



MULTI-DETECTOR COMPUTED TOMOGRAPHIC EVALUATION OF NORMAL RENAL SIZE IN NEPALESE ADULTS

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ABSTRACT

Background: Status of the renal size plays the pivotal role in making diagnosis, deciding the management strategy and prognostication of various nephropathies. This study was conducted to measure the normal renal size in Nepalese adults by computed tomography and determine its variation in relation to age, sex, side, body weight, height and body mass index. **Methods:** Renal dimensions were measured on 330 adults undergoing CT scan of abdomen for non-kidney pathology. Mean renal dimensions in male & female and right & left side were compared. The mean kidney dimensions in <60 years and ≥60 years age group were also compared. Renal dimensions were correlated with body weight, height and BMI. **Results:** The mean renal length, width and thickness were 100.33±9.31mm, 53.06±5.60mm and 44.55±4.63mm on right side and 102.84±9.52mm, 54.61±5.71mm and 47.89±5.50mm on left side respectively. There was decline in the size of the kidney after 60 years of age. All three dimensions of kidneys were smaller in ≥60-year age group as compared to those in <60-year age group and the differences in all these dimensions (except right renal thickness) were statistically significant. The mean kidney dimensions were significantly larger in males than in females. Left renal size was significantly larger than right in both genders. The mean renal length, width and thickness showed a positive relationship with body weight, height and body mass index. **Conclusion:** The mean renal length, width and thickness were 100.33±9.31mm, 53.06±5.60mm and 44.55±4.63mm on right side and 102.84±9.52mm, 54.61±5.71mm and 47.89±5.50mm on left side respectively. Renal size was influenced by age, sex, side, body weight, height and BMI.

KEYWORDS: Body height, Body weight, BMI, Computed tomography, Kidney size.

INTRODUCTION

Background knowledge of normal kidney size is essential in clinical practice because it helps in making the diagnosis, deciding the management strategy and prognostication of various nephropathies. Alteration of the kidney size occurs in various renal disorders due to hypertrophic process and/or atrophy.^[1] Kidney size is frequently affected by renal infection/inflammation, hypertension, renal artery stenosis & diabetes mellitus. Status of the renal size eases differentiation of acute & chronic renal failure and helps in deciding whether to take renal biopsy or not. Assessment of renal size is also an important parameter for making decision in kidney transplant candidates. Normal renal size can be influenced by various factors viz. age, gender, body habitus, and ethnicity.^[2,3] It is therefore necessary to first establish the normal measurement values of various parameters of kidney. The value of measurements in one group of people may not be generalized to the other group as the normal renal size may vary according to ethnic group and body habitus.^[4] Most of the previous studies used ultrasonography or intravenous urography to

measure renal dimensions. In 2007, Kang et al^[5] evaluated different radiological methods for estimating renal size and concluded that CT scan was the most accurate radiological method for measuring renal dimensions. Furthermore, CT scans are more reproducible and less operator and patient dependent than ultrasound. Renal size can be determined by measuring length, width and thickness. Serial assessment of different renal parameters can be done during follow-ups to establish the progression or stability of various renal diseases. The purpose of this study was to measure the normal renal size in Nepalese adults by computed tomography and determine its variation in relation to age, sex, side, body weight, height and body mass index.

METHODS

A hospital based cross-sectional study was carried out on 330 patients at B.P. Koirala Institute of Health Sciences (BPKIHS), Dharan, Nepal over a period of 9 months. Informed consent was taken from all the participants. Approval of ethical clearance was obtained from the institutional ethical review board (IERB), BPKIHS,

Dharan, Nepal. This study had no influence on the treatment of the patients or execution/ indication of the CT scan. The patients above 16 years of age referred for CT scan of the abdomen for evaluation of non-kidney related pathologies were included in the study. Patients with known diabetes mellitus, hypertension, renal disease, previous renal interventions, incidental renal abnormalities including renal mass/ cyst/ calculus/ hydronephrosis or congenital anomaly, deranged serum urea/ creatinine, and lower urinary tract diseases were excluded from the study. Patients too ill to allow weighing and measuring height were also excluded.

The scans were performed by taking 7.5 mm contiguous sections on a Hitachi 16-slice MDCT scanner. Intravenous contrast agent was administered and the CT protocol was modified based on the nature of the pathology for which the patient was referred. Coronal and sagittal images were reformatted from the raw data of the patient stored on the computer to measure the size of the kidneys. The kidney length was measured as maximum distance between the renal poles (upper and lower poles) on reformatted coronal image. Renal width was measured as maximum distance between medial and lateral borders perpendicular to the length at the level of hilum. The maximum distance between ventral and dorsal surfaces of the kidney perpendicular to the length was taken as thickness. Dimensions of bilateral kidneys, body weight, height and gender of the patients were

recorded on a structured proforma for the analysis of data.

Statistical analysis was performed using SPSS software. For descriptive statistics, mean $\pm$ SD was calculated and presented for age, renal length, renal width and renal thickness. Frequencies and percentages were computed for gender and age groups. Pearson's correlation coefficient (r) was computed to assess correlation of renal sizes with body weight, height and BMI. The kidney dimensions in <60 years and $\geq$ 60 years age group were compared with independent t-test. Mean renal dimensions of male and female were analyzed and compared by independent t-test. Comparative analysis between dimensions of left and right kidney was done by means of paired t-test. P-value <0.05 was considered as statistically significant with 95% confidence interval.

RESULTS

Of total 330 patients, 180(54.5%) were male and 150(45.5%) were female with male to female ratio of 1.2:1. The age of the participants ranged from 18 to 84 years with mean age of 47.12 ± 18.03 years. Height of the patient ranged from 142-174 cm with a mean of 161.82 ± 7.34 cm, body weight ranged from 40-85 kg with a mean of 57.04 ± 11.47 kg and the BMI ranged from 16.2-29.1 kg/m² with a mean of 21.69 ± 3.52 kg/m². The values for mean body weight, height and BMI (Table 1) were significantly higher in males as compared to those in females (P-value <0.05).

Table 1: Body habitus of the participants.					
Parameters	Sex	N	Range	Mean $\pm$ SD	P-Value
Body Height (cm)	Male	180	150-174	165.54 ± 6.13	P<0.001 (Significant)
	Female	150	142-167	157.36 ± 6.07	
	Total	330	142-174	161.82 ± 7.34	
Body Weight (Kg)	Male	180	43-85	60.77 ± 12.53	P<0.001 (Significant)
	Female	150	40-65	52.57 ± 8.06	
	Total	330	40-85	57.04 ± 11.47	
BMI (Kg/m ²)	Male	180	16.8-29.1	22.06 ± 3.69	P=0.038 (Significant)
	Female	150	16.2-27.5	21.25 ± 3.26	
	Total	330	16.2-29.1	21.69 ± 3.52	

The mean renal length, width and thickness were 100.33 ± 9.31 mm, 53.06 ± 5.60 mm and 44.55 ± 4.63 mm on right side and 102.84 ± 9.52 mm, 54.61 ± 5.71 mm and 47.89 ± 5.50 mm on left side respectively (table 6).

Statistically significant difference was found between dimensions of right and left kidneys, with left being slightly larger than right in length, width and thickness (p<0.05).

Table 2: Comparison of renal size below 60 years and 60+ years of age.				
Parameters		<60 Years (N=230)	$\geq$ 60 Years (N=100)	P-Value (t-test)
Length (mm)	Right Kidney	102.98 ± 8.44	94.21 ± 8.33	P<0.001
	Left Kidney	105.76 ± 8.18	96.12 ± 8.99	P=0.001
Width (mm)	Right Kidney	54.55 ± 4.93	49.65 ± 5.57	P<0.001
	Left Kidney	55.76 ± 5.38	51.97 ± 5.58	P<0.001
Thickness (mm)	Right Kidney	44.84 ± 4.46	43.88 ± 4.96	P=0.082
	Left Kidney	49.04 ± 4.83	45.23 ± 6.04	P<0.001

When renal dimensions were analyzed with respect to sex (Table 7), it was found that renal length, width and thickness were significantly higher in males as compared to females ($p < 0.05$). Mean renal length, width and thickness in male were 102.30 ± 10.32 mm, 54.52 ± 5.28 mm and 46.21 ± 4.82 mm on right side and

104.54 ± 9.96 mm, 56.77 ± 5.20 mm and 49.45 ± 4.69 mm on left side respectively. For female these measurements were 97.95 ± 7.28 mm, 51.32 ± 5.48 mm and 42.56 ± 3.49 mm on right side and 100.79 ± 8.55 mm, 52.02 ± 5.21 mm and 46.01 ± 5.83 mm on left side for mean length, width and thickness respectively.

Table 3: Renal dimensions according to body weight expressed as mean $\pm$ SD.

Weight (Kg)	N	Length (mm)		Width (mm)		Thickness (mm)	
		Right	Left	Right	Left	Right	Left
≤ 50	111	96.95 ± 7.83	98.52 ± 7.91	51.46 ± 4.45	52.85 ± 5.00	42.51 ± 2.90	46.92 ± 4.98
51-60	98	97.79 ± 8.15	100.84 ± 9.55	50.98 ± 5.70	52.73 ± 5.51	43.01 ± 3.90	45.64 ± 4.87
61-70	74	99.38 ± 6.58	103.39 ± 6.43	53.70 ± 4.66	54.80 ± 4.21	45.95 ± 4.65	48.49 ± 5.10
71-80	17	114.90 ± 0.83	116.24 ± 0.54	60.22 ± 2.73	62.85 ± 1.93	50.54 ± 3.16	54.33 ± 5.34
≥ 81	30	115.15 ± 0.69	116.37 ± 0.58	60.18 ± 2.24	62.13 ± 2.13	50.28 ± 4.06	53.71 ± 2.78
Total	330	100.33 ± 9.31	102.84 ± 9.52	53.06 ± 5.60	54.61 ± 5.71	44.55 ± 4.63	47.89 ± 5.50

Mean renal dimensions were calculated for < 60 years and ≥ 60 years age group and compared with independent t-test which is shown in table 2. It was found that all dimensions (length, width and thickness) of bilateral

kidneys were smaller in ≥ 60 years age group as compared to those in < 60 years age group. And, the differences in all these renal dimensions, except right renal thickness, were statistically significant.

Table 4: Renal dimensions according to body height expressed as mean $\pm$ SD.

Height (cm)	N	Length (mm)		Width (mm)		Thickness (mm)	
		Right	Left	Right	Left	Right	Left
141-150	27	89.76 ± 1.31	90.80 ± 1.71	46.24 ± 4.16	48.38 ± 4.39	42.73 ± 6.24	43.15 ± 4.64
151-160	131	95.70 ± 6.69	98.16 ± 7.47	50.77 ± 4.45	52.37 ± 4.35	43.48 ± 3.94	45.84 ± 5.30
161-170	123	101.68 ± 6.96	105.06 ± 7.05	54.48 ± 4.40	55.76 ± 4.71	43.98 ± 3.54	48.98 ± 4.02
171-180	49	115.11 ± 0.64	116.39 ± 0.53	59.38 ± 4.04	61.17 ± 4.74	49.87 ± 4.14	53.26 ± 4.68
Total	330	100.33 ± 9.31	102.84 ± 9.52	53.06 ± 5.60	54.61 ± 5.71	44.55 ± 4.63	47.89 ± 5.50

Table 3, 4 & 5 show the mean renal dimensions according to patient's body weight, height & BMI respectively. Pearson's correlation showed statistically

significant positive correlation of bilateral renal length, width & thickness with patient's body weight, height & BMI which is shown in table 8.

Table 5: Renal dimensions according to BMI expressed as mean $\pm$ SD.

BMI (kg/m^2)	N	Length (mm)		Width (mm)		Thickness (mm)	
		Right	Left	Right	Left	Right	Left
< 18.5	84	99.20 ± 8.51	100.44 ± 8.50	52.21 ± 5.51	53.43 ± 5.90	43.06 ± 3.16	47.26 ± 5.79
18.5-24.9	175	99.68 ± 8.41	102.99 ± 8.92	52.87 ± 5.30	54.38 ± 5.17	43.72 ± 4.22	47.30 ± 5.46
25.0-29.9	71	103.24 ± 11.60	105.30 ± 11.37	54.56 ± 6.18	56.60 ± 6.29	48.37 ± 5.04	50.08 ± 4.70
Total	330	100.33 ± 9.31	102.84 ± 9.52	53.06 ± 5.60	54.61 ± 5.71	44.55 ± 4.63	47.89 ± 5.50

Table 6: Comparison of dimensions of right and left kidneys.

Parameter	Right Kidney	Left Kidney	P-value
Length (mm)	100.33 ± 9.31	102.84 ± 9.52	$P < 0.001$
Width (mm)	53.06 ± 5.60	54.61 ± 5.71	$P < 0.001$
Thickness (mm)	44.55 ± 4.63	47.89 ± 5.50	$P < 0.001$

Table 7: Comparison of renal size in males and females.

Parameters		Male	Female	P-Value
Length (mm)	Right Kidney	102.30 ± 10.32	97.95 ± 7.28	$P < 0.001$
	Left Kidney	104.54 ± 9.96	100.79 ± 8.55	$P = 0.001$
Width (mm)	Right Kidney	54.52 ± 5.28	51.32 ± 5.48	$P < 0.001$
	Left Kidney	56.77 ± 5.20	52.02 ± 5.21	$P < 0.001$
Thickness (mm)	Right Kidney	46.21 ± 4.82	42.56 ± 3.49	$P < 0.001$
	Left Kidney	49.45 ± 4.69	46.01 ± 5.83	$P < 0.001$
Male: $P < 0.001$ for each renal parameter on right and left side				
Female: $P < 0.001$ for each renal parameter on right and left side				

Table 8: Correlation of renal dimensions with height, weight and BMI.							
Kidney dimensions		Height		Weight		BMI	
		r	p	r	p	r	p
Right Kidney	Length	0.71	<0.001	0.55	<0.001	0.24	<0.001
	Width	0.64	<0.001	0.51	<0.001	0.24	<0.001
	Thickness	0.45	<0.001	0.57	<0.001	0.42	<0.001
Left Kidney	Length	0.71	<0.001	0.56	<0.001	0.26	<0.001
	Width	0.62	<0.001	0.54	<0.001	0.29	<0.001
	Thickness	0.51	<0.001	0.42	<0.001	0.21	<0.001
Correlation is significant at the 0.01 level (2-tailed).							

DISCUSSION

Many clinical decisions & diagnoses in medical practice are based on the status of the kidney size which serve as surrogate for renal functional reserve. Status of renal size on serial measurements can also provide information about disease progression or stability.^[6] In order to determine the abnormalities of kidney size, normal values of renal dimension must be established first. The normal size of a kidney is variable and is affected by age, gender, body weight, height of the individual as well as the side.^[7,8]

In present study, renal size of 330 patients were measured on CT scan and analyzed in term of length, width and thickness which are simple, reliable and objective measurements. The mean renal length, width and thickness in our study were 100.33±9.31mm, 53.06±5.60mm and 44.55±4.63mm on right side and 102.84±9.52mm, 54.61±5.71mm and 47.89±5.50mm on left side respectively. Arooj et al^[7] analyzed kidney size in 100 normal Malaysian adults on ultrasonography and found that the mean renal length, width and thickness were 9.7±0.79 cm, 3.8±0.52 cm and 3.8±0.57 cm on right side and 9.9±0.96 cm, 4.4±0.59 cm and 4.3±0.79 cm on left side respectively. Gupta et al^[8] studied renal dimensions in 340 normal adults of north-east India on ultrasonography and found that mean kidney length and width in male were 8.9±0.9 cm and 4.7±0.8 cm on right side and 9.1±0.9 cm and 4.7±0.6 cm on left side respectively. Similarly, the mean kidney length and width in female were 8.9±1.1 cm and 4.3±0.9 cm on right side and 8.8±0.9 cm and 4.2±0.7 cm on left side respectively. They concluded that the renal size was very closely related to age, side, sex and the individual's height and body weight. Shin et al^[9] studied renal size in 113 Korean population on CT scan and found that the mean renal length was 10.70 ± 0.76 cm on right side and 10.90 ± 0.72 cm on left side. Present study showed that the mean length, width and thickness of left kidney was significantly larger than the right kidney in both males and females which is in accordance with the results of the previous studies.^[8,9] The theory postulated for this is because the left renal artery is shorter and straighter than right, which increases blood flow to the left kidney, with the corresponding increase in size of the kidney. Another possible explanation is, due to the size of spleen which is smaller than the liver, thus the left kidney has more space for its growth.^[10]

It was found that the mean renal length, width and thickness were significantly higher in males as compared to females in our study. This has been reported by other investigators as well and has been related to differences in body size in male and female.^[4,11,12] In this study also, the values for mean body weight, height and BMI (table 1) were significantly higher in males as compared to those in females (P-value <0.05).

The age of an individual has a significant impact on the kidney size. In present study, it was found that all dimensions (length, width and thickness) of bilateral kidneys were smaller in ≥60 years age group as compared to those in <60 years age group and the differences in all of these dimensions (except right renal thickness) were statistically significant. Previous studies have shown that ageing leads to progressive decrease in kidney size from 5th decade onwards at rate of 0.5 cm per decade.^[13]

Normal renal size varies according to individual's physique and can be expressed as a function of body weight and height.^[3] The present study showed statistically significant positive correlation of renal length, width and thickness with body weight, height and BMI which is shown in table 8. Arooj et al^[7] reported a significant positive correlation of renal size with individual's body weight & height. Gupta et al^[8] reported significant positive correlation of renal size with body mass index. Shin et al^[9] reported a significant positive correlation of renal length and volume with body weight, height, body surface area and total body water. The present study revealed positive relationship between the individual's body size and the kidney size which is consistent with the results of similar previous studies.^[7,8,9] This association implies that the bigger individuals have larger kidneys than their lighter counterparts. This is probably because the kidney develops at the equal rate as the whole body develops. It can also be explained from physiological viewpoint as the individuals with bigger physique will have larger blood volume necessitating bigger kidneys for filtration.^[3]

Most of the studies have looked at kidney length as it is the most practical & most commonly used renal parameter in clinical practice and is correlated to renal function.^[4,10,11] Out of the three measured parameters,

bilateral renal length showed a strong positive correlation with body height in our study (table 8).

CONCLUSION

The mean renal length, width and thickness were 100.33 ± 9.31 mm, 53.06 ± 5.60 mm and 44.55 ± 4.63 mm on right side and 102.84 ± 9.52 mm, 54.61 ± 5.71 mm and 47.89 ± 5.50 mm on left side respectively. The mean kidney dimensions were smaller in ≥ 60 years age group as compared to those in < 60 years age group. The mean kidney dimensions were significantly larger in males than in females. Left renal size was significantly larger than right in both genders. The mean renal length, width and thickness showed a significant positive correlation with body weight, height and BMI.

CONFLICT OF INTEREST: None.

REFERENCES

1. Elkin M. Kidney Size. In: Elkin M (ed.), *Radiology of the Urinary System*. Boston, Little, Brown and Company, 1980; 1014-1032.
2. Hiraoka M, Hori C, Tsuchida S, Tsukahara H, Sudo M. Ultrasonographic findings of acute tubulointerstitial nephritis. *Am. J. Nephrol*, 1996; 16(2): 154-158.
3. Harmse SW. Normal variance in renal size in relation to body habitus. *SA journal of radiology*, 2011; 15(4): 123-126.
4. Odita JC, Ugboaga CI. Roentgenologic estimation of kidney size in adult Nigerians. *Trop. Geogr. Med.*, 1982; 34(2): 177-181.
5. Kang KY, Lee YJ, Park SC, Yang CW, Kim YS, Moon IS, et al. A comparative study of methods of estimating kidney length in kidney transplantation donors. *Nephrol Dial Transplant*, 2007; 22(8): 2322-2327.
6. 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; 2(1): 38-45.
7. Arooj A, Lam J, Wui YJ, Supriyanto E. Comparison of Renal Size among Different Ethnicities. *International journal of biology and biomedical engineering*, 2011; 5(4): 221-229.
8. Gupta S, Devi ND, Sinam SS, Khumukcham S, Singh AK. Ultrasonographic Renal Dimensions in Normal Adult Population of North-East India. *Int J Med Health Sci.*, 2013; 2(4): 433-437.
9. Shin HS, Chung BH, Lee SE, Kim WJ, Ha HI, Yang CW. Measurement of Kidney Volume with Multi-Detector Computed Tomography Scanning in Young Korean. *Yonsei Med J.*, 2009; 50(2): 262-265.
10. Emamian SA, Nielsen MB, Pedersen JF, Ytte L. Kidney dimensions at sonography: correlation with age, sex, and habitus in 665 adult volunteers. *Am J Roentgenol*, 1993; 160(1): 83-86.
11. Wang F, Cheok SP, Kuan BB. Renal size in healthy Malaysian adults by ultrasonography. *Med. J. Malaysia*, 1989; 44(1): 45-51.
12. Miletic D, Fuckar Z, Sustic A, Mozetic V, Stimac D, Zauhar G. Sonographic measurement of absolute and relative renal length in adults. *J. Clin. Ultrasound*, 1998; 26(4): 185-87.
13. Fernandes MM, Lemos CC, Lopes GS, Madeira EP, Santos OR, Dorigo D, et al. Normal renal dimensions in a specific population. *Int Braz J Urol*, 2002; 28(6): 510-515.