A Sonographic Study of Kidney Dimensions Among Nepalese Children

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ABSTRACT

Introduction: Any variations in shape or size of either one or both kidneys may indicate sign of its pathology. The study was aimed to determine normal values for renal dimensions among Nepalese children.

Methods: This was a cross-sectional study of the renal dimensions among 211 children. The length, breadth and thickness of kidneys were measured by computerised in built calliper in centimetre by using ultrasound and volume of the kidney was calculated.

Results: The mean values of length, breadth, thickness and volume were 7.05 ± 1.80 cm, 2.95 ± 0.48 cm, 1.35 ± 0.15 cm and 15.09 ± 5.91 cc for right kidneys respectively; and 7.36 ± 1.89 cm, 2.98 ± 1.89 cm, 1.35 ± 0.18 cm and 15.98 ± 6.44 cc for left kidneys respectively. The mean values for length, breadth, thickness and volume of right kidney was 7.57 ± 1.99 cm, 3.11 ± 0.46 cm, 1.38 ± 0.14 cm and 17.38 ± 6.20 cc among boys respectively; and 6.50 ± 1.39 cm, 2.78 ± 0.44 cm, 1.31 ± 0.17 cm and 12.69 ± 4.43 cc among girls respectively. Similarly, these values for length, breadth, thickness and volume of left kidneys were 7.91 ± 2.04 cm, 3.13 ± 0.49 cm, 1.39 ± 0.18 cm and 18.46 ± 6.89 cc among boys respectively; and 6.78 ± 1.52 cm, 2.83 ± 0.45 cm, 1.31 ± 0.17 cm and 13.38 ± 4.73 cc among girls respectively.

Conclusions: It was concluded that mean values for renal length and volume was found to be higher on left side than right side in all age groups. These values for renal breadth and thickness were observed almost same on both sides in all age groups. All measurements of renal dimensions were found significantly higher among boys than girls on both sides. This study has provided the reference values for renal sizes among Nepalese children.

Key words: Child; Kidney; Kidney Disease; Ultrasonography

INTRODUCTION

Kidneys are a pair of main excretory organs which maintain the electrolyte and water balance and also serve as endocrine organs.[1] A normal dimension of kidney is an essential indicator of normal renal function. The kidney size is an important tool in the assessment of children with renal diseases.[2] The change in kidney size may be an evidence of disease. The deviation of renal dimensions from established normal values is an important criterion in diagnosis of renal diseases.[3]

Generally each adult kidney is bean shaped and approximately 11 cm in length, 6 cm in breadth and 3 cm in thickness. The left kidney may be 1.5 cm longer than the right.[1] Sonography is useful, non-invasive and safe method for reliably performing the measurement of kidney size. It plays an important role in the evaluation of renal disease in children[4] and can be helpful for the clinicians to manage children with chronic pyelonephritis, obstructive uropathy and chronic glomerulonephritis.[5]

In Nepalese children, studies on kidney dimensions are inadequate and references for renal dimensions are made from the measurements obtained in other communities. Hence, the study was aimed to evaluate various dimensions of kidney among Nepalese children which would be helpful for the clinicians to make diagnosis and treatment plan for renal diseases.

METHODS

The present study was observational and cross sectional type, consisting ultra-sonographs of abdomen of 211 (108 boys and 103 girls) school going children (Six to 16 years). The study was conducted in the Department of Anatomy and ultra-sonographs were collected from the Department of Radio-Diagnosis, Kathmandu University School of Medical Sciences, Dhulikhel Hospital, Dhulikhel, Nepal during the period from July 2019 to May 2020. The children had undergone ultra-sonogram of abdomen, who were referred from the Paediatrics Department. Verbal consent was taken from each children / parents. The apparently normal kidneys were included for this study after diagnosis was made by a faculty from the Department of Radio-diagnosis. The children with history of previous renal surgery or any congenital anomaly, children with any kidney pathology such as multiple renal cysts, polycystic kidney disease, unilateral kidney, chronic kidney disease or malignancy were excluded from the study. Prior to beginning of this study, approval from institutional review committee was taken (Ref. no. 161/19).

Sample size was calculated by using the formula,[6] $N = z^2 \times p\,(1\text{-}p) / e^2$ (where, n = minimum required sample size; z = 1.96 at 95% confidence interval; p = prevalence, 50%; q = 1-p; e = margin of error, 7%). Calculated minimum sample size was 196, however total sample size taken for the study was 211. All 211 children were scanned using Aloka alfa 6 ultra sonogram machine with 5 MHz convex transducers. The sonographic electronic caliper was used to measure the renal dimensions of each kidney with the child placed in a supine oblique position in centimetre (cm). Each kidney was measured for the maximal length in its longitudinal axis (bipolar axis) with transducer, transducer was oriented transversely at the hilum for breadth and anteroposterior diameter was measured as thickness. The renal volume was calculated by the formula: Volume = 0.5233 × length × breadth × width in cubic centimetre (cc).[7]

Random sampling technique was done. The data was collected and entered in Microsoft excel. Point estimate at 95% Confidence Interval was calculated along with frequency and proportion for binary data. The collected data was analysed by using Statistical Package for the Social Sciences (SPSS 16.0) for statistical analysis. The measured data was summarised as range, mean and standard deviation. The correlation between right and left kidneys; and between boys and girls kidneys was evaluated with student's t-test.

RESULTS

A total of 211 children were studied, which comprised 108 boys (51.18%) and 103 girls (48.82%). The age group ranged from six to 16 year old with the mean age of 11 year old.

The length of right kidney ranged from 4.10 cm to 11.50 cm with the mean value of 7.05 ± 1.80 cm and left kidney ranged from 3.90 cm to 11.98 cm with the mean value of 7.36 ± 1.89 cm. Hence, it was concluded that left kidney was found to be longer than the right kidney which was statistically significant ($p < 0.05$) as shown in table 1. When comparing with age, the left kidney was found to be longer than the right kidney in all age groups which was only statistically significant ($p < 0.05$) from age of 10 years to 16 years old as illustrated in table 3.

The breadth of right kidney was in the range of 2.00 - 3.90 cm with the mean value being 2.95 ± 0.48 cm and left kidney was in the range of 2.10 - 4.50 cm with the mean value being 2.98 ± 1.89 cm. Therefore, it was evident that there was no statistically significant ($p > 0.05$) differences between right and left renal breadth in all age groups as shown in table 1 and 3.

The thickness of right kidney ranged from 0.60 cm to 1.80 cm with the mean value of thickness being 1.35 ± 0.15 cm and left kidney ranged from 0.80 cm to 1.90 cm with the mean value of 1.35 ± 0.18 cm. Hence, it was cleared that there was also found insignificantly ($p > 0.05$) differences between right and left renal thickness in all age groups as shown in table 1 and 3.

The volume of right kidney ranged from 4.82 cc to 32.77 cc with the mean value of volume being 15.09 ± 5.91 cc and left kidney ranged from 4.82 - 33.56 cc with the mean value of 15.98 ± 6.44 cc. Hence, it was observed that volume of right kidney was found slightly higher than left kidney which was statistically significant ($p < 0.05$) as shown in table 1. In comparison, volume of the left kidney was found slightly larger than the right kidney in all age groups which was only statistically significant ($p < 0.05$) differences found at age of 10 and 14 years old as illustrated in table 3.

The mean values of length of right kidneys were found to be 7.57 ± 1.99 cm among boys and 6.50 ± 1.39 cm among girls. Similarly, the mean values of length of left kidneys were found to be 7.91 ± 2.04 cm among boys and 6.78 ± 1.52 cm among girls. Hence, it was observed that both kidneys of boys were found to be significantly ($p < 0.05$) longer than that of girls as shown in table 2.

The mean values of breadth of right kidneys were found to be 3.11 ± 0.46 cm and 2.78 ± 0.44 cm among boys and girls respectively. Similarly, the mean values of breadth of left kidneys were found to be 3.13 ± 0.49 cm and 2.83 ± 0.45 cm among boys and girls respectively. Hence, it was cleared that the renal breath was found to be significantly ($p < 0.05$) larger among boys than girls on both sides as shown in table 2.

The mean values of thickness of right kidneys were found to be 1.38 ± 0.14 cm among boys and 1.31 ± 0.17 cm among girls. Similarly, the mean values of

Table 1. Descriptive statistical analysis of kidney dimensions (cm)

Dimensions	Side	Range	Mean±SD	p-value
Length	Right	4.10 - 11.50	7.05 ± 1.80	0.00
	Left	3.90 - 11.98	7.36 ± 1.89	
Breadth	Right	2.00 - 3.90	2.95 ± 0.48	0.24
	Left	2.10 - 4.50	2.98 ± 1.89	
Thickness	Right	0.60 - 1.80	1.35 ± 0.15	0.83
	Left	0.80 - 1.90	1.35 ± 0.18	
Volume	Right	4.82 - 32.77	15.09 ± 5.91	0.00
	Left	4.82 - 33.56	15.98 ± 6.44	

Table 2. Gender wise comparison of kidney dimensions (cm)

Dimensions	Side	Boys (108)	Girls (103)	p-value
Length	Right	7.57 ± 1.99	6.50 ± 1.39	0.00
	Left	7.91 ± 2.04	6.78 ± 1.52	0.00
Breadth	Right	3.11 ± 0.46	2.78 ± 0.44	0.00
	Left	3.13 ± 0.49	2.83 ± 0.45	0.00
Thickness	Right	1.38 ± 0.14	1.31±0.17	0.00
	Left	1.39 ± 0.18	1.31 ± 0.17	0.00
Volume	Right	17.38 ± 6.20	12.69 ± 4.43	0.00
	Left	18.46 ± 6.89	13.38 ± 4.73	0.00

Table 3. Age wise comparison of kidney dimensions (cm)

Age in years			6	7	8	9	10	11	12	13	14	15	16
Length	Right	Mean	5.26	5.48	5.83	5.92	6.14	6.69	8.00	8.49	8.56	9.56	9.58
		SD	0.89	0.83	0.95	0.97	0.98	1.29	1.12	0.51	0.98	1.21	1.03
	Left	Mean	5.32	5.57	5.97	6.08	6.67	7.24	8.26	8.79	9.14	9.85	9.99
		SD	1.10	0.68	0.96	0.94	1.08	1.37	1.17	0.61	1.19	1.18	0.84
	p-value		0.84	0.21	0.05	0.07	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Breadth	Right	Mean	2.72	2.78	2.81	2.88	2.83	3.09	2.95	3.32	2.98	3.14	3.15
		SD	0.45	0.45	0.50	0.43	0.37	0.52	0.45	0.32	0.54	0.46	0.49
	Left	Mean	2.67	2.76	2.78	2.91	2.92	3.06	3.07	3.29	3.15	3.08	3.32
		SD	0.47	0.41	0.42	0.46	0.37	0.52	0.48	0.53	0.53	0.37	0.61
	p-value		0.53	0.83	0.76	0.61	0.04	0.79	0.25	0.85	0.08	0.51	0.21
Thickness	Right	Mean	1.28	1.25	1.30	1.38	1.40	1.34	1.37	1.40	1.38	1.40	1.39
		SD	0.15	0.16	0.13	0.12	0.14	0.15	0.21	0.14	0.14	0.14	0.13
	Left	Mean	1.26	1.29	1.31	1.33	1.45	1.32	1.40	1.34	1.41	1.33	1.42
		SD	0.16	0.19	0.13	0.14	0.22	0.18	0.17	0.17	0.14	0.02	0.19
	p-value		0.65	0.17	0.88	0.31	0.17	0.70	0.70	0.31	0.21	0.24	0.59
Volume	Right	Mean	9.76	10.11	11.20	12.37	12.80	14.72	17.35	20.67	18.50	22.21	22.16
		SD	3.11	3.29	2.94	2.94	3.44	4.79	5.60	2.62	4.49	5.45	5.01
	Left	Mean	9.23	10.45	11.45	12.32	15.01	15.54	19.03	20.56	21.55	21.30	24.55
		SD	1.97	2.71	3.02	2.69	4.71	5.03	6.07	5.10	5.97	4.83	4.83
	p-value		0.44	0.51	0.58	0.93	0.00	0.25	0.08	0.93	0.00	0.50	0.03

thickness of left kidneys were found to be 1.39 ± 0.18 cm among boys and 1.31 ± 0.17 cm among girls. So, it was noted that the renal thickness was found to be significantly ($p < 0.05$) higher among boys than girls on both sides as shown in table 2.

The mean values of volume of right kidneys were found to be 17.38 ± 6.20 cc and 12.69 ± 4.43 cc among boys and girls respectively. Similarly, mean values of volume of left kidneys were found to be 18.46 ± 6.89 cc and 13.38 ± 4.73 cc among boys and girls respectively. So, it was noted that right and left kidneys were found to be higher in volume

among boys than girls which was statistically significant ($p < 0.05$) as shown in table 2.

DISCUSSION

Congenital anomalies of the kidney and urinary tract are relatively common, accounting for approximately 20% - 30% of all anomalies identified in the prenatal period.[8] Among the congenital anomalies of the kidney and urinary tract, reflux nephropathy, obstructive uropathy, and renal agenesis or hypoplasia or dysplasia are responsible for 30% - 50% of end-stage renal disease in children.[9] Hence, kidney dimensions play an important role in the assessment of renal disease in children.[2] It has been shown that ageing leads to a progressive decrease in kidney size.[10] In fact, many diseases progress with an increase or a decrease in kidney size and there are few diseases that can affect renal size without altering the architecture.[4] The other affecting factors are age, ethnicity, gender, weight and height of individuals.[10] The variations in dimensions of kidney may also be due to variations in climate of different geography. Therefore, accurate measurement of renal size is important in the clinical setting, and many nomograms have been developed for assessing renal size by sonography.[2]

There are various imaging methods which have been used to measure kidney dimensions.[11] Among them, ultrasound is the preferred method of diagnosis in most clinical practice.[12] It can be easily and safely performed, without radiation exposure in children. It can provide important information regarding renal anomalies and indirect renal function.[13] It appears to be an ideal method for evaluating renal dimensions in children.[4] It is useful, non-invasive and cheap method for reliably performing the measurement of kidney size. It is the method of choice for assessment of renal size in children.[14]

It is already known that the growth rate for renal length are highest during the first one to two years of life, then slows during two to five years of age, and stabilises in a linear fashion thereafter.[15] Hence the present study was conducted among children between six to 16 years old. The children of the same age had greatly varying overall size of the kidneys.[16] A difference in length of 2 cm or more between the right and left kidneys may raise the possibility of unilateral kidney disease.[12] Many congenital and acquired diseases directly or indirectly affect renal dimensions in all age groups.[17]

It was also reported that the changes in kidney length, width and volume could be associated with atherosclerotic kidney disease, arterial hypertension and renal vascular disease.[18] A short kidney length allows chronic renal failure to be easily distinguished from acute renal failure with normal or enlarged values.[19] Authors reported a study to identify differences in renal measurements and compared the volume of kidney with glomerular filtration rate and body mass index, which might be of great relevance in selection of patients undergoing donor nephrectomy.[20]

Renal volume assessment is an important parameter in evaluation and follow up of kidney transplant recipients, chronic renal failure and hypertension secondary to renal artery stenosis. It is also useful in younger patients with vesico-ureteric reflux which alters the morphometrical profile of the kidney.[21] Since the estimation of renal volume requires measurement of three dimensions of the kidney, the error associated with renal volume increases in geometric proportion.[22]

Renal dimensions can also be considered as an important parameter or indicator of subsequent changes in the diagnosis and treatment plan of renal diseases.[21] In various renal diseases, the kidney size changes, may be due to inflammation caused by infections or because of water and mineral imbalance. Similarly diabetes can also increase the size of kidneys and chronic diseases can decrease the size of kidneys.[23] Renal ischaemia also leads to a decrease in renal size.[24]

A study had concluded that left kidney was found to be longer than the right kidney with statistical significance[13] which is also consistent with this study. However, another study has reported no significant differences between the left and right kidney sizes.[22] The reason is that the spleen is smaller than liver, so the left kidney has more space

to grow. Another region was that, because the left renal artery is shorter and straighter than the right one, hence increased blood flow in the left artery might result in relatively increased volume.[19] Also, the left renal artery is shorter than the right one, so increased blood flow in the left renal artery may result in a relatively increased size of the left kidney.[25]

A study has shown that there were statistically significant differences between boys and girls in renal length and volume[26] which is in accordance with the present study. This may be due to body proportion and rate of general somatic growth which is noticeably different between boys and girls.[22] In contrast, a study revealed that there were no significant differences with respect to genders.[27] Some studies suggested that girls have smaller kidneys,[26] while an another study has found no statistically significant differences in renal dimensions between boys and girls.[28] Therefore, gender certainly is not a determining factor for kidney dimensions in school-age children in this population.[27] The present study found a noticeable difference in kidney length and volume by sex. Both kidneys were found to be longer in boys than girls. These differences may be due to greater body surface area of boys than girls.

Knowledge of normal renal size is essential not only to follow up children with renal disease but also to know whether the kidneys are growing appropriately or not.[4] This is of particular importance in childhood, when renal length changes with age, and when renal tract abnormalities exist, such as reflux nephropathy, renal hypoplasia, obstructive uropathy and renal agenesis.[26]

Although our study comprised of good number of study participants, the findings could not be generalised to the entire Nepalese population as ours is a single centric study, involving mostly the children from local region.

CONCLUSIONS

This study might have provided normal measurements of renal length, breadth, thickness and volume of kidneys among Nepalese children which might be used as a reference by the clinicians. This, however, requires validation from larger, multi-centric data. It may help to determine anatomical variations of kidney. It may also be useful to differentiate a pathological kidney from a normal sized healthy kidney. It may also contribute to upgrade the information of anatomists and anthropologists regarding renal dimensions in future research activities.

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