (p >0.05). (Table IV).

There was significant difference of kidney (both right and left) parameters between moderate and severe malnutrition (p<0.05) (Table V).

There was no significant difference in kidney parameters (length and width) between male and female (p> 0.05).

In our study it has been seen that there were significant correlations between anthropometric measurements and left kidney size in study children, but the strongest correlations were found between children's height and their kidney length (r=0.5686, p<0.001) and width (r=0.3174, p<0.05). Kidney length and width were negatively correlated with BMI (Table VI).

DISCUSSION

From various literature there are few studies on visceral growth like kidney size and role of malnutrition especially under nutrition leading to impairment of kidney size. We found only few studies in literature which reported that most severely malnourished means undernourished children had smaller kidneys (mainly size) than normal ones.[2,15,16]

In our study, Kidney size was normal in 38 (52.78%) cases out of 72 cases and decreased in 34 (47.22%) cases which is really a matter of concern in relation to adverse health problem like hypertension, chronic kidney disease, chronic morbidity or end stage renal disease. Distribution of kidney size in male and female was statistically insignificant (p>0.05).

In our study, in moderate malnutrition, normal kidney size was found in 18 (78.26%) cases, decrease in 5 (21.74%) cases in contrast to severe malnutrition where kidney size was normal in 20 cases (40.82%) and decreased in 29 (59.18%) cases. Size of kidney vary according to severity of malnutrition; this was statistically significant (p<0.05) as there is decrease in kidney size in our study in severe under nutrition.

There was significant difference of kidney (both right and left) parameters between moderate and severe malnutrition (P<0.05).

Left Versus Right Kidney Sizes

In our study, all measurements (Length, Width) of the right kidney were lower than those of the left kidney. The difference of width between both kidneys was statistically significant (p=0.00207) but there is difference of length between both kidneys was not statistically significant (p=0.20061) in our study. Some study found the kidneys to be equal size [17-19] and other found that the left kidney is larger than the right kidney.[20,21] However concerning length, there has been no disagreement about the left kidney being the longest. [21-26]

Male Versus Female Kidney Sizes

Female and male children had similar right and left kidney sizes (p>0.05). However, all the parameters (length and width) of right and left kidney in female study children had higher than the male study children. Same result was observed by G. Gopal et al,[15] Aydin Ace et al.[2] Some study found girls had smaller kidneys than boys[112,113] while others found no gender differences.[17,21,25]

Correlation Between Anthropometric Measurements and Kidney Size

Important correlations between kidney sizes and anthropometric measurements has been seen in our study group of children but the strongest correlations were found between children's height and their kidney length (r=0.5686, p<0.001) and width (r=0.3174, p<0.05). Kidney length and width were negatively correlated with Body Mass Index (BMI). A. Ece[2] et al found strongest positive correlations between height and kidney sizes. Other study done by G. Gopal[15]et al and Singh GR [27]et al found strongest correlations between kidney sizes and weight of study population and kidney sizes and BSA respectively.

CONCLUSIONS

Undernourished children had smaller kidneys. We have not found any significant difference of kidney size between female and male (p>0.05) undernourished children but there was significant difference of kidney parameters between moderate and severe malnutrition (<0.05). Kidney size best correlates with their length/height (r=0.5686) which is very important from clinical point of view, because most of the adult onset chronic kidney disease may have beginning in their undernourished childhood life. Correct nutrition during nephron development should be given proper importance for a healthy future.

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