Original Article

Variations in renal morphometry: A hospital-based Indian study

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ABSTRACT

Introduction: The currently available standard renal nomograms for comparison of renal dimensions in India are based on the measurements made in the Western population. The objectives of our study were to identify variations in renal morphometric parameters in subjects with no known renal disease in a hospital-based Indian population and to find out any correlation between renal volumes with split renal functions and body mass index (BMI).

Materials and Methods: One hundred and fifty-one subjects undergoing contrast-enhanced computerized tomography (CT) scan for various purposes, including donor nephrectomy, from June 2012 to August 2014 were included in the study. The renal and ureteral dimensions were assessed from the contrast-enhanced CT scan images of these patients.

Results: The mean length, width, thickness and volume of the left kidney were 11.02 ± 1.13 cm, 5.21 ± 0.75 cm, 4.65 ± 0.84 cm and 138.22 ± 29.81 mL, respectively, and those for the right kidney were 10.86 ± 1.12 cm, 5.13 ± 0.77 cm, 4.73 ± 0.95 cm and 137.54 ± 34.48 mL, respectively. The mean length of the left ureter was 23.51 ± 1.48 cm and that of the right ureter was 23.24 ± 1.93 cm. The mean volume of the kidneys in males and females was also different. The volume of the kidney did not statically correlate with the split glomerular filtration rate (($P = 0.12$) and BMI ($P = 0.52$)).

Conclusions: Our study revealed that there exist differences in various morphometric parameters of the kidney and ureter in different subsets of the Indian population attending our hospital as compared with the standard values quoted in the world literature.

Key words: Computerized tomography, ellipsoid formula, kidney volumes, renal dimensions

INTRODUCTION

Evaluation of renal measurements such as length, width and thickness is important in the diagnosis and management of many renal disorders as there is a close relationship between renal size and its function.[1] However, many studies have shown that renal size and measurements are influenced by factors such as age, ethnicity, gender, weight and height.[2-4] It is also known that the left kidney is larger than the right kidney in normal adults, independent of gender.[5] Many studies also concluded that renal measurement variations occur in nephropathies due to hypertrophic processes and/or atrophy.[6] Renal infections/inflammations, nephrologic disorders, diabetes mellitus and hypertension are the most important co-morbid conditions affecting renal size. Thus, it is imperative to establish the pattern of renal measurements for accurate diagnosis of renal diseases. There are various methods of measuring renal dimensions, such as X-rays, ultrasonography, computerized tomography (CT) and magnetic resonance imaging (MRI), each having its own advantages and disadvantages.[7] In common practice, measurements of renal size of any age are compared with the

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measurements that are predicted by standard nomograms. However, the current nomograms that are widely used have been derived from the Western literature. Therefore, there is an urgent need to develop nomograms for an Indian population to provide better accuracy of renal and ureter measurements for proper medical diagnosis and monitoring the progress of the disease. This study was conducted as an initial step in order to identify differences in renal measurements in an adult Indian population attending our hospital and to compare the volume of the kidney with glomerular filtration rate (GFR) and body mass index (BMI), which might be of great relevance in selection of patients undergoing donor nephrectomy.

MATERIALS AND METHODS

A total of 151 subjects aged >18 years were included in this retrospective, hospital-based study conducted between May 2012 and August 2014. Of these subjects, 50 (100 renal units) were voluntary renal donors, who were considered equivalent to healthy individuals. Institutional Ethical Committee approval and informed consent from subjects were obtained for the study protocol. Healthy voluntary renal donors and patients with non-renal diseases like carcinoma colon, diverticulitis, intestinal obstruction, appendicitis, etc., undergoing helical CT scan were included in the study. The criteria for normal renal functions included a serum creatinine of <1.3 mg% (as per the hospital lab standards), normal urinalysis and ultrasonogram showing normal corticomedullay differentiation with no evidence of hydronephrosis. Patients with known renal diseases, diabetes mellitus and hypertension were excluded from the study.

Renal morphometry was performed by a single Urology Resident with the help of an expert Radiology Technician. Both renal and ureteric measurements were performed by evaluating the contrast-enhanced images of the subjects using 3D soft ware (Philips Brilliance Extended Workspace v4 (USA)), which was approved by the Food and Drug Administration and validated by M/s. Philips. The length of the kidney was measured in the cranio–caudal direction from the superior to the inferior pole. The width of the kidney was measured as the widest diameter in the transverse plane and the thickness was measured by rotating the image using 3D software, as maximum distance between the anterior and posterior surfaces of the kidney. Renal pelvis and vasculature were excluded from the area measurements. Ureteral length was measured as the distance from the uretero–pelvic junction (UPJ) to the uretero–vesical junction (UVJ). Volume of the kidney was measured using the Ellipsoid formula ($\pi/6 \times$ length $\times$ width $\times$ thickness).[8] The mean values obtained by various measurements were compared with similar values quoted in the world literature. Split renal function of each kidney was measured by diethylene triamine penta acetic acid scan in a subset of 50 voluntary renal donors (100 renal units). Height, weight and BMI of the renal transplant donors were also noted. Correlation was done between volume of the kidney with split GFR and BMI of these subjects. Pearson's correlation test was performed to assess the statistical significance of the correlated data. A P value <0.05 was considered statistically significant.

RESULTS

The mean age of the patients was 46 ± 15 years; 95 subjects were male and 56 were female. The weight of the subjects ranged from 41 kg to 108 kg and the height ranged from 150 cm to 187 cm. The mean length, width, thickness and volume of the left and right kidneys are shown in Table 1. The mean volume of the left kidney in male subjects was 142.94 ± 30.48 mL and that of the right kidney was 143.94 ± 35.69 mL; in female subjects, the mean volume of the left kidney was 130.20 ± 27.07 mL and that of the right kidney was 126.67 ± 30.16 mL. The volume of both the right and the left kidneys was higher among males compared with females ($P = 0.04$). However, there was no statistically significant difference between volumes of the right and left kidneys in either sex. The mean length of the left ureter was 23.29 ± 1.77 cm and that of the right ureter was 23.57 ± 1.48 cm in male subjects. The corresponding measurements in female subjects were 23.11 ± 2.12 cm and 22.93 ± 1.60 cm, respectively. In male subjects, the fractional GFR of the left kidney was 54.55 ± 6.50 mL/min and that of the right kidney was 53.85 ± 6.13 mL/min; the total GFR was 108.42 ± 12.16 mL/min. In female subjects, the fractional GFR of the left kidney was 53.53 ± 5.67 mL/min and that of the right kidney was 53.25 ± 5.56 mL/min; the total GFR was 106.74 ± 10.61 mL/min.

On correlating kidney volumes with split GFR of the patient, a slightly positive correlation was seen ($P = 0.12$), but it was not statistically significant. Similarly, the kidney volumes did not correlate with the BMI of the patient ($P = 0.52$), as shown by the scatter diagrams [Figures 1 and 2].

DISCUSSION

Although there have been many studies on renal measurements carried out globally, most of the studies available have been performed in the pediatric population and there is limited data available for adults. Also, the quoted

Table 1: Mean values of renal dimensions and volume

	Left kidney	Right kidney
Length (cm)	11.02±1.13	10.86±1.23
Width (cm)	5.2±0.75	5.13±0.77
Thickness (cm)	4.65±0.84	4.73±0.95
Volume (mL)	138.22±29.81	137.54±34.48

adult renal dimension have been largely derived from studies performed in Caucasians and hence may not be applicable to the Indian population. Our current study, although on a small sample size, showed that renal dimensions in the Indian population attending our hospital were smaller than those in the Caucasian population, but were similar to the values reported from some of the Asian countries [Table 2]. Previous reports had also shown that renal length differed in various countries and races.[9-12] In our study, we observed that males had larger kidney dimensions and kidney volumes than females, probably because of greater body indices like height, weight, body surface area and total body water. Similarly, values of mean ureteral lengths in our study were smaller compared with those mentioned in the standard published literature,[13] and the difference was statistically significant.

The relationship between ureteric length and other anthropometric parameters like height, weight, body surface area and BMI require further evaluation. It has been shown that relative renal length (renal length to body height ratio) is insensitive to sex and height differences, and is thus a more reliable parameter than absolute renal length. Similarly, renal lengths have been shown to have a positive correlation with body height, weight and BMI; however, this was not seen in our study, probably because of the small sample size.

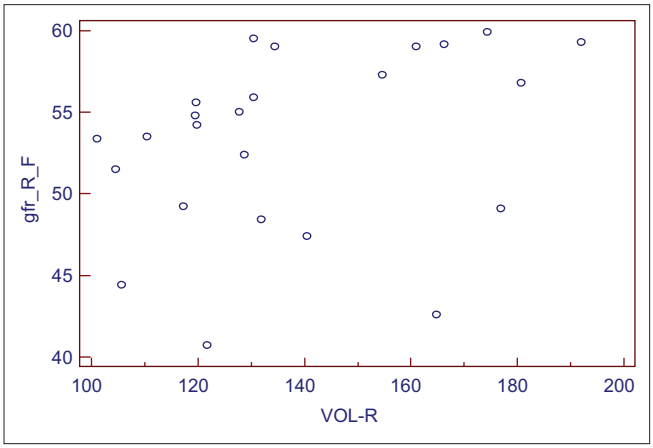

Figure 1: Scatter diagram showing correlation of kidney volume (on horizontal axis) with split glomerular filtration rate (on vertical axis)

While the above trends might be true within each individual population or race, the same cannot be said about different populations with comparable anthropometric indices. In the present study, all measurements were carried out by the same operator with a pre-defined technique to ensure maximal homogeneity to avoid inter-observer variability. Intra-observer variability was reduced by averaging multiple readings. Care was also taken to ensure that none of the subjects were known diabetics or hypertensives or had urinary tract infections, as these conditions and their treatment could affect kidney sizes. In spite of this, one of the limitations of our study was that the subjects included patients with non-renal pathologies as well, and probably further studies in a "healthy" population are warranted. The low sample size could be a causal factor for not observing gender-dependent or right–left differences in renal length. Another limitation of our study was that it focused on linear renal parameters and did not involve the collection or calculation of renal volumetric data. The results of this hospital-based study on a small sample size indicate that there is need for larger multicentric studies across India to derive nomograms in the Indian population in various age groups and ethnicities, irrespective of the association of renal dimensions with anthropometric values.

CONCLUSION

Our study revealed that there exist significant differences in various morphometric parameters of the kidney and

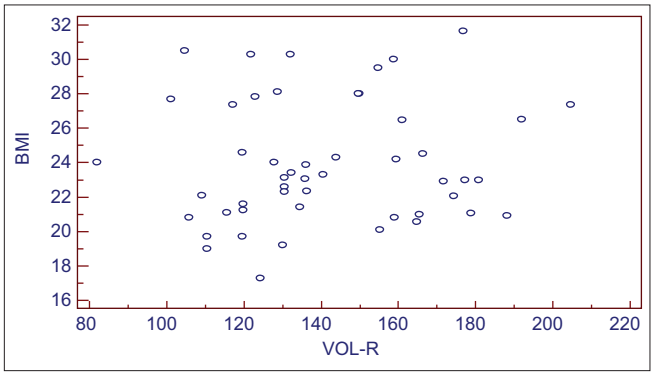

Figure 2: Scatter diagram showing correlation of kidney volume (on horizontal axis) with body mass index (on vertical axis)

Table 2: Comparison of renal dimensions of the present study with the standard published literature

	Mean renal length (cm)	Mean renal width (cm)	Mean renal thickness (cm)	Mean renal volume (mL)
Present study	10.86±1.23	5.13±0.77	4.73±0.95	137.54±34.48
Bucholz *et al.*,[1] Pakistani study	10.4±0.8	4.5±0.6	1.6±0.2 (cortical thickness)	76.16±21.7 (cm^2)
Kang *et al.*,[8] Korean study	11.08±0.96	6.23±0.65	4.73±0.67	158.7±62.9
Breau *et al.*,[14] Canadian study	11.8±1.75	Not measured	Not measured	186±22.4
Cheong *et al.*,[15] American study	12.4±0.9	Not measured	Not measured	202±36

ureter in the subsets of Indian population attending our hospital compared with the standard values quoted in the world literature.

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Conflicts of interest
There are no conflicts of interest.

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