Original Article

DOI: 10.7860/JCDR/2023/59775.18126

Surgery Section

Determination of Renal Volume using Ultrasonography and its Correlation with Renal Function: A Cross-sectional Study

ANKIT SANDHU[1], SANDEEP GUPTA[2], DILIP KUMAR PAL[3]

ABSTRACT

Introduction: Renal length and volume are important indicators for the presence or progression of disease in urology and nephrology. Estimation of renal volume by Ultrasonography (USG) has clinical utility for the physician, nephrologist, and urologist.

Aim: To measure individual renal volume by ultrasonography and determine its relationship with renal function as measured by the Diethylene Triamine Penta-acetic Acid (DTPA) in normal adults.

Materials and Methods: It was a cross-sectional study conducted on 50 patients who underwent DTPA scans both in Outpatient (OPD) and In-Patient Department (IPD) in the Department of Urology, Institute of Postgraduate Medical Education and Research and SSKM Hospital, Kolkata, West Bengal, India, from January 2020 to December 2020. All the transplant donors who underwent donor nephrectomy were included in the study. A sonographic assessment was done and the Glomerular Filtration Rate (GFR) was calculated by Technetium (Tc)-154 DTPA. The primary outcome was to determine the relationship between renal volume with renal function in normal adults. The secondary outcome was to measure individual renal parameters sonographically. They were assessed for correlation between renal parameters (mainly renal volume) and DTPA using Pearson's coefficient.

Results: The age range of the subjects was 18-70 years. GFR calculated by DTPA for the right kidney had a better correlation with renal volume (r=0.241) on the right and 0.162 on the left, both with a p-value of 0.001. GFR of the left kidney had a better correlation with left kidney volume (r=0.184) than right kidney volume (r=0.130). No correlation was found between GFR with renal Anteroposterior (AP) dimension, renal width, and renal length. The kidney volume was more significant on the left-side (r=0.351) than on the right kidney (r=0.263).

Conclusion: Renal volume correlated well with renal function. Sonographic assessment of renal volume rather than renal length would serve as a tool to evaluate renal status for evaluation and follow-up.

Keywords: Diethylene triaminepentaacetic acid, Glomerular filtration rate, Pearson coefficient, Renal length

INTRODUCTION

Renal length and volume are important indicators for the presence or progression of disease in urology and nephrology practice [1]. The assessment of renal disease using biochemical assay is often carried out by the estimation of serum electrolyte, urea, and creatinine in blood and also through the determination of the amount of endogenous or exogenous substances present in urine (urinalysis, 24 hours creatinine or iohexol clearance) [2-4]. Renal function can be determined from the GFR by estimating endogenous creatinine clearance using the Cockcroft-Gault equation [5-7]. GFR can also be calculated by recording the clearance of exogenous substances that are eliminated by filtration only and neither secreted nor reabsorbed in the kidney. It includes renal marker and plasma marker clearance of chromium 512 labelled Ethylenediaminetetraacetic Acid (51Cr-EDTA), DTPA, iohexol, and iothalamate [8].

Estimation of renal volume by ultrasonography reflects renal mass or the number of surviving nephrons. Renal volume tells about the functional capacity of the kidneys [1]. Alteration in kidney volume can be associated with different renal diseases. Renal volume, rather than length, has been proposed as a true predictor of kidney size in states of good health and disease [2-4].

According to Emamian SA et al., the renal volume gives the most exact measurement of renal mass and better correlates with body surface area. Renal length on the other hand correlates with body height [4]. More so, renal volume is said to be stable with minimal change as one ages [3]. Widjaja E et al., (study done in UK) stated that renal volume is a more sensitive measure of detecting renal abnormality than any single linear measurement and better correlates with renal mass and estimated Glomerular Filtration Rate (eGFR), respectively [9]. To our knowledge, such a study correlating renal volume with DTPA has not been done in India.

The aim of the study was to provide a range of values of renal volume in the normal adult population and to determine the relationship between renal volume and anthropometric parameters such as age, weight, height, Body Mass Index (BMI), and gender.

MATERIALS AND METHODS

It was a cross-sectional study conducted on the patients who underwent DTPA scans both in OPD and IPD in the Department of Urology, Institute of Postgraduate Medical Education and Research and SSKM Hospital, Kolkata, West Bengal, India, from January 2020 to December 2020. The study was approved by the Institutional Ethical Committee (Memo no. IPGME&R/IEC/2020/178, dated 18.02.2020). As the average number of live transplant patients per year was forty, so a total number of patients included was fifty transplant donors that underwent transplant during the course of the study.

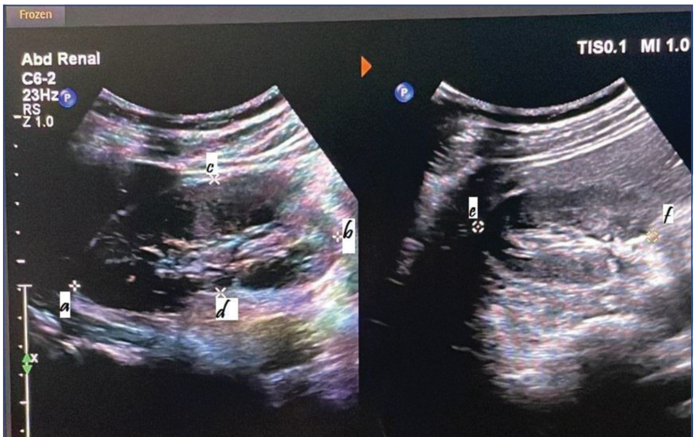
Inclusion criteria: All the transplant donors who underwent donor nephrectomy were included in the study. Those adults aged 18-60 years who gave consent for the procedure with the absence of any history of renal disease, a malignant or systemic illness that may modify renal dimensions like diabetes mellitus, renal artery stenosis, renal cancer, etc., with an arterial normotensive blood pressure of <140/90 mmHg, normal renal function (confirmed by normal serum creatinine <1.5 mg/dL and normal eGFR), with BMI <30 kg/m^2 and patients who underwent DTPA scan for urological indications like renal transplant donor, unilateral ureteric obstruction (like Pelvi-ureteric Junction Obstruction (PUJO), Extrinsic compression) were included in the study.

Exclusion criteria: Pregnant women or postpartum women (within the last 3 months), participants in whom the entire renal outline was not properly visible in a prone position during USG (despite deep breathing exercises), and patients with a history of prior surgery like atrophic nephrolithotomy, partial nephrectomy, Percutaneous Nephrolithotomy (PCNL), Extracorporeal Shock Wave Lithotripsy (ESWL) as these procedures cause nephron loss and hence affect renal function. Obese subjects were excluded from this study.

Study Procedure

The procedure was explained to all the subjects, and informed consent was obtained. History was taken for each adult, including age, gender, and the presence of any illness (acute/chronic) excluded. Healthy kidney of the patients was taken up for the measurement of renal volume for correlation with DTPA.

Systolic as well as diastolic blood pressure (with the help of mercury column sphygmomanometer), standing height (by stadiometer), weight (by weighing machine), and BMI were calculated. Using this, the patients were categorised as underweight (<18.5 kg/m^2), normal or lean BMI (18.5-22.9 kg/m^2), overweight (23.0-24.9 kg/m^2) and obese (≥25 kg/m^2). Subjects underwent (99 m) Tc-DTPA scan. On ultrasonography, the superior and inferior poles were identified and marked on the longitudinal scan of the kidney. The longest distance between the poles using an electronic calliper was taken as renal length. Similarly, on the longitudinal scan, the maximum distance between the anterior and posterior walls at the mid-third of the kidney was taken as Antero-posterior (AP) diameter (thickness). The renal width (W) was measured from the maximum transverse diameter at the hilum on the transverse scan [Table/Fig-1]. In view to minimise intraobserver error, the mean of two readings were taken. The unit of measurement was a centimetre (cm). Renal volume was calculated using the formula: L×W×AP×0.523 [2,10].



[Table/Fig-1]: Measurement of renal parameters. (a,b) Renal Length, (c-d) Renal width, (e-f) Anterior-posterior diameter.

STATISTICAL ANALYSIS

Data were recorded in the participant's ultrasound data sheet and transferred into Microsoft excel (Microsoft Corporation, USA) and Statistical Package for Social Science for windows (SSPS Inc. Chicago IL, USA) version 25.0. The correlation between parameters was derived using Pearson coefficient correlation.

RESULTS

A total of 50 subjects were systematically selected for the study out of which 19 (38%) were females and 31 (62%) were males. The age range of the subjects was 18-70 years with a mean age 47.95 (±11.54) years and 43.74 (±10.437) years for males and females, respectively [Table/Fig-2]. Serum creatinine values of male (0.94±0.14 mg/dL) were significantly higher than females (0.84±0.11 mg/dL) with p-value of 0.008. On both sides, GFR (derived from DTPA) in males had a higher value than in females as shown in [Table/Fig-3].

Sex		Age (years)	Weight (kg)	Height (m)	BMI kg/m^2
Female (n=19)	Mean	43.74	58.58	1.5932	23.106
	Std. Deviation	10.437	6.893	.05492	3.0237
Male (n=31)	Mean	47.95	64.53	1.6895	22.621
	Std. Deviation	11.540	5.920	.04684	2.1068
Total	Mean	45.34	60.84	1.6298	22.922
	Std. Deviation	10.948	7.104	.06985	2.6990

[Table/Fig-2]: Socio-demographic characteristics of the subjects.
BMI: Body mass index

Sex	Values	GFR right kidney mL/min/1.73^2	GFR left kidney mL/min/1.73^2
Male (n=31)	Mean	48.4168	45.4353
	SD	8.947	8.61359
Female (n=19)	Mean	47.5452	44.3616
	SD	7.97934	7.28224
Total n=50	Mean	47.8764	44.7696
	SD	8.28083	7.74597
p-value		0.722	0.639

[Table/Fig-3]: Glomerular Filtration Rate (GFR) of the patient.
Paired t-test was used

The mean renal length for the total population was greater on the left than the right. The difference in right kidney and left kidney with respect to total population was found to be significant with p-value of 0.004 and p-value of 0.008, respectively as shown in [Table/Fig-4]. There was a marked correlation between the subjects age and renal length on both the right kidney (r=-0.357) and left kidney (r=-0.390). The strongest correlation was observed between the subject's BMI and left kidney AP dimension (r=0.310) as shown in [Table/Fig-5].

Sex	Right kidney length	Left kidney length
Male (m)	9.66±0.36	9.70±0.42
Female (m)	9.37±0.30	9.40±0.32
Total (m)	9.48±0.35	9.52±0.39
p-value	**0.004**	**0.008**

[Table/Fig-4]: Sonographic renal length values and side differences for the subjects.

There was no significant difference in GFR value calculated by DTPA on either side in normal, underweight and overweight individuals as shown in [Table/Fig-6]. GFR calculated by DTPA for the right kidney was seen to have a better correlation with renal volume (r=0.241 on the right and 0.162 on the left, both with p-value of 0.001). GFR of the left kidney had a better correlation with left kidney volume (r=0.184) than right kidney volume (r=0.130). No correlation was found about GFR with renal AP dimension, renal width and renal length with p-value >0.05 as shown in serum creatinine (mg/dL) was seen to have the better correlation with renal width on the left-side (r=0.319) than on the right-side (r=0.220) [Table/Fig-7].

On plotting correlation of renal volume with GFR on a scatter diagram, most points were seen to cluster around the line of best fit and trend line showing increasing trend, showing a higher positive

Parameters	Right kidney				Left kidney			
	Kidney length	Kidney AP dimension	Kidney width	Kidney volume	Kidney length	Kidney AP dimension	Kidney width	Kidney volume
Age	**-0.357***	**-0.023**	0.011	-0.263	-0.390**	**-0.104**	-0.149	**-0.351***
Height (m)	0.137	0.092	-0.033	-0.061	0.120	0.054	-0.151	-0.208
Weight (kg)	-0.042	-0.195	-0.146	-0.028	-0.049	-0.275	-0.140	-0.096
BMI (kg/m²)	0.162	-0.267	-0.128	0.016	-0.145	-0.310*	-0.018	0.070

[Table/Fig-5]: Relationship between the anthropometric parameters and sonographic renal dimensions in the total population.
Values indicate correlation coefficient (r)
*=correlation is significant at p<0.05

BMI	GFR (DTPA) Mean±SD (mL/min/1.73²)		p-value
	Right kidney	Left kidney	
Underweight (n=2)	46±11.31	39.5±13.45	0.653
Normal weight (n=38)	47.60±8.72	44.12±8.12	0.075
Overweight (n=10)	49.26±8.72	48.28±3.71	0.685

[Table/Fig-6]: Renal Glomerular Filtration Rate (GFR) of sample population according to Body Mass Index (BMI) classification.
DTPA: Diethylene triamine-pentaacetic acid

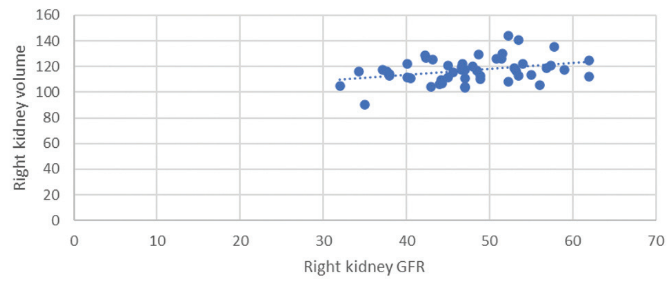
easy, quick, affordable, and accessible modality for evaluating renal dimensions [10].

A number of reports have described ultrasonographic measurements of renal length and volume in the healthy Western population and African population but there are scant data regarding the same in Asian countries. The overall length of right kidney was found to be 9.48±0.35 cm and left kidney to be 9.52±0.39 cm. The overall mean renal length (right 10.4 cm and left 10.6 cm) in the study done by Okoye I et al., in South eastern Nigeria was found to be higher [11].

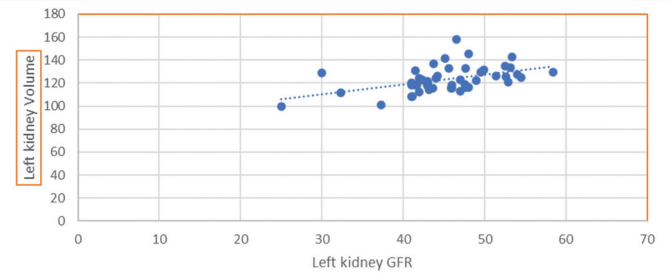
Parameters	Right kidney				Left kidney			
	Length	AP dimension	Width	Volume	Length	AP dimension	Width	Volume
Serum creatinine	0.0184	0.101	0.220	0.089	0.110	0.070	0.319*	0.194
GFR right kidney (DTPA)	-0.029	0.028	0.019	0.241**	0.038	0.064	0.150	0.162
GFR left kidney (DTPA)	0.054	0.032	0.070	0.130*	0.052	0.019	0.058	0.184*

[Table/Fig-7]: Relationship between the anthropometric parameters and sonographic renal. dimensions in the total population.
Values indicate correlation coefficient (r)
(*=correlation is significant at p<0.05)

correlation with GFR [Table/Fig-8,9]. Linear regression equations from independent variables (age, height and weight) for both females and males, respectively are shown in [Table/Fig-10,11]. GFR can be calculated using the prediction equation from the renal volume as seen in both females and males respectively as well as for total subjects [Table/Fig-12-14].



[Table/Fig-8]: Relationship between right kidney Glomerular Filtration Rate (GFR) and the right kidney volume in both male and female subjects.



[Table/Fig-9]: Relationship between left kidney Glomerular Filtration Rate (GFR) and the left kidney volume in both male and female subjects.

DISCUSSION

The sonographic assessment of renal dimensions is an integral tool for the evaluation and serial follow-up of suspected renal disease in adults, especially in urological and nephrological settings. Sonographic renal size assessment remains the most reproducible, real-time, tridimensional, non invasive, non ionising,

Parameters	Prediction equation
Right kidney length	9.004-(0.010×age)-(0.772×height)-(0.08×weight)
Left kidney length	9.445-(0.006×age)+(0.627×height)-(0.013×weight)
Right kidney volume	209.803-(0.146×age)-(53.621×height)-(0.066×weight)
Left kidney volume	320.968+(0.047×age)-(117.113×height)-(0.291×weight)

[Table/Fig-10]: Prediction equation for sonographic renal length and volume using anthropometric parameters in female subjects.
(Age in year; height in meter and weight in kilogram)

Parameters	Prediction equation
Right kidney length	19.949-(0.015×age)-(2.903×height)+(0.06×weight)
Left kidney length	15.070-(0.025×age)-(2.862×height)+(0.010×weight)
Right kidney volume	224.120-(0.402×age)-(50.063×height)-(0.007×weight)
Left kidney volume	334.064-(0.687×age)-(101.274×height)-(0.065×weight)

[Table/Fig-11]: Prediction equation for sonographic renal length and volume using anthropometric parameters in male subjects.
(Age in year; height in meter and weight in kilogram)

Parameters	Prediction equation
Right kidney GFR	51.988-(0.030×Right kidney volume)
Left kidney GFR	72.596-(0.216×Left kidney volume)

[Table/Fig-12]: Prediction equation for Glomerular Filtration Rate (GFR) of both kidneys using sonographic renal volume in the male subjects (n=31).

Parameters	Prediction equation
Right kidney GFR	51.574-(0.035×Right kidney volume)
Left kidney GFR	38.817+(0.046×Left kidney volume)

[Table/Fig-13]: Prediction equation for Glomerular Filtration Rate (GFR) of both kidneys using sonographic renal volume in the female subjects (n=19).

Parameters	Prediction equation
Right kidney GFR	50.599-(0.023×Right kidney volume)
Left kidney GFR	50.601-(0.048×Left kidney volume)

[Table/Fig-14]: Prediction equation for Glomerular Filtration Rate (GFR) of both kidneys using sonographic renal volume in the total subjects (n=50).

Similar results were found in the present study when compared with Eastern India study population results. This similarity could probably be due to similar body habitus and type of diet of this part of the country [13]. Moreover, the values of the present study were similar to the North western Indian and Pakistan findings by Shani D et al., and Raza M et al., respectively [14,15]. Mean renal width and (AP) depth obtained in this study were slightly higher than those in the Pakistani population [Table/Fig-15] [4,12-15].

S. No.	Author name with reference	Location	Variables
1.	Gupta S et al., [12]	Eastern India	Mean kidney length Male population (n=236) Right-side: 8.9±0.9 cm Left-side: 9.1±0.9 cm Female population (n=104) Right-side: 8.9±1.1 cm Left-side: 8.8±0.9 cm [12]
2.	Raza M et al., [15]	Pakistan	Right-side Mean renal length: 101.6±8.9 mm Renal width: 42.7±7.1 mm Parenchymal thickness: 14.4±2.9 mm Mean renal volume: 99.8±37.2 cm^3 On left-side Mean renal length: 102.7±9.2 mm Renal width: 47.6±7.0) mm Parenchymal thickness 15.1±3.1 mm Renal volume: 124.4±41.3 cm^3 Left renal size was significantly larger than right in both genders
3.	Maaji SM et al., [13]	North western part of Nigeria	Renal volume values were lower in the North western population (119.7±32.8 cm^3 and 109.6±29.3 cm^3 for the left and right-side, respectively)
4.	Shani D et al., [14]	North West Indian Population	The renal size of Indian population is relatively similar to the Malaysian. The kidney of Malaysian is slightly thicker than the Indian in both male and female categories
5.	Emamian SA et al., [4]	Africa	Renal length and height in this study showed strong correlation (r=0.46, 0.42) for the left and right-side, respectively

[Table/Fig-15]: Compilation of relevant studies [4,12-15].

It is shown that the left kidney is somewhat larger than the right kidney. It is thought that the left renal artery is shorter in length, which increases blood flow to the left kidney, leading to the increase in the size of the kidney [16]. Another reason could be due to the fact that the liver is bigger than the spleen, giving the right kidney less space to grow. Physiologically, renal length is shown to decrease by 0.5 cm per decade after middle age [4]. Studies have also tried to establish a correlation between renal size and age [17]. The length and renal volume in subjects aged between 30-50 years showed slight differences and a clear decrease in both parameters [4].

There was no correlation between renal length and height in this study (r=0.120, 0.137 for the left and right-side, respectively), whereas studies done by Adebayo SB et al., Gavela T et al., and Fernandes MM et al., showed strong correlation [18-20]. This finding was at variance to studies done by Okoye I et al., Maaji SM et al., who reported that renal length correlated best with body weight [11,13]. Renal volume in this study showed no significant correlation with body weight on both sides with an r value of 0.028 and 0.096 on the right and left-side; this was in contrast with studies done in South Western Nigeria and in the Turkish Population which showed significant correlation between renal volume and body weight [21,22].

In the present study, BMI showed a good correlation with AP dimension of left kidney (r=0.310). In a study by Cheong B et al., rather showed that the renal length correlated better with BMI than renal volume [23].

The correlation between renal volume and function is important. Okur A et al., and Cheong B et al., have shown that renal volume strongly correlates with eGFR, and implied that since renal volume varies with metabolic demand, it is therefore closely linked to renal function [22,23]. The present study also showed that renal volume correlated better with GFR, hence, a better index of measurement of renal function than renal length which is the same as proposed Moorthy HK and Venugopal P; and Cheong B et al., [2,23]. Gong IH et al., observed that renal volume best correlated with eGFR than with body height and weight with correlation coefficients of 0.615, 0.344 and 0.343 respectively, each with significant p-value of <0.0140 [24].

The established equations can be used to predict renal length and volume in males and females, provided the subject's age, height and weight is known, especially in remote settings where access to sonography may be unavailable due to poor access roads or absence of an ultrasound machine/qualified radiologist/sonologist. However, when the subject's height and weight is not known but renal sonography has been done, in such cases GFR can be calculated from the sonographically determined renal dimensions (especially renal volume).

Limitation(s)

The sample size was restricted to renal transplant donors as they reflected the normal adult population. Similar studies should be conducted in infants and children, using Computerised tomography and Magnetic resonance imaging. A multicentre study to draw a normogram for the whole country is encouraged.

CONCLUSION(S)

Renal volume had best correlated with renal function. Sonographic assessment of renal volume rather than renal length is therefore clinically relevant and would serve as a tool to evaluate renal status for evaluation and follow-up. It should be integrated into our daily routine as this would inform the clinicians on the functional reserve of the renal status of the individual and not just the renal length and AP dimensions as is common practice. The prediction equations could also serve as an alternative measure for the assessment of renal dimensions and GFR in remote settings where DTPA facilities are not available or in a busy practice where urgent renal status evaluation is required in the studied population.

REFERENCES

[1] Ferrer FA, McKenna PH, Bauer MB, Miller SF. Accuracy of renal ultrasound measurements for predicting actual kidney size. J Urol. 1997;157(6):2278-81.
[2] Moorthy HK, Venugopal P. Measurement of renal dimensions in vivo: A critical appraisal. Indian J Urol. 2011;27(2):169-75.
[3] Sanusi AA, Arogundade FA, Famurewa OC, Akintomide AO, Soyinka FO, Ojo OE, 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;24(5):1690-94.
[4] 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.
[5] Glassock RJ, Rule AD. The implications of anatomical and functional changes of the aging kidney: With an emphasis on the glomeruli. Kidney International. 2012;82(3):270-77.
[6] Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. Nephron. 1976;16(1):31-41.
[7] Lascano ME, Poggio ED. Kidney function assessment by creatinine-based estimation equations. Disease management project: Nephrology. Cleveland, Center for Continuing Education. 2010;1:22-26. https://teachmemedicine.org/cleveland-clinic-kidney-function-assessment-by-creatinine-based-estimation-equations/.
[8] Soveri I, Berg UB, Björk J, Elinder CG, Grubb A, Mejare I, et al. Measuring GFR: A systematic review. Am J Kidney Dis. 2014;64(3):411-24.
[9] Widjaja E, Oxtoby J, Hale T, Jones P, Harden P, McCall I. Ultrasound measured renal length versus low dose CT volume in predicting single kidney glomerular filtration rate. Br J Radiol. 2004;77(2):759-64.
[10] Hamid A, Tariq S, I Shaq M, Ganine FA, Roohi S, Akhter S, et al. Sonographic measurement of renal size in normal North Indian children. IAIM. 2015;2(3):47-53.
[11] Okoye I, Agwu K, Idigo F. Normal sonographic renal length in adult southeast Nigerians. Afri J Med Sci. 2005;34(2):129-31.
[12] 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;2:433-37. https://www.ijmhs.net/articles/1381563550Ultrasonographic_Renal_Dimensions_in_Normal_Adult_Population_of_North_East_India.pdf.

[13] Maaji SM, Daniel O, Adamu B. Sonographic measurement of renal dimensions of adults in northwestern Nigeria: A preliminary report. Sub-Saharan Afr J Med. 2015;2(3):123-27.
[14] Shani D, Jit I, Sodhi L. Weight and Measurements of kidneys in Northwest Indian adults. American Journal of Human Biology. 2001;13(6):726-32.
[15] 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;23(3):64-68.
[16] Moëll H. Size of normal kidneys. Acta Radiol. 1956;46:640-45. https://doi.org/10.3109/00016925609171457.
[17] Chandra J, Mathur S, Mittal SK, Mittal KP. Sonographic assessment of renal volume in Indian children. Indian J Pediatr. 1999;66(2):175-78.
[18] Adebayo SB, Alebiosu CO, Awosanya GO. Correlation of sonographically determined renal sizes with demographic parameters in Nigerian Adults. Nigerian Hospital Practice. 2009;4(1-2):01-02.
[19] Gavela T, Sánchez-Bayle M, Gómez-Mardones G, Gallego S, Martínez-Pérez J, Pintado M. Ultrasonographic study of kidney size in children. Nefrologia. 2006;26(3):325-29.
[20] 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):510-15.
[21] Arooj A, Lam J, Wui Y, Supriyanto E. Comparison of renal size among different ethnicities. Int J Biol Biomed Eng. 2011;5:221-29. https://www.researchgate.net/publication/293683333_Comparison_of_renal_size_among_different_Ethnicities/citation/download.
[22] Okur A, Serin HI, Zengin K, Erkoc MF, Tanık S, Yıldırım U, et al. Relationship between kidney volume and body indexes in the Turkish population determined using ultrasonography. International Braz J Urol. 2014;40(6):816-22.
[23] 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 Nephro. 2007;2(1):38-45.
[24] Gong IH, Hwang J, Choi DK, Lee SR, Hong YK, Hong JY, et al. Relationship among total renal volume, renal function and age. J Urol. 2012;187(1):344-49.

PARTICULARS OF CONTRIBUTORS:

1. Photodynamic Therapist (PDT), Department of Urology, Institute of Postgraduate Medical Education and Research, Kolkata, West Bengal, India.
2. Associate Professor, Department of Urology, Institute of Postgraduate Medical Education and Research, Kolkata, West Bengal, India.
3. Professor and Head, Department of Urology, Institute of Postgraduate Medical Education and Research, Kolkata, West Bengal, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dilip Kumar Pal,
244, AJC Bose Road, Kolkata, West Bengal, India.
E-mail: urologyipgmer@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Sep 02, 2022
- Manual Googling: Dec 28, 2022
- iThenticate Software: Jan 03, 2023 (11%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Aug 23, 2022**
Date of Peer Review: **Sep 22, 2022**
Date of Acceptance: **Jan 05, 2023**
Date of Publishing: **Jun 01, 2023**