Ultrasound Assessment of Kidney Sizes in Different Age Groups without Renal Disease

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ABSTRACT

BACKGROUND

Ultrasound imaging is a lightweight, effective, non-invasive, and radiation-free imaging tool. It helps to diagnose and treat many renal disorders, as it is known that renal size is closely related to its function. Study was carried out among individuals who do not have renal disease to investigate the normal parameters of the renal size and cortical thickness by ultrasound and determine the normal curves for these parameters that can be compared with those of patients with renal disease.

METHODS

This was a prospective observational study carried out in the departments of nephrology and radiology. A total of 500 balanced normotensive, male and female volunteers, between the ages of 18 and 80 years, were enrolled in the study.

RESULTS

Body mass index, left length, left breadth, right cortical thickness, left cortical thickness and body surface area is statistically significant with respect to gender. There is a difference between the right length, breadth, and left breadth that is not statistically significant with respect to gender. Body mass index is negatively correlated with the right breadth and left cortical thickness. The right length is positively correlated with body mass index, left length, left breadth, and right cortical thickness. Further, it is negatively correlated with the right breadth, left breadth, and left cortical thickness. Right breadth is positively and significantly correlated with body mass index, left length, left breadth, and right cortical thickness. Further, it is correlates negatively with the right length and left cortical thickness.

CONCLUSIONS

Our study concludes that when the height and weight of the subject were correlated with renal volume and length in both sexes, there was an important positive relationship. This association between renal volume and the height and weight of the subject was relatively stronger.

KEYWORDS

Renal Disease, Ultrasound, Renal Length, Cortical Thickness

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BACKGROUND

When assessing patients with potential renal disease, measurement of renal size by ultrasound is important. However, the population being examined, it needs prior knowledge of the actual standard renal scale. Renal ultrasound is simple, inexpensive and can be performed at the bedside to give the clinician with low inter observer variability essential anatomical information of the kidneys.[1] It is also an essential procedure when performing a renal biopsy in adults or children,[2] with both renal length and cortical thickness being important parameters that should be within normal limits before the procedure.[3] The safety of the diagnostic procedure using ultrasound is well established. It is possible to measure renal size by sonography by measuring renal length, renal volume, cortical volume, or thickness. The most accurate of these is provided by the renal volume.[3] However, due to its low inter-observer variance and improved reproducibility, the renal length is the most clinically useful parameter, as measured in the longitudinal plane parallel to the longest renal axis. Renal length as well as the renal cortical thickness has been closely related to creatinine clearance in patients with chronic kidney disease.[4,5] Similarly, the medullary parenchymal thickness is essential for hydronephrosis grading, especially in the paediatric age group, and ultrasound remains the key basis for hydronephrosis diagnosis.

In animals, renal length and cortical thickness have been extensively studied and their parameters are well recorded. In humans, however, there have been only a few studies actually designed to measure these parameters in adults who do not have renal disease.[6] Unfortunately, in previous studies, some of the adults included had diseases such as diabetes and hypertension that could affect the kidneys.[7] In order to rule out glomerular structural anomalies, the majority have used serum creatinine alone as an indicator of normal renal function without testing for urinary sediments and daily urinary protein excretion. Serum creatinine is not an accurate estimate of kidney function and does not rule out the presence of renal disease even if it is within a normal range.[8,9] The objective of this study was to investigate the standard ultrasound parameters of renal size and cortical thickness in people without renal disease and to determine the normal curves for these parameters that can be compared in situations where the renal disease is at issue.

METHODS

This was a prospective observational study conducted in the Department of Nephrology and Radiology at Gandhi Medical College, Telangana. A total number of 500 healthy normotensive volunteers were enrolled in the study. Both male and female volunteers, between 18 to 80 years of age were included in the study. Students and employees of our institute and attendants of the patients admitted to the nephrology department as well as those attending the OPD were part of the study population. This research enrolled only those subjects who met the inclusion requirements. Patients with acute or chronic disease capable of causing damage to renal function, pregnant women, patients with established urinary calculus, renal cysts or prior history of renal surgery were excluded from the study.

The normal appearance of the kidneys by ultrasound was defined as the thickness of renal parenchyma > 1 cm and corticomedullary differentiation detectable by ultrasound. All the participants emptied their bladders prior to the examination, to avoid an increase in renal length caused by oral hydration.[8] Length (distance pole to pole), width (transverse axis), and cortical thickness, in millimeters, were the renal measurements measured, correlating closely with the renal volume. To enter the necessary data, a predesigned proforma was used. On a single ultrasound unit, all the ultrasounds were carried out by us and a standard procedure was followed to calculate the renal measurements. In order to achieve the highest precision of the dimensions, these measurements were then cross-checked by a single observer. Age, gender, height, weight, body mass index, and history of proven hypertension and diabetes mellitus are additional reported data. This research was accepted by the institutional ethics committee and written informed consent was obtained from all the participants.

RESULTS

Body mass index, left length, left breadth, right cortical thickness, left cortical thickness and body surface area is statistically significant with respect to gender. The difference among the right length, right breadth and left breadth are not statistically significant with respect to gender.

From the above table body mass index is positively correlated with right length, right breadth, left length and right cortical thickness. Body mass index is negatively correlated with right breadth and left cortical thickness. Right length is positively correlated with body mass index, left length, left breadth and right cortical thickness. Further it is negatively correlated with right breadth, left breadth and left cortical thickness. Right breadth is positively significantly correlated with body mass index, left length, left breadth and right cortical thickness. Further it is negatively correlated with right length and left cortical thickness.

Values of body mass index, right breadth, left breadth, right cortical thickness, and left cortical thickness values are significant (sig. Value are < 0.05), reject null hypotheses. It means difference among the body mass index, right breadth, left breadth, right cortical thickness, and left cortical thickness are statistically significant with respect to age group.

Gender	Body Mass Index	Right Length	Right Breadth	Right. Cortical Thickness	Left Length	Left Breadth	Left Cortical Thickness
Male	25.2 ± 3.9	10.11 ± 0.9	4.5 ± 0.5	13.6 ± 0.9	10.89 ± 0.4	4.6 ± 0.43	13.94 ± 2.4
Female	24.0 ± 3.2	10.143 ± 7.6	4.53 ± 0.43	12.63 ± 0.93	9.98 ± 0.76	4.59 ± 1.91	13.4 ± 2.3
Total	25.62 ± 3.7	9.9 ± 40	4.46 ± 0.44	13.8 ± 2.4	10.19 ± 0.9	4.51 ± 2.53	14.3 ± 0.4

Table 1. Comparison of Renal Dimensions in between Genders.

Gender		Body Mass Index	Right. Length	Right Breadth	Left. Length	Left Breadth	Right. Cortical Thickness	Left. Cortical Thickness
body mass index	Pearson Correlation	1	0.04	- 0.055	0.043	- 0.008	0.047	0.079
	Sig. (2-tailed)		0.476	0.326	0.433	0.885	0.402	0.154
Right. Length	Pearson Correlation	0.04	1	.201**	.699**	.167**	.469**	.373**
	Sig. (2-tailed)	0.476		0	0	0.002	0	0
Right Breadth	Pearson Correlation	- 0.055	.201**	1	0.082	.294**	.262**	.116*
	Sig. (2-tailed)	0.326	0		0.139	0	0	0.037
Left Length	Pearson Correlation	0.043	.699**	0.082	1	.172**	.388**	.402**
	Sig. (2-tailed)	0.433	0	0.139		0.002	0	0
Left Breadth	Pearson Correlation	- 0.008	.167**	.294**	.172**	1	0.061	.182**
	Sig. (2-tailed)	0.885	0.002	0	0.002		0.272	0.001
Right. Cortical Thickness	Pearson Correlation	0.047	.469**	.262**	.388**	0.061	1	.693**
	Sig. (2-tailed)	0.402	0	0	0	0.272		0
Left. Cortical Thickness	Pearson Correlation	0.079	.373**	.116*	.402**	.182**	.693**	1
	Sig. (2-tailed)	0.154	0	0.037	0	0.001	0	
body mass index	Sig. (2-tailed)		0.733	0.846	0.858	0.088	0.442	0.231
Right. Length	Pearson Correlation	0.026	1	- 0.051	0.03	- 0.068	0.012	- 0.006
	Sig. (2-tailed)	0.733		0.508	0.692	0.379	0.876	0.934
Right Breadth	Pearson Correlation	0.015	- 0.051	1	0.083	.221**	.213**	- 0.024
	Sig. (2-tailed)	0.846	0.508		0.278	0.004	0.005	0.759
Left. Length	Pearson Correlation	0.014	0.03	0.083	1	- 0.019	.295**	.359**
	Sig. (2-tailed)	0.858	0.692	0.278		0.809	0	0
Left Breadth	Pearson Correlation	- 0.131	- 0.068	.221**	- 0.019	1	- 0.013	0.054
	Sig. (2-tailed)	0.088	0.379	0.004	0.809		0.866	0.481
Right. Cortical Thickness	Pearson Correlation	0.059	0.012	.213**	.295**	- 0.013	1	.585**
	Sig. (2-tailed)	0.442	0.876	0.005	0	0.866		0
Left. Cortical Thickness	Pearson Correlation	- 0.092	- 0.006	- 0.024	.359**	0.054	.585**	1
	Sig. (2-tailed)	0.231	0.934	0.759	0	0.481	0	

Table 2. Correlation of Gender with Variable

		N	Mean	Std. Deviation	Std. Error	95 % Confidence Interval for Mean LB	UB	Min	Max
Body Mass Index	< 30 yrs.	89	23.9854	3.01094	.31916	23.3511	24.6197	18.14	32.34
	30 - 60 yrs.	257	24.9096	3.88790	.24252	24.4320	25.3872	17.31	42.53
	> 60 yrs.	153	25.1609	3.95196	.31950	24.5297	25.7921	17.63	37.95
	Total	**499**	**24.8218**	**3.78201**	**.16931**	**24.4892**	**25.1545**	**17.31**	**42.53**
Analysis of Variance									
				Sum of Squares		**Df**	**Mean Square**	**F**	**Sig.**
Body Mass Index	Between Groups			81.839		2	40.919	2.882	.057
	Within Groups			7041.354		496	14.196		
	Total			**7123.193**		**498**			

Table 3. Correlation of Age Groups with body mass index

DISCUSSION

We evaluated renal size in the present study in terms of length, width, and thickness, which are plain, reproducible, accurate, and objective measurements. In the present study, the right mean renal length is 9.9 ± 40 and the left renal length is 10.19 ± 0.978 and is correlating with body mass index. This was similar to the previous studies showing left side kidney length is greater than right-sided kidney length. Due to the size of the spleen, which is smaller than the liver, one potential reason is that the left kidney has more space to expand. Another potential reason is that the left renal artery is narrower and straighter than the right one because of the left renal artery; this creates increased blood flow through the left artery that can result in the volume being relatively increased. Body mass index is positively correlated with right length, left length, right cortical thickness, and left cortical thickness in both the gender. Based on the Pearson correlation coefficient and analysis of variance (ANOVA), there is a correlation of right renal length and left renal length, with respect to gender, the sizes are more in male gender than female gender. Left volume, left breadth, right cortical thickness, left cortical thickness and body surface area are significant (sig. Value is < 0.05) based on t-test values of body mass index, reject the null hypothesis. This means that with respect to gender, the difference between body mass index, left length, left breadth, right cortical thickness, left cortical thickness and body surface area is statistically important.

In the present study, the differences in right and left renal length are not statistically significant with respect to the age group but are significant with respect to gender, and further they correlated with body mass index. Further, the present study shows that the mean length of kidneys in females is relatively smaller than the males. When compared with other studies done in Malaysia the mean length of kidneys in the present study is smaller, showing the difference of kidney sizes with ethnicity. Adeela Arooj, et al.[10] studies done in the Malaysian population, the research analysed 200 kidney samples from the average adult Malaysian population after taking ultrasonic photos.

Authors	Ethicity	N		Length (cm)			Width (cm)			Thickness (cm)		
				All	Male	Female	All	Male	Female			
Emamian et al.[11]	Danish	665	L	11.2								
			R	10.9								
J Oyuela-Carrasco et al.[12]	Mexican	153	L	10.5	10.7	10.4						
			R	10.4	10.5	10.2						
Okoye IJ et al.[13]	Nigerian	200	L	10.6								
			R	10.3								
D.Shani et al.[14]	Northwest Indian		L	10	9.97	9.21	4.6	4.64	4.35	3.4	3.4	3.11
			R	9.9	9.95	9.13	4.6	4.58	4.46	3.3	3.33	3.12
Buchholz NP[15]	Pakistani	194	L &R	10.4			4.6					
Barton EN et al.[16]	Jamaican	49	L	10								
			R	9.7								
Mc Minn[17]	Caucasians			12			6			3		
Williams et al.[18]	Caucasians				11			6			3	
Tanaka et al.[19]	japanese		L		11.5	11.4		5.7	5.2		3.5	3.1
			R		11.3	11.2		5.5	5.2		3.2	3
K.Y. Kang et al.[20]	Korean	125		11.1			6.2			4.73		
Present Study	Indian	499	L	10.19	10.89	9.98	4.51	4.6	4.59	14.3	13.9	13.4
			R	9.9	10.11	10.14	4.46	4.5	4.53	13.8	13.6	12.63

Table 4. Comparison of Renal Length and Breadth with Other Studies

The renal parameters examined were length, width, thickness, and volume, plotted against the height, weight, and gender of the respondent. The findings show that among different ethnicities, the kidney size for comparable weight and height differs. Renal dimensions of right kidney area (cm^3), where kidney sizes are larger than the population in the present study. This shows that renal dimensions differ with ethnicity and this has to be taken into consideration during the diagnosis of renal disease.

In the above table, the study done by D. Sahni et al.[14] done in Indian scenario shows that kidney sizes are smaller when compared to the western population. In the present study, the mean kidney sizes are 10.1 x 4.5 and 9.89 x 4.53 the renal lengths are lesser than the Japanese, Korean and Danish population and are correlated with other Indian studies.

Sandeep Gupta et al.[21] study done in north east India, in the males, the mean right kidney length was 8.9 ± 0.9 cms and the mean left kidney length was 9.1 ± 0.9 cms while in females, the mean right kidney length was 8.9 ± 1.1 cms and the mean left kidney length was 8.8 ± 0.9 cms.

Prakash Muthusami et al.[22] study done at JIPMER in 2012, has stressed the need for the development of nomograms for kidney sizes in the Indian population. Correlations between renal length and body indices, namely height, weight, body surface area and body mass index, were individually tested using the Pearson coefficient of correlation, which revealed a moderate positive correlation between renal length and body weight (r = 0.33 for right kidney and r = 0.31 for left kidney) and body surface area (r = 0.35 for right kidney and r = 0.33 for left kidney), while there was a weak positive correlation with body height (r = 0.19 for both right and left kidneys) and body mass index (r = 0.23 for right kidney and r = 0.21 for left kidney). The following equations for determining renal length from anthropometric parameters were provided by multiple regression performed on these results.

Right renal length (cm) = 6.44 + 1.13 height + 0.03 weight, left renal length (cm) = 6.94 + 1.01 height + 0.02 weight, Where there is weight in kilograms and height in meters. But this study was done in 300 volunteers the sample size is less. Much of the similarities focus on the shortness of renal length in the Indian population when considering the comparisons that have been made between many populations. The physical size of Asia itself may clarify this. A study was done by Mario et al.[23] in 2002 and another study conducted in Pakistan illustrates the need to examine renal measurements for each population, reinforcing the fact that data from European and American populations should not be seen as standardized patterns, as Westerners are considered to be larger and larger compared to other ethnic groups such as Asians. It has been a fact that along with the body, our organs grow. There is no question that the size of an organ is closely related to the size of the body.

On the other side of the matter, O. Bircan et. al.[24] who had conducted a similar study, found that the Hudson equation could not accurately estimate the length of the kidneys of the Turkish population. The study strongly stressed that there should be no use of European data in their clinics. In addition, the study also pointed out that the lack of renal length in their population could offer the clinician an incorrect understanding as the pathological conditions had a significant impact on the size of the kidney. It is shown that the norm based on Caucasian data is no longer appropriate for universal indication. Therefore further research should be carried out on this issue for each particular group so that, depending on each individual ethnic race, more detailed references can be made in the near future. In the course of constructing and improving the normal renal standard or nomogram there are a few things that should be taken into account.

First of all, in order to detect clinically relevant results, the sample size must be large enough. If the sample size is too small, a false-negative finding is likely to be high. However, an over-large sample analysis should not be undertaken as it seems immoral to include unnecessary additional subjects and correspondingly higher costs.

Next, the research subjects should live in India for at least 10 years and above. This is closely related not only to genetic differences but also to the regional diversity of humans. In one population, the climate, nutrition, and dietary intake may influence the growth rates of one population. The rate of growth coincides with an individual's weight and height. The molecular biologist claimed that the main explanation for such diversity in height heritability is the distinct genetic history of ethnic groups and the diverse environments (climates, dietary habits and lifestyle) they encounter.

CONCLUSIONS

Our study concludes that when the height and weight of the subject were correlated with renal volume and length in both sexes, there was an important positive relationship. This association between renal volume and the height and weight of the subject was relatively stronger. Renal size has been compared between various ethnicities in this study. The research is performed with ultrasound within our population and compared to other studies. The outcome shows that the renal size differs among various ethnicities.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
Financial or other competing interests: None.
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REFERENCES

[1] Noble VE, Brown DF. Renal ultrasound. Emerg Med Clin North Am 2004;22(3):641-659.
[2] Sheikh M, Al-Essa A, Francis IP. Ultrasound guided core biopsy of the kidneys in infants and children: Kuwait experience. Med Princ Pract 1999;8:213-216.
[3] Agrawal PK, Rai HS, Amitabh V. Ultrasound guided percutaneous renal biopsy. J Indian Med Assoc 1993;91:231-232.
[4] Jerassi R, Krusteva R, Kiperova B. Indications for renal biopsy in patients with renal failure based on ultrasound investigations. Int Urol Nephrol 1991;23(4):393-397.
[5] Sanusi AA, Arogundade FA, Famurewa OC, et al. Relationship of ultrasonographically determined kidney volume with measured GFR, calculated creatinine clearance and other parameters in chronic kidney disease (CKD). Nephrology Dialysis Transplantation 2009;24(5):1690-1694.
[6] Webb JA. Ultrasonography in the diagnosis of renal obstruction. BMJ 1990;301(6758):944-946.
[7] Sienz M, Ignee A, Dietrich CF. Sonography today: reference values in abdominal ultrasound: aorta, inferior vena cava, kidneys. Z Gastroenterol 2012;50(3):293-315.
[8] Barton EN, West WM, Sargeant LA, et al. A sonographic study of kidney dimensions in a sample of healthy Jamaicans. West Indian Med J 2000;49(2):154-162.
[9] Okoye IJ, Agwu KK, Eze CU. Relationship between sonographic renal length and renal parenchymal thickness in normal adult southeast Nigerians. West Afr J Med 2006;25(3):231-234.
[10] Arooj AA, Supriyanto E, Yeoh J. Comparison of renal size among different ethnicities. International Journal of Biology and Biomedical Engineering 2011:5.
[11] Emamian SA, Nielsen MB, Pedersen JF, et al. Kidney dimensions at sonography: correlation with age, sex and habitus in 665 adult volunteers. AJR Am J Roenthenol 1993;160(1):83-86.
[12] Oyuela-Carrasco J, Rodriguez-Castellanos F, Kimura E, et al. Renal length by ultrasound in Mexican adults. Nefrologia 2009;29(1):30-34.
[13] Okoye IJ, Aqwu KK, Indigo FU. Normal sonographic renal length in adult southeast Nigerians. Afr J Med Med Sci 2005;34(2):129-131.
[14] Shani D, Jit I, Sodhi L. Weight and measurements of kidneys in Northwest Indian adults. American Journal of Human Biology 2001;13(6):726-732.
[15] Buchholz NP, Abbas F, Biyabani SR, et al. Ultrasonographic renal size in individuals without known renal disease. J Pak Med Assoc 2000;50(1):12-16.
[16] Barton EN, West WM, Sargeant LA, et al. A sonographic study of kidney dimensions in a sample of healthy Jamaicans. West Indian Med J 2000;49(2):154-157.
[17] McMinn RMH. Last's anatomy, regional and applied. 9th edn. Edinburgh: Churchill Livingstone 1994.
[18] Williams PL, Bannister LH, Berry MM, et al. Gray's anatomy: the anatomical basis of medicine and surgery. 38th edn. New York: Churchill Livingstone 1995.
[19] Tanaka G, Nakahara Y, Nakazima Y. Japanese reference man 1988 – 1V. Studies on the weight and size of internal organs of normal Japanese. Nihon Igaku Hoshasen Gakkai Zasshi 1989;49(3):344-364.
[20] Kang KY, Lee YJ, Park SC., et al. A comparative study of methods of estimating kidney length in kidney transplantation donors. Nephrol Dial transplant 2007;22(8):2322-2327.
[21] Sandeep G, Damayanti DN, Sekharjit SS, et al. Ultrasonographic renal dimensions in normal adult population of North-East India. Int J Med Health Sci 2013;2(4):433-437.
[22] Muthusami P, Ananthakrishnan R, Santosh P. Need for a nomogram of renal sizes in the Indian population– findings from a single centre sonographic study. Indian J Med Res 2014;139(5):686-693.
[23] Fernandes MMR, Lemos CCS, Guilherme LS, et al. Normal renal dimensions in a specific population. Int Braz J Urol 2002;28(6):510-515.
[24] Bircan O, Öner G, Saka O, et al. The estimation of kidney sizes in Turkish population. Med J Islamic World Acad Sci 1993;6(3):197-201.