Original Research Article

Ultrasound assessment of kidney size and its correlation with body mass index in healthy volunteers without renal disease

Nazma[1], Manjusha Yadla[2], Muzamil Latief[3*]

[1]Department of Nephrology, GMC, Secunderabad, Hyderabad, Telangana, India
[2]Professor and Head, Department of Nephrology GMC Secunderabad, Hyderabad, Telangana, India
[3]Department of Nephrology, GMC Secunderabad Hyderabad, Telangana, India

Received: 22-01-2021 / Revised: 20-03-2021 / Accepted: 27-04-2021

Abstract

Introduction:Renal length as well as renal cortical thickness has been closely related to creatinine clearance in patients with chronic kidney disease. Our primary aim was to establish a normal range of values for kidney length in our adult population with normal renal function.**Materials and Methods**:This was a prospective observational study. Ultrasonographic assessment of renal parameters in 499 healthy volunteers between 18 to 80 years of age was done. Volunteers with any known renal condition or any comorbidity were excluded from the study population. Correlation between BMI and renal parameters was assessed. **Results:**Out of 499 volunteers 327 (65%) were males and 172(35%) were females. 17.8% volunteers were less than 30 years of age, 51.5% volunteers were in the age group of 30-60 years and 30.7 % were above 60 years of age. Mean Body mass index (BMI) in males was 25.20 +/- 3.96 whereas mean BMI in females was 24.08+/- 3.28. In males the mean cortical thickness in Right kidney was 13.68+/- 2.47 mm and in left kidney CT was 13.94+/- 2.6 mm. In females right kidney cortical thickness was 12.63+/- 1.91 mm and left kidney CT was 13.40+/-2.37 mm. In the present study the right mean renal length was 9.9± 40cm and left renal length was 10.19±0.97cm.**Discussion**:In the present study, we analyzed renal size in terms of length, breadth, and cortical thickness which are simple, reproducible, reliable and objective measurements. Our finding that left side kidney length is greater than right sided kidney length is similar to the previous studies showing left side kidney length is greater than right sided kidney length. We observed positive correlation BMIwith renal length.**Conclusion:** Size of kidney has significant ethnic and geographic basis and there is a positive correlation between BMI and kidney size in our study population.

Keywords: Renal length, BMI, Ultrasonography.

Introduction

Measurement of renal size by ultrasound is essential when evaluating patients with possible renal disease. However, it requires prior knowledge of actual normal renal size in the population being studied. Renal ultrasound is simple, inexpensive and can be done at the bedside to provide the clinician with important anatomical details of the kidneys with a low inter-observer variability[1-3]. It is also an essential procedure when performing renal biopsy in adults or children.[4,5] Both renal length and cortical thickness are important parameters that should be within normal limits before the procedure.[6] The safety of the diagnostic procedure using ultrasound is well established.[7] Estimation of renal size by sonography can be performed by measuring renal length, renal volume, cortical volume or thickness. The most accurate of these is provided by the renal volume.[6,7] Due to its low inter-observer variation and better reproducibility, renal length; as measured in the longitudinal plane parallel to the longest renal axis, is the most clinically useful parameter.[6] Renal length as well as renal cortical thickness has been closely related to creatinine clearance in patients with chronic kidney disease.[8] Similarly, medullary parenchymal thickness is important for grading hydronephrosis especially in the pediatric age group and ultrasound remains the mainstay for diagnosis of hydronephrosis.Renal length and cortical thickness have been studied extensively in animals and their parameters are well documented [8, 9]. In humans, however, there have been only a few studies actually designed to measure these parameters in adults who do not have renal disease.[10, 11] Unfortunately, in previous studies, some of the adults included had diseases such as diabetes and hypertension that could affect the kidney size.[12] Others studies also used serum creatinine alone as a measure of normal renal function without checking for urinary sediments and daily urinary protein excretion to rule out glomerular or structural abnormalities [11,12]. 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.[11,13]Renal size can be determined by measuring renal length, renal volume and cortical volume or thickness. Renal length and volume measurements are clinically relevant, serving as surrogates for renal functional reserve, and are used frequently as the basis for making clinical decisions. Serial measurements can also provide information regarding disease progression or stability.[14] Kidney length correlates best with body height in both adults and children[10,12,14]and, after correctionfor body height, does not vary between sexes. Kidney length rapidly increases during the first year of life with a moregradual enlargement up to about 18 years.[14,15]Progressive enlargement occurs during pregnancy that resolvesby 12 weeks postpartum, due primarily to parenchymal enlargement although some pelvicalyceal enlargement too occurs, particularly in the right kidney.[16] Proper interpretationof kidney

**Correspondence*
Dr. Muzamil Latief
Department of Nephrology, GMC, Secunderabad, Hyderabad, Telangana, India.
E-mail: muzamillatief.b@gmail.com

size must take into account the effect of these nonpathologic factors. Compensatory hypertrophy iscommon in solitary kidneys in children [80%or above increase in volume] and after.In subjects with normal renal function, an important measurement of renal size is longitudinal length, however, the renal parenchymal volume is the more exact Ultrasound parameter in end-stage renal failure.[13]Renal volume is correlated with subject's height [ht],weight [wt] and total body area, but it is not a precise method due to high inter-observer variations.[5]The presence of close relationship between kidney sizes and functions has stimulated the research related to renal sizes for different ethnic groups and body sizes, which are known to be helpful in diagnosis of kidney disease. In this study we aimed to help establish standardised data of normal renal dimensions in our population and study correlation of renal size with body mass index [BMI].

Materials and methods

In this prospective observational study a total number of 499 healthy normotensive [defined as systolic blood pressure < 140mmHg and diastolic blood pressure < 80 mmHg] volunteers, both male and female, between 18 to 80 years of age, were included . Volunteers with known urinary calculi, renal cysts or having a past history of renal surgeries, volunteers with existence of acute or chronic disease capable of causing damage to renal function, pregnant females were excluded from the study. The study population included students, staff at our institute and attendants of the patients admitted in the Nephrology department as well as those attending the outpatient services. Those subjects who fulfilled the inclusion criteria and consented for the study were enrolled.Normal appearance of the kidneys by ultrasound was defined as thickness of renal parenchyma > 1cm and coticomedullary differentiation detectable by ultrasound. All the participants emptied their bladders prior to the examination. The renal dimensions measured included length [distance pole to pole], width [transversal axis] and cortical thickness, in millimeters[mm], which correlates closely to the renal volume. A predesigned proforma was used to enter the required data. All the ultrasounds were performed by us on a single ultrasound machine and a standard protocol was followed to measure the renal dimensions. These measurements were then cross checked by a single observer to obtain the maximum accuracy of the dimensions. Additional data recorded include age, gender, height, weight, BMI and history of established hypertension and diabetes mellitus. The Institutional ethics committee approved this study and written informed consents were obtained from all the participants.

Observations and results

Out of 499 volunteers 327 [65%] were males and 172[35%] were females. Most of the volunteers [51.5%] volunteers were in the age group of 30-60 years. The mean BMI[kg/m^2] in males was 25.20 +/- 3.96 whereas mean BMI[kg/m^2] in females was 24.08+/- 3.28. In males the mean cortical thickness in Right kidney was 13.68+/- 2.47 mm and in left kidney CT was 13.94+/- 2.6 mm. In females right kidney cortical thickness was 12.63+/- 1.91 mm and left kidney CT was 13.40+/-2.37 mm. In the present study the right mean renal length was 9.9± 40 and left renal length was 10.19±0.978 and had correlation with BMI. [Table 1 & 2 and figure 1]]

Table 1: Gender wise Renal parameters

Parameter	GENDER	N	Mean	Std. Deviation	Std. Error Mean	Variance
BMI[kg/m^2]	Male	327	25.2091	3.96835	.21945	15.748
	Female	172	24.0855	3.28660	.25060	10.802
RT LENGTH [cm]	Male	327	10.11	.953	.053	.909
	Female	172	10.43	7.617	.581	.580
RT BREADTH [cm]	Male	326	4.54	.446	.025	.199
	Female	172	4.53	.434	.033	.188
LT LENGTH [cm]	Male	327	10.187	.9943	.0550	.989
	Female	172	9.987	.9371	.0715	.878
LT BREADTH [cm]	Male	326	4.61	.402	.022	.162
	Female	171	4.59	.769	.059	.592
RIGHT CORTICAL THICKNESS[mm]	Male	327	13.66	2.474	.137	6.122
	Female	172	12.63	1.917	.146	3.674
LEFT CORTICAL THICKNESS[mm]	Male	326	13.94	2.607	.144	6.797
	Female	172	13.40	2.371	.181	5.622
BSA[m^2]	Male	327	1.57072	.109805	.006072	.012
	Female	172	1.53314	.106106	.008091	.011

Table 2: Age group wise Renal parameters

AGE GROUP		N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
< 30 yrs	HEIGHT	89	51	129	180	154.03	9.514	90.510
	WEIGH	89	32	39	71	56.64	6.423	41.256
	BMI	89	14.20	18.14	32.34	23.9854	3.01094	9.066
	RT LENGTH	89	5	8	13	9.85	.804	.646
	RT BREATH	89	5	1	6	4.53	.612	.374
	LT LENGTH	89	4.3	8.0	12.3	9.939	.8742	.764
	LT BREATH	89	2	4	6	4.69	.431	.186
	Right Cortical Thickness	89	8	10	18	12.54	2.012	4.047
	Left Cortical Thickness	89	10	10	20	12.97	2.323	5.397
	BSA	89	.631	1.220	1.851	1.53606	.121552	.015
30-60 yrs	Height	257	51	132	183	154.26	9.529	90.793
	Weight	257	38	43	81	58.62	6.336	40.150
	BMI	257	25.22	17.31	42.53	24.9096	3.88790	15.116

	RT LENGTH	257	102	7	109	10.54	6.247	39.028
	RT BREATH	257	2	4	6	4.58	.410	.168
	LT LENGTH	257	5.5	7.5	13.0	10.202	.9799	.960
	LT BREATH	256	10	3	13	4.65	.680	.462
	Right Cortical Thickness	257	12	10	22	13.47	2.540	6.453
	Left Cortical Thickness	257	12	9	21	13.90	2.745	7.533
	BSA	257	.739	1.281	2.020	1.55784	.108850	.012
> 60 yrs	HEIGHT	153	41	135	176	154.32	9.118	83.140
	WEIGH	153	37	45	82	59.34	6.502	42.278
	BMI	153	20.32	17.63	37.95	25.1609	3.95196	15.618
	RT LENGTH	153	4	8	12	9.88	.902	.814
	RT BREATH	152	2	4	6	4.46	.361	.130
	LT LENGTH	153	5.9	7.5	13.4	10.082	1.0230	1.047
	LT BREATH	152	2	4	6	4.48	.323	.104
	Right Cortical Thickness	153	10	10	20	13.47	2.103	4.422
	Left Cortical Thickness	152	10	10	20	13.97	2.202	4.847
	BSA	153	.460	1.320	1.780	1.57026	.103102	.011

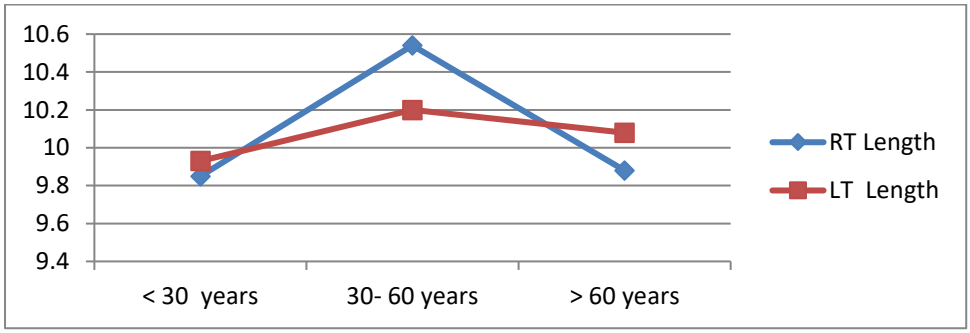

Fig 1: Showing the Comparison between right and left renal length in different age groups

As shown in table 3, BMI is positively correlated with right length, left length, right cortical thickness and left cortical thickness in males where as BMI is positively correlated with right length, right breadth, left length and right cortical thickness in females.

Table 3: Correlation of BMI with Renal parameters

			BMI	RT LENGTH	RT BREATH	LT LENGTH	LT BREATH	RIGHT CORTICAL THICKNESS	LEFT CORTICAL THICKNESS
Male	BMI	Pearson Correlation	1	.040	-.055	.043	-.008	.047	.079
		Sig. [2-tailed]		.476	.326	.433	.885	.402	.154
		N	327	327	326	327	326	327	326
Female	BMI	Pearson Correlation	1	.026	.015	.014	-.131	.059	-.092
		Sig. [2-tailed]		.733	.846	.858	.088	.442	.231
		N	172	172	172	172	171	172	172

Discussion

In the present study, we analyzed renal size in terms of length, breadth, and cortical thickness which are simple, reproducible, reliable and objective measurements. We found that the right mean renal length was 9.9±40cm and left renal length was 10.19±0.97cm and there was a positive correlation with BMI. Our finding that left side kidney length is greater than right sided kidney length is similar to the previous studies showing left side kidney length is greater than right sided kidney length. [12,21,]One possible explanationis, due to the size of spleen which is smaller than the liver, thus the left kidney has more space for its growth. Another possible explanation is that because of the left renal artery is shorterand straighter than the right one; this causes increased blood flow in the left artery which may result in relatively increased in volume.BMI is positively correlated with right length, left length, right cortical thickness and left cortical thickness in both the gender. In the present study ,the differences in right and left renal length are not statistically significant with respect to age group ,but are significant with respect to gender,and further they correlated with BMI.When compared with other studies like the one done in Malaysia by Adeela Arooj et al, the mean length of kidneys in the present study was smaller,implying difference of kidney sizes with ethnicity.[22]As the renal dimensions differ with ethnicity and this must be taken into consideration during diagnosis

of renal disease. In a study from India based on medicolegal autopsies by D. Sahnietal that included 155 males and 84 females the renal lengths were almost similar to our findings. [23] As seen in our study and also corroborated by other Indian studies the renal lengths in our study population are lesser than Japanese, Korean and Danish population.[21,23-26]PrakashMuthusami etal in their study including 140 patients stressed up on the need for development of nomograms for kidney sizes in Indian population.Correlations between renal lengths and body indices namely height, weight, BSA and BMI, were individually assessed using Pearson's correlation coefficient, which showed a moderate positive correlation of renal length with body weight [r = 0.33 for right kidney and r = 0.31 for left kidney] and BSA [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 BMI [r = 0.23 for right kidney and r = 0.21 for left kidney]. [27] In our study we found a positive correlation of BMI with renal length. Similar findings were observed in another study from Asia where in they observed the Right and left renal length 101.6 +/- 8.9 mm and 102.7 +/- 9.2 mm, respectively. Further they observed that Renal length and volume have a direct relationship with body mass index. [28] The environment, nutrition and diet intake of one population may affect the growth rates of one population. The growth rate corresponds with the weight and height of an individual and different genetic background of ethnic groups and the distinct environments [climates, dietary habits and lifestyle] they experience are the main reason for such diversities in height heritability.A significant body of evidence [Table 4] has accumulated suggesting that the renal dimensions from European and American population data cannot be used as reference standard for defining the normal limits across different ethnicities.[12,21,23,24,26-28]

Table 4: Comparison of renal parameters in different studies with our study

STUDY	ETHNICITY	N	SIDE	LENGTH[cm]			WIDTH[cm]		
				ALL	M	F	ALL	M	F
CURRENT STUDY	INDIAN	499	L	10.19	10.89	9.98	4.51	4.6	4.59
			R	9.9	10.11	10.14	4.46	4.5	4.53
J Oyuela - Carrasco et al[26]	MEXICAN	153	L	10.5	10.7	10.4	-	-	-
			R	10.4	10.5	10.2	-	-	-
D Sahni et al[23]	INDIAN	239	L		9.97	9.21	4.6	4.64	4.35
			R		9.95	9.13	4.6	4.58	4.46
Tanaka et al[24]	JAPANESE		L		11.5	11.4	-	5.7	5.2
			R		11.3	11.2	-	5.5	5.2
Emamian et al[21]	DANISH	665	L	11.2	-	-	-	-	-
			R	10.9	-	-	-	-	-
Okoye IJ et al[12]	NIGERIAN	309	L	10.4	-	-	-	-	-
			R	10.3	-	-	-	-	-

Therefore, more studies on this issue should be conducted for each different population so that, in the future there will be more accurate reference depending on each particular ethnic race.

References

1. Noble VE, Brown DF. Renal ultrasound. Emerg Med Clin North Am. 2004 Aug;22(3):641-59.
2. Rosenberg ER. Ultrasonographic evaluation of the kidney. Crit Rev Diagn Imaging. 1982 Apr;17(4):239-76.
3. Emamian SA, Nielsen MB, Pedersen JF. Intraobserver and interobserver variations in sonographic measurements of kidney size in adult volunteers. A comparison of linear measurements and volumetric estimates. Acta Radiol. 1995 Jul;36(4):399-401.
4. 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.
5. Agrawal PK, Rai HS, Amitabh V. Ultrasound guided percutaneous renal biopsy. J Indian Med Assoc. 1993 Sep;91(9):231-2.
6. 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):393-7. doi: 10.1007/BF02549612
7. Hergesell O, Felten H, Andrassy K, Kühn K, Ritz E. Safety of ultrasound-guided percutaneous renal biopsy-retrospective analysis of 1090 consecutive cases. Nephrol Dial Transplant. 1998 Apr;13(4):975-7. doi: 10.1093/ndt/13.4.975.
8. Sanusi AA, Arogundade FA, Famurewa OC, Akintomide AO, Soyinka FO, et al Relationship of ultrasonographically determined kidney volume with measured GFR, calculated creatinine clearance and other parameters in chronic kidney disease (CKD). Nephrol Dial Transplant. 2009 May; 24(5):1690-4.
9. Webb JA. Ultrasonography in the diagnosis of renal obstruction. *BMJ*. 1990;301(6758):944-946.
10. Sienz M, Ignee A, Dietrich CF. (Sonography today: reference values in abdominal ultrasound: aorta, inferior vena cava, kidneys). Zeitschrift fur Gastroenterologie. 2012 Mar; 50(3): 293-315.
11. Barton EN, West WM, Sargeant LA, Lindo JF, Iheonunekwu NC. A sonographic study of kidney dimensions in a sample of healthy Jamaicans. West Indian Med J. 2000 Jun;49(2):154-7.
12. 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 Jul-Sep; 25(3):231-4. doi: 10.4314/wajm.v25i3.28284.
13. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. Nephron. 1976;16(1):31-41.
14. Cheong B, Muthupillai R, Rubin MF, Flamm SD. Normal values for renal length and volume as measured by magnetic resonance imaging. Clin J Am Soc Nephrol. 2007 Jan;2(1):38-45.
15. Mazzotta L, Sarteschi LM, Carlini A, Antonelli A (Comparison of renal ultrasonographic and functional biometry in healthy patients and in patients with chronic renal failure). Arch Ital Urol Androl. 2002 Dec;74(4):206-9.
16. Miletić D, Fuckar Z, Sustić A, Mozetic V, Stimac D, Zauhar G. Sonographic measurement of absolute and relative renal length in adults. J Clin Ultrasound. 1998 May;26(4):185-9.
17. Brandt TD, Neiman HL, Dragowski MJ, Bulawa W, Claykamp G. Ultrasound assessment of normal renal dimensions. J Ultrasound Med. 1982 Mar;1(2):49-52.

18. Marchal G, Verbeken E, Oyen R, Moerman F, Baert AL, Lauweryns J. Ultrasound of the normal kidney: a sonographic, anatomic and histologic correlation. Ultrasound Med Biol. 1986 Dec;12(12):999-1009.
19. Patriquin H, Lefaivre JF, Lafortune M, Russo P, Boisvert J. Fetal lobation. An anatomo-ultrasonographic correlation. J Ultrasound Med. 1990 Apr;9(4):191-7.
20. Troell S, Berg U, Johansson B, Wikstad I. Comparison between renal parenchymal sonographic volume, renal parenchymal urographic area, glomerular filtration rate and renal plasma flow in children. Scand J Urol Nephrol. 1988;22(3):207-14.
21. Emamian SA, Nielsen MB, Pedersen JF, Ytte L. Kidney dimensions at sonography: correlation with age, sex, and habitus in 665 adult volunteers. AJR Am J Roentgenol. 1993 Jan;160(1):83-6.
22. Arooj A, Lam J, Wui YJ, Supriyanto E. Comparison of renal size among different ethnicities. IntJ Biol Biomed Eng. 2011;5:221-9.
23. D. Sahni, I. Jit, L. Sodhi, Weight and Measurements of kidneys in Northwest Indian adults. American Journal of Human Biology 2001; 13:726-732.
24. Tanaka G, Nakahara Y, Nakazima Y. 1989. Japanese Reference Man 1988 – 1V studies on the weight and size of internal organs of normal Japanese. Nippon Acta Radiol 49 :344-364.
25. Kang KY, Lee YJ, Park SC, Yang CW, Kim YS, Moon IS, Koh YB, Bang BK, Choi BS. A comparative study of methods of estimating kidney length in kidney transplantation donors. Nephrol Dial Transplant. 2007 Aug; 22(8):2322-7.
26. Oyuela,C.J., Rodriguez,C.F., Kimura, E., Delgadu, R.E. and Herrera-Felix, J.P. Renal length by ultrasound in Mexican adults. Nefrologia; 2009;29: 30-4.
27. 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.
28. Raza M, Hameed A, Khan MI. Ultrasonographic assessment of renal size and its correlation with body mass index in adults without known renal disease. J Ayub Med Coll Abbottabad. 2011 Jul-Sep;23(3):64-8.

Conflict of Interest: Nil
Source of support:Nil