

Correlation of Kidney Dimensions in Adults by Ultrasonography

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Abstract

Background: Estimation of renal size by ultrasonography could be performed by measuring renal length, width, anteroposterior (AP) diameter, cortical thickness and renal volume. Renal length was measured in the longitudinal plane parallel to the longest renal axis and that was the most clinically useful parameter. The changes in renal structure and shape had changed with age and renal size and had correlated with different parameters of kidneys in between males and females. So, the present study was conducted to measure the average kidney dimensions [length, width, thickness (AP diameter) and cortical thickness, volume] in adults and to find out possible correlations with the age, gender, and sides of the kidneys. Materials & methods: Medison SONOACE X8 with 3.5 MHz sector curvilinear transducer probe was used for ultrasonography to measure all the kidney dimensions. The mean renal dimensions were taken by measuring three times.

Results: No significant difference was observed in length, cortical thickness and volume between left and right kidneys. But only AP diameter of left kidney (42.02 ± 5.58 mm) was significantly (p value 0.00) higher than right kidney (39.86 ± 5.39 mm). The length, width and volume of both the kidneys had no significant differences between both genders. Only the Cortical thickness was significantly higher in male compare to female in both the kidneys.

Conclusion: The length which was a sole significant dimension to detect the pathology or disease in kidneys had been found to be within normal range in both kidneys. Anteroposterior diameter was significantly higher in left kidney, whereas a statistically non-significant increase in left kidney volume was observed. The cortical thickness of both right and left kidneys had significant increase in males comparing to females. Age-related changes in the dimensions of right and left kidney were well observed among different age group. The present study had concluded that kidney dimensions were very closely related to age, gender and sides of kidney.

Keywords: Cortical thickness, Dimension, Kidney, Ultrasonography.

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Introduction

Ultrasonography was the established method for initial evaluation of kidneys.[1] It was readily available, cheap and easily reproducible to a large extent.[2] It was important to have a set of standard ultrasonographic measurements to recognize anatomical deviations in individuals with renal diseases.[3] Estimation of renal size by ultrasonography could be performed by measuring renal length, width, cortical thickness and renal volume. Renal length as measured in the longitudinal plane parallel to the longest renal axis was the most clinically useful parameter.[4] Renal size was correlated with height, weight and body mass index (BMI) of adult males and females.[5,6] The average height for adult males significantly differed than adult females.[7] The left kidney was somewhat larger than the right kidney.[8] In this context, the changes in renal structure and shape that take place in human beings with age, decreased renal mass and renal weight and size, were well known.[9]

Renal length decreased 0.5 cm per decade after middle age. A correlation between renal size and age were observed and reduction of up to 40% in renal weight occurs over the years. The length and renal volume in subjects aged between 30 to 50 years had shown slight differences and a clear decrease in both parameters.[10]

The renal dimensions varied in races as we move from one geographical region to another. Kidney size changed significantly in the presence of renal diseases.[8] The volume of kidney also varied with height and weight of the individual.[8,11] Size of the kidneys had shown individual variations. These variations might be due to individual's age, gender, height, weight. Many renal diseases were associated with increased or decreased size of the kidneys.[8,11,12] The normal length of the kidney was 11 ± 1 cm on right side and 11.5 ± 1 cm long on the left side. But

variations were observed 11 to 12 cm for right and left kidneys, similarly width varied 5 and 7 to 7.5 cm and thickness varied from 2.5 to 3 cm. the kidneys of less than 8 cm and more than 14 cm could be normal.[12]

The deviations of the kidney parameters from the established normal values were important criteria in diagnosing kidney diseases.[8,12] As renal size changes significantly in the presence of renal disease, it was necessary to determine the normal anatomical kidney dimensions in the population of a particular region. Though ultrasonography was used routinely to evaluate visceral organs in adults in Tripura, no studies were found on population of Tripura to measure kidney dimensions by ultrasonography to correlate with different parameters.

So, the present study was conducted: to measure the average kidney dimensions [length, width, thickness (AP diameter) and cortical thickness]; to estimate the average of kidney volume by ultrasonography in adults; to find out possible correlations with the age, gender, and sides of the kidneys.

Materials & Methods

This study was a cross-sectional study, conducted in the Department of Anatomy and Department of Radiodiagnosis, Tripura Medical College & Dr. B.R.A.M. Teaching Hospital among 180 numbers of individuals/patients for a period of Six (06) months. Minimum sample size was calculated 139 individuals/patients [Kidney size on right side (length x width x cortical thickness) was $76.5 \pm 30.1 \text{ cm}^3$ ($23.7 - 184.1 \text{ cm}^3$); Sample size (n) = $z^2 \times \sigma^2/d^2 = 139$; Where, $z = 1.96$ $\sigma = 30.1$ (variance) $d = 5\%$ (margin of error)].

Study subjects were individuals (in-patients or out-patients) attending the Tripura Medical College & Dr. B.R.A.M. Teaching Hospital for conditions other

than genitourinary system. Normotensive patients (Systolic BP <140 mm Hg and Diastolic BP <90 mm Hg) with normal blood sugar and serum Creatinine within normal limit [blood sugar: fasting <100 mg/dl; post prandial <140 mg/dl; random <140 mg/dl, serum creatinine (mg/dl): male 0.7 - <1.3; female 0.5 - <1.1] and individuals with demonstrated normal homogenous echo-pattern of the kidneys with clear cut cortico-medullary demarcation were included.

Individuals or patients who were not willing to participate and suffering from psychiatric disorders, having history of medical, surgical and oncologic disorders affecting kidney (hypertension, diabetes, acute and chronic kidney diseases etc.), history of obvious renal pathology (e.g., calculi, cysts, hydronephrosis etc.); pregnant woman and woman who had given birth in the last 12 months, patients with congenital anomalies of kidneys were excluded from the study. The individuals were divided into four (04) groups according to their age: 18 to 30 years; 31 to 45 years; 46 to 60 years; above 60 years; Study variables: a) For subjects – age, gender; b) For observation of kidneys (both right and left) – length, width, antero-posterior (AP) diameter, cortical thickness (in millimetre), volume of kidneys. Medison SONOACE X8 with 3.5 MHz sector curvilinear transducer probe was used for transabdominal USG.

After getting formal permission from the Institutional Ethics Committee, the informed consent from the respective individual/patient was taken after fully explaining the purpose of the study. After taking informed consent, an elaborate history was taken.

Individuals were physically examined and were asked to empty bladder prior to the examination to avoid an increased renal length and pelvicalyceal fullness caused by hydration. The sonographic examination was performed with 3.5 MHz sector

curvilinear transducer probe. The patient was placed in supine position and the ultrasonographic gel was applied. The individual was made to take a deep inspiration and hold it for a few seconds to evaluate the kidneys and its echogenicity and related structures.

The kidneys were identified as having bright echogenic renal capsule with a central (sinus) echogenicity. The superior and inferior poles were clearly identified and marked in the longitudinal scan of the kidney. The renal length was taken as the longest distance between the poles. The major distance between the lateral and medial borders perpendicular to the length (L) was taken as the width (W). The renal cortical thickness was measured at mid renal zone in sagittal images. The anteroposterior (AP) diameter or thickness was also be measured on longitudinal scan, and the maximum distance between the anterior and posterior walls at the mid-third of the kidney was taken as AP diameter. The renal width (W) was measured on transverse scan, and the maximum transverse diameter was taken at the hilum as the renal width. The unit of measurement was centimetre (mm). Kidney volume was calculated using the formula: Length (L) x Width (W) x Thickness (AP Diameter) x 0.523.[13] The unit of volume was cm³.

The mean renal dimensions were taken by measuring three times. One single radiologist had measured all the dimensions for a particular patient following the procedure of the study to avoid inter-observer variability. All the measurements were saved in master chart for statistical analysis. Kolmogorov Smirnov test and Levene test were applied to check the normality and equality of Variances. Independent student's t test and one way ANOVA were applied. A p value <0.05 were taken as a significant. Welch's correction was done where ever required.

Results

In this study the minimum calculated study sample was 139 individuals. But within the

study period the study sample was collected 180 (male – 80 and female – 100). So, the data was analysed among 180 participants.

Table 1: Demographic profile and age group wise frequency and percentage (N = 180)

Parameter		Frequency	Percentage (%)
Gender	Male	80	44.44
	Female	100	55.56
Religion	Hindu	159	88.33
	Muslim	19	10.56
	Buddhist	1	0.56
	Others	1	0.56
Age (in Years) Groups	18 to 30	52	28.89
	31 to 45	69	38.33
	46 to 60	48	26.67
	Above 60	11	6.11

The mean age and mean serum creatinine of the participants were 39.73 ± 13.26 years and 0.931 ± 0.15 mg/dl respectively.

Table 2: Difference of Right kidney and left kidney dimensions (N = 180)

Parameters	Kidney dimensions		p value
	Right kidney	Left kidney	
Length	97.66 ± 8.41	97.89 ± 7.55	0.78
Width	44.49 ± 6.24	43.37 ± 5.39	0.07**
AP Diameter	39.86 ± 5.39	42.02 ± 5.58	0.00
Cortical Thickness	13.30 (11.60 – 15.10)	13.60 (12.00 – 15.70)	0.15***
Volume	88.35 (74.46 – 108.39)	93.31 (76.22 – 111.50)	0.22***

[Student's independent t test ** Student's independent t test with Welch's correction *** Mann–Whitney U test, Length in millimetre (mm), Width in mm, AP diameter in mm, Cortical thickness in mm, Volume in cm^3]

In the present study, no significant difference was observed in length, cortical thickness and volume between left and right kidneys (Table 2). But only AP diameter (Figure 1) of left kidney (42.02 ± 5.58) was significantly (p value 0.00) higher than right kidney (39.86 ± 5.39).

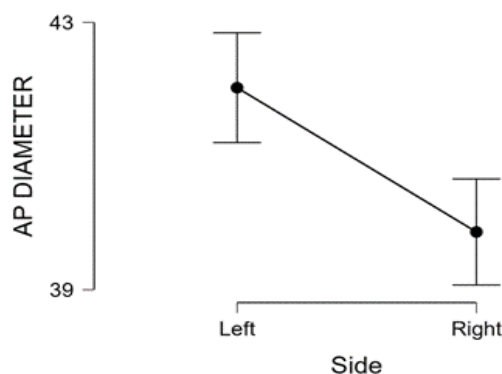


Figure 1: Showing AP diameter of the left kidney higher than the right kidney

Table 3: Difference in dimensions between male and female in both right and left kidneys

Parameters		Female	Male	p value
Right kidney	Length	98.27 ± 7.83	96.90 ± 9.09	0.28
	Width	44.01 ± 5.95	45.09 ± 6.58	0.25
	AP Diameter	39.29 ± 5.59	40.58 ± 5.08	0.11
	Cortical Thickness	13.10 (11.50 – 14.22)	13.75 (12.35 – 19.42)	0.00***
	Volume	90.02 ± 24.01	94.19 ± 26.23	0.27
Left Kidney	Length	98.27± 7.43	97.42 ±7.73	0.46
	Width	43.09± 5.16	43.71 ±5.67	0.44
	AP Diameter	41.01 ±5.07	43.29± 5.97	0.00 **
	Cortical Thickness	13.30 (11.60 – 14.65)	14.90 (12.90 – 18.98)	0.00
	Volume	92.11± 22.99	98.45 ±27.27	0.09

[Student's independent t test ** Student's independent t test with Welch's correction *** Mann–Whitney U test; Length in millimetre (mm), Width in mm, AP diameter in mm, Cortical thickness in mm, Volume in cm³]

The length, width and volume of both the kidneys had no significant differences between both genders. Only the Cortical thickness was significantly higher in male compare to female in both the kidneys. The AP diameter of left kidney was significantly higher among male (Table 3).

Table 4: Difference in dimensions of Right and Left kidneys among age groups, (N = 180)

Parameters		Age group				p value
		18 – 30 years	31 – 45 years	46 – 60 years	Above 60 years	
Right kidney	Length	96.59 ± 7.68	99.69 ± 8.56	95.94 ± 8.87	97.45 ± 7.06	0.07
	Width	43.40± 6.12	45.41± 6.11	44.44± 6.07	44.08± 8.21	0.37
	AP Diameter	37.55 (34.90 – 41.53)	40.00 (36.70 – 44.70)	40.85 (38.38 – 42.60)	39.90 (37.20 – 41.75)	0.10**
	Cortical Thickness	12.75 (10.90 – 13.93)	13.60 (12.40 – 15.30)	13.05 (11.50 – 15.11)	18.20 (13.50 – 29.65)	0.00**
	Volume	85.52 ± 22.51	96.89 ±25.15	92.15± 27.15	89.22± 22.75	0.10
Left Kidney	Length	97.06 ± 6.55	99.30 ± 7.77	96.65 ± 8.27	98.45± 6.82	0.23
	Width	42.63 ± 5.01	44.38 ± 5.52	43.05 ± 5.31	41.87 ± 6.21	0.22
	AP Diameter	38.55 ± 5.59	40.47 ± 5.28	40.48 ± 5.55	39.62 ± 3.69	0.20
	Cortical Thickness	14.18± 4.99	16.14 ± 7.38	15.56 ± 7.86	21.89 ± 12.55	0.11***
	Volume	90.57± 21.35	100.31±26.65	93.03±26.62	89.98±21.38	0.16

[One way ANOVA, **Kruskal–Wallis test, ***One way ANOVA with Welch's correction; Length in millimetre (mm), Width in mm, AP diameter in mm, Cortical thickness in mm, Volume in cm³]

In the left kidney, length, width, AP diameter, cortical thickness, and volume had shown no significant changes with the changes in age. However, in the right kidney, only cortical thickness has shown increased significantly after 60 years of age (Table 4).

Discussion

Kidney dimensions were observed differently for the North-Eastern region of India.[8] The dimensions of kidney varied according to race and individual anthropometric measurements. The established dimensions in the reference

text books reflected the Western Countries dimensions and could not be applicable to the population of Tripura as the people of the state was different from the other parts of India. So, it was necessary to established kidney dimensions in local region to have a reference value as kidney was frequently involved in various systemic and local diseases prevalent in our state.

Normal kidney size was observed among 47.10% individuals with normal kidney

size in disease processes.[13] The minimal size of fully functional kidney was 90 mm in length.[14] In the present study, the length of right kidney was similar with the study conducted by Addela A et al.[15] The right kidney length was more compared to study conducted by Purohit K et al.[14] but it was found to be less from the studies conducted by others.[14,16,17,18,19] Whereas, the left kidney length was similar with the study conducted by Purohit K et al[14] (Table 5).

Table 5: Comparison of kidney length in different studies conducted by various authors

Parameter (Mean \pm SD)	Present study	Purohit K et al. ¹⁴ (2017)	Adeela A et al. ¹⁵ (2011)	Saeed Z et al. ¹⁶ (2012)	Mujahid R et al. ¹⁷ (2011)	Justo OC et al. ¹⁸ (2009)	Buchholz NP et al. ¹⁹ (2000)
Right kidney length (mm)	97.66 \pm 8.41	94.4 \pm 11.8	97 \pm 7.9	98.5	101.6 \pm 8.9	104.3 \pm 6.4	104 \pm 9
Left kidney length (mm)	97.89 \pm 7.55	97.3 \pm 12.0	99 \pm 9.6	100	102.7 \pm 9.2	105.8 \pm 7	105 \pm 9

It was observed that, the length of the left kidney was larger compared to the right kidney (Table 6) which was similar in an anatomical study conducted by Murlimanju BV et al.[12] No statistically significant difference was observed.[12] But a statistically significant larger length

in left kidney was observed in the studies conducted by Emamian SA et al.[9] and Shine HS et al.[20] In the present study, the above observations of kidney length in right and left sides was differing with present study, where both the right and left kidney lengths were similar.

Table 6: Comparison of kidney dimensions in males and females in different studies conducted by various authors

Parameter		Right kidney (Mean \pm SD)				Left kidney (Mean \pm SD)			
		Length	Width	Cortical thickness	Volume	Length	Width	Cortical thickness	Volume
Present study (in mm) and Vol in cm ³	Male	96.90 \pm 9.09	45.09 \pm 6.58	13.75 (12.35 – 19.42)	94.19 \pm 26.23	97.42 \pm 7.73	43.71 \pm 5.67	14.90 (12.90 – 18.98)	98.45 \pm 27.27
	Female	98.27 \pm 7.83	44.01 \pm 5.95	13.10 (11.50 – 14.22)	90.02 \pm 24.01	98.27 \pm 7.43	43.09 \pm 5.16	13.30 (11.60 – 14.65)	92.11 \pm 22.99
Gupta S et al. ⁸ (in cm)	Male	8.9 \pm 0.9	4.7 \pm 0.8	1.8 \pm 0.4	76.5 \pm 30.1	9.1 \pm 0.9	4.7 \pm 0.6	1.8 \pm 0.3	80.7 \pm 26.0
	Female	8.9 \pm 1.1	4.3 \pm 0.9	1.8 \pm 0.3	69.2 \pm 28.1	8.9 \pm 0.9	4.2 \pm 0.7	1.9 \pm 0.3	63.9 \pm 25.1
Purohit K et al. ¹⁴ (in mm) (2017)	Male	94.866 \pm 13.777	–	–	–	98.181 \pm 14.052	–	–	–
	Female	94.009 \pm 9.757	–	–	–	96.611 \pm 10.026	–	–	–
Srivastava A et al. ²² (in mm)	Male	98.9 \pm 7.09	–	–	–	103.5 \pm 7.09	–	–	–
	Female	94.6 \pm 8.56	–	–	–	98.4 \pm 9.96	–	–	–

An important indicator for normal kidney function was kidney length which varied from 9 to 13.5 cm and was observed

smaller than normal probably due to small body size.[21] kidney length of 9 cm (90 mm) had been widely accepted as cut-off

reference value indicating irreversible renal diseases.[19] The present study was conducted among the normal individuals and average length of both right and left kidneys were more than 9 cm. The smaller length of kidneys observed in the study conducted by Gupta S et al. [8] might be due to relatively small body size in the study population.[16]

In the present study, the length of the right kidney in males was larger compared to left kidney, whereas, the length of both the kidneys was similar in females which might be compared with the study conducted by Gupta S et al. [8] The studies conducted by Purohit K et al. [14] and Srivastava A et al. [22] suggested that, in both males and females the length of the left kidney was larger than the right kidney. The relatively larger kidney length had been explained with the relative position of small spleen in left side and large liver in right side where the space for growth of left kidney was more compared to more space occupied by the liver during the growth and ascent of kidneys.[9]

The width of right kidney in both males and females were larger than the left kidney in our study. In contrary, the width of right and left kidneys in males were observed similar in the study conducted by Gupta S et al.[8] but in females right kidney width was larger than left kidney in female.[8]The cortical thickness of the right kidney was smaller in both males and females in our study which was found to be larger in the study conducted by Gupta S et al.[8] They have observed that, the cortical thickness of left kidney in females was larger than the left kidney cortical thickness in males. Whereas, in the present study, the opposite was observed in left kidney of males and females. Significant differences in cortical thickness of males and females were observed in both right and left kidneys.

In the present study, the volume of right and left kidneys in males was more

compared to females. Similar was observed in the study of Gupta S et al.[8] The shorter and straighter left renal artery than the right renal artery might cause increased blood flow to the left kidney resulting in relatively increased volume of left kidney.[9]

In males, the left kidney volume was more than the right kidney which was compared with the study of Gupta S et al.[8] They had observed that, in females, the right kidney volume was more than the left kidney which was not comparable with the present study, where the left kidney volume was more than the right kidney.

The study conducted by Purohit K et al.[14] had concluded that an increased length of kidneys was observed till the age of 30 years and thereafter, it remained stable beyond 30 years upto 50 years and then started decreasing which was not similar to the present study where an increase of kidney length was observed after 60 years of age.

It was observed that, all the dimensions of the right kidney except cortical thickness had increased with age till the middle of fourth decade (31 - 45 years), after that those had started to decline. In the left kidney, similar changes in dimensions were observed in width, AP diameter and volume. The length of the left kidney was increased similarly but a second increase in length was also observed above 60 years of age. These might be compared with the study conducted by Gupta S et al.[8] where, they had found that all the kidney dimensions increased with age till the fourth decade and started to decline thereafter.

It was important to have a set of standard sonographic measurements of kidney dimensions for appropriate comparison to recognize anatomical deviations in individuals with renal disease.[16]

Conclusion

The kidney dimensions were very closely related to age, gender and sides of kidney. The length, cortical thickness of right and left kidneys was similar. The length which was a sole significant dimension to detect the pathology or disease in kidneys had been found to be within normal range in both kidneys. Anteroposterior diameter was significantly higher in left kidney, whereas a statistically non-significant increase in left kidney volume was observed. The cortical thickness of both right and left kidneys had significant increase in males comparing to females. Age-related changes in the dimensions of right and left kidney were well observed among different age group. A statistically significant increase in cortical thickness was observed in right kidney with extreme age above 60 years.

So, the study had provided normal reference dimensions of the kidney in adult population of Tripura which would be useful in assessing the kidney for any pathological enlargement or reduction of size in clinical practice.

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