ORIGINAL ARTICLE

MORPHOMETERIC ANALYSIS OF NORMAL RENAL DIMENSIONS IN ADULTS BY MULTIDETECTOR COMPUTERIZED TOMOGRAPHY SCAN

Maria Mohiuddin,[1]Arsalan Manzoor[1] Muhammad Ali,[2] Nuzhat Hassan[1]
[1]*Department Of Anatomy, Ziauddin University, Hospital. Karachi*
[2] *Department of Radiology, Ziauddin University,Hospital. Karachi*

ABSTRACT

Background: Kidney dimensions are influenced by different factors such as side, age, gender and geographical location. Thus, the purpose of our study was to determine reference range of kidney dimensions and effect of age, gender and side on renal dimensions in adults in a subset of Karachi population.

Methods: The study was conducted from December, 2016 to May, 2017 in the department of Radiology, Ziauddin Hospital, Clifton Campus, Karachi. A total of 250 individuals (129 males and 121 females) aged 21 to 60 years without known renal disease were included in the study. Study participants were those who presented to Radiology Department with non-renal disease for abdominal contrast computerized scan. All individuals were categorized according to gender and age. Statistical analysis was done on Statistical Package for Social Sciences (SPSS) version 20. Independent sample T test, one way ANOVA and Pearson's correlation analysis were applied. P- value of ≤ 0.05 was considered significant.

Results: Mean right renal length, width and anteroposterior thickness were 10.81±0.71 cm, 4.77±0.23 cm and 4.36±0.21cm respectively. Mean left renal length, width and anteroposterior thickness were 11.12±0.73 cm, 4.84±0.23 cm and 4.44±0.19 cm respectively. Mean volume of right and left kidneys were 118.80±17.98 cm3 and 126.00±18.36 cm3 respectively. A significant difference (p=0.001) was found between right and left kidney dimensions. A weak positive correlation of mean renal volume of both kidneys was observed between males and females (right renal volume r=0.024, left renal volume r=0.035). While a significant moderate negative correlation was seen between mean renal volume and age (right r= -0.456, p < 0.001: left r= -0.462, p < 0.001).

Conclusion: This study presents a reference range of renal dimensions in adults without known renal disease in a subset of Karachi population. It is concluded that renal dimensions and renal volume varies significantly with side of kidney, gender and age.

KEYWORDS: Kidney, Gender, Adult, Tomography

Corresponding Author
Dr. Maria Mohiuddin
Senior Lecturer,
Department of Anatomy.
Ziauddin University, Karachi.
Email: mohiuddinmaria22@gmail.com

INTRODUCTION

Renal dimensions is speculated as a marker of functional nephron mass and among renal measurements, length and volume of kidney has been emphasized as most important parameters for making clinical decisions. [1]Kidney disease is an emerging public health issue worldwide.[2-4] Kidney diseases are progressively increasing in South Asian countries like Pakistan.[3] The growing incidence of renal diseases is likely to produce major burden on both healthcare system and the economy in future

years.[3] The overall prevalence of chronic kidney disease (CKD) in Pakistan is estimated to be 12.5% [5], annual incidence of end-stage renal disease (ESRD) is>100 patients per million population and approximately 400 renal transplantation done every year in Pakistan[6]. Evaluation of kidney measurements is of great importance to clinician and surgeons, as estimation of renal size is vital for the diagnosis, treatment and evaluation of renal diseases.[7]

A normal human kidney is 12 cm in length, 6 cm in width and 3 cm in anteroposterior thickness.[8]However, previous studies showed that renal dimensions are affected by many factors such as gender, age, side of kidney and ethnicity.[9, 10]

There are different methods available for measuring kidney dimensions such as Ultrasonography (US), Computerized Tomography (CT scan) and Magnetic Resonance Imaging (MRI Scan). [11]US is associated with notable inter observer and intra observer variability and reported to underestimate the kidney measurements by 15-18%.[12-14]Studies have reported MRI to be associated with disadvantages like lower spatial resolution and higher cost compared to (MDCT scan).[12,15] Moreover, gadolinium chelates present in contrast agents used in contrast enhanced MRI scan results in a condition called nephrogenic systemic fibrosis.[16] In this study all measurements were taken on Multidetector Computerized Tomography scan (MDCT-scan), which with multiple CT slices have many advantages. It shows structural details of the kidney and other surrounding structures including kidney vasculature in a very short period of time.[12] It has a very thin slice collimation, high spatial resolutions and allows reformatting in multiplanar imaging which provide good anatomical details.[17, 18]

During routine clinical and radiological assessment, measurements of kidneys are compared with standard normogram based on western population. However, information available in studies conducted in Western countries may not be applicable to our population. Thus, the purpose of this study was to establish baseline morphometeric data concerning renal dimensions in adults with no known renal disease in our population and to find its variation with age, gender and side of kidney by using the most accurate modality that is Multidector Computerized Tomography (MDCT) scan.

METHODS

This was a cross-sectional study conducted in the Radiology department at Ziauddin University Hospital, from December, 2016 to May, 2017.Study was conducted after approval from Ethics Review Committee of Ziauddin University. Samples were taken through non-probability consecutive sampling technique. Sample size of 250 individuals (500 kidneys) was calculated by using WHO sample size calculator keeping prevalence at 12% of Chronic kidney disease in Pakistan[5], Confidence level of 95% and bound of error at 5%. Study participants included were those who presented to Radiology Department for abdominal contrast CT examination with non renal diseases for various indications such as liver lesions, pancreatic lesions and gastrointestinal diseases. Informed and written consent was obtained from all participants. Participants included, had serum creatinine ≤ 1.3 mg /dl (as per Hospital Lab value) and adults having age between 21 years to 60 years. Patients who had history of renal transplant, renal surgery, renal tumor, renal stones, hydronephrosis and allergic reaction to contrast agent were excluded from study. Patients with hypertension, diabetes mellitus and congenital anomalies of kidney were also excluded.

Multidetector Computed Tomography: All CT examinations were performed after intravenous contrast administration on a 16-slice MDCT scanner (Toshiba 16 slicer Alexion, Japan) in the arterial phase. Contrast was given at the rate of 4 ml/sec. Patient was instructed to hold his/her breath for 10 seconds and scan was initiated. The scanned area was extended from the diaphragm to the pubic symphysis. At workstation post-processing of volumetric MDCT data sets was done. Multiplanar Reconstruction (MPR) images were reconstructed. Oblique sagittal and axial MPR images were created. The parameters for kidney dimensions measured were maximum length of kidney from superior to inferior pole, maximum transverse diameter (width), maximum anterior posterior diameter (thickness) at the level of renal hilum and kidney volume was calculated by using ellipsoid formula. [11, 19] Kidney Volume (cm^3) = length (cm) × width (cm) × thickness (cm) × $\pi/6$. Data was analyzed on SPSS version 20. Quantitative variables were as expressed mean and standard deviation. These variables were compared by using one sample t-test, independent t-test and one way ANOVA. Correlation analysis by using Pearson's correlation. P-value ≤ 0.05 was considered significant.

RESULTS

Out of 250 study participants 129 were males and 121 were females. The mean age of study participants was 43.9 ± 11.8 years. The mean age of males were 43.5 ± 11.0 years and mean age of females were 44.3 ± 12.69 years. All participants were stratified into four age groups aged 21 years to 60 years. Group 1 (21 ≤ 30) having 45 individuals, group 2 (31 ≤ 40) having 46, group3 (41 ≤ 50) having 78 and group 4 (51 ≤ 60) having 81individuals (Table 3)The mean dimensions of right kidney were, length 10.81 ± 0.71 cm, width 4.77 ± 0.23cm and anteroposterior diameter (thickness) 4.36 ± 0.2 cm. The mean dimensions of left kidney were, length 11.12 ± 0.73 cm, width 4.84 ± 0.23 cm and anterior posterior diameter 4.44 ± 0.19 cm. The mean volume of right

and left kidneys were 118.80 ± 17.98 cm3 and 126.00 ± 18.36 cm3 respectively. On comparing means of right renal dimensions including mean right renal volume with left renal dimensions, a significant difference was observed (p = 0.001) **(Table1)**.

Table 1: Renal dimensions and Renal volume of right kidney and left kidney

Total participants (n) 250	Mean±SD(cm)	P-value	95% Confidence Interval of the Difference	
			Lower	Upper
Rt Rental L	10.81±0.71	0.001*	10.722769	10.901631
Lt Rental L	11.21±0.73	0.001*	11.029099	11.212341
Rt Rental W	4.771±0.23	0.001*	4.747795	4.806845
Lt Rental W	4.84±0.23	0.001	4.814698	4.874102
Rt Rental AP	4.36±0.21	0.001*	4.340547	4.393533
Rt Rental AP	4.44±0.19	0.001*	4.418850	4.469430
Rt Rental Volume(cm^3)	118.80±17.98	0.001*	116.5630	121.0429
Rt Rental volume (cm^3)	126.00±18.36	0.001*	123.7140	128.2883

Renal L=Renal length, Renal W=Renal width, Renal AP=Renal anteroposterior thickness.
*Confidence interval 95%, p-value ≤ 0.05 is significant**

Moreover on comparing mean value of renal dimension between males and females, all renal dimensions including renal volume of both right and left kidneys were found significantly greater in males as compared with females (p-value= 0.001) as shown in Table 2. By using Pearson's correlation analysis a weak positive non significant correlation in renal volume (right; r=0.024, p=0.79 and left; r=0.035, p=0.70) was observed between males and females.

Table 2: Renal dimensions in males and females

Parameters	Males n=129 Mean±SD	Males n=129 Mean±SD	P-Value
Rt RenalL(cm)	11.32±0.48	10.46±0.48	0.001*
Rt RenalW(cm)	4.91±0.20	4.62±0.17	0.001*
Rt RenalAP(cm)	4.47±0.16	4.24±0.19	0.001*
Lt RenalL(cm)	11.60±0.50	10.59±0.56	0.001*
Lt RenalW(cm)	4.98±0.19	4.69±0.16	0.001*
Lt RenalAP(cm)	4.54±0.16	4.33±0.17	0.001*
Rt Renalvolume(cm^3)	130.89±13.99	105.91±11.72	0.001*
Lt RenalLvolume(cm^3)	137.97±14.56	113.23±12.44	0.001*

*Rt = Right, Lt = left, Confidence interval 95%, p-value ≤ 0.05 is significant**

Mean values of renal dimensions of both kidneys were observed to gradually increase in third decade of life, remain stable in fourth decade and fifth decade of life and decreases significantly during sixth decade of life **(Table 3)**.

Table 3: Comparison of renal dimensions in different age groups

Age groups (years)	Group 1 (21 < 30)	Group 2 (31 < 40)	Group 3 (41 < 50)	Group 4 (51 < 60)	P-value
Totalparticipants (n)	n=45	n=46	n=78	n=81	
RtRenal L (cm)	10.89±0.55	11.24±0.48	11.25±0.52	10.09±0.46	0.001*
RtRenal W (cm)	4.79±0.17	4.94±0.17	4.88±0.20	4.56±0.16	0.001*
RtRenal AP (cm)	4.41±0.09	4.49±0.14	4.48±0.18	4.15±0.14	0.001*
LtRenal L (cm)	11.19±0.52	11.59±0.45	11.59±0.50	10.35±0.47	0.001*
LtRenal W (cm)	4.85±0.18	5.01±0.18	4.95±0.20	4.63±0.15	0.001*
LtRenal AP (cm)	4.48±0.09	4.55±0.14	4.55±0.17	4.25±0.13	0.001*
RtRenal volume (cm^3)	120.68±10.79	131.09±12.75	129.56±14.69	100.41±9.93	0.001*
LtRenal volume (cm^3)	127.66±10.73	139.00±12.90	137.21±14.60	106.88±9.77	0.001*

Rt= right, Lt=left, L=length, W=width, AP= anterior posterior thickness, Confidence interval 95%, p-value ≤ 0.05 is significant

By using Pearson's correlation analysis a significant negative moderate correlation was found between right renal volume and age (r = -0.456, p < 0.001). And same significant negative moderate correlation was found between left renal volume and age (r = - 0.462, p < 0.001). **(Figure 1 and Figure 2)**

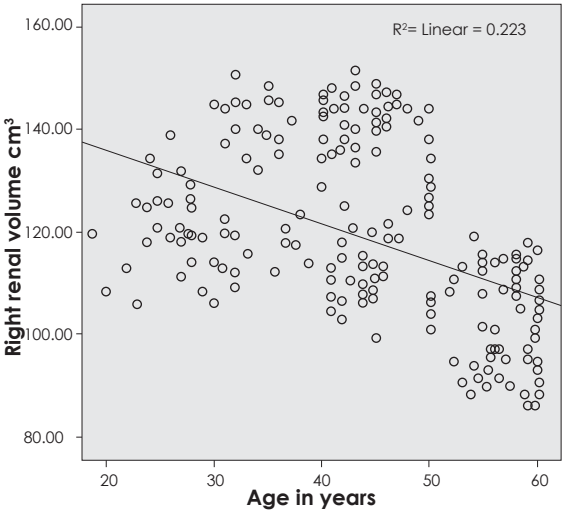

Figure 1: Scatter dot graph showing significant moderate negative correlation between Right renal volume and age, r = - 0.456, p < 0.001

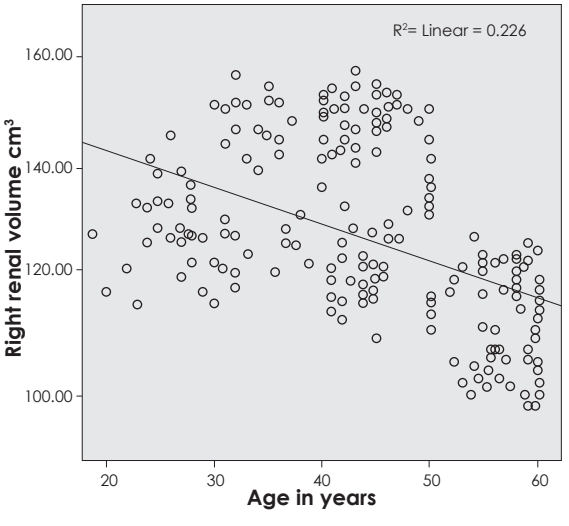

Figure 2: Scatter dot graph showing significant moderate negative correlation between Left renal volume and age, r = -0.462, p < 0.001

DISCUSSION

Renal dimensions which are commonly used for renal assessment are largely based on data derived from studies performed in western populations.[20] Most studies previously done in adults were anatomical studies or done on urograms or on ultrasonography. This study was carried out by using multiplanar reformatted CT scan images as this approach was proven to be the most accurate way of measuring kidney dimensions among imaging techniques.[12]

In present study, a total 500 kidneys of 250 adult individuals with no known renal pathology were evaluated to determine a baseline reference range of renal dimensions including renal volume and its association with age, gender and side of kidney in a subset of Karachi population.

Mean dimensions of right kidney were found to be length 10.81 ± 0.71 cm, width 4.77 cm ± 0.23, anteroposterior diameter (thickness) 4.36 cm ± 0.21 and volume 118.80 ± 17.98 cm^3. For left kidney mean dimensions were 11.12 cm ± 0.73, renal width 4.84 cm±0.23, renal anterior posterior diameter 4.44 cm ± 0.19 and renal volume 126.00 ± 18.36 cm^3. The results of our study are in accordance with similar studies conducted in India, Turkey and Malaysia.[11, 15, 21] However, our results were lower than reported in studies done in Denmark, Nigeria and South Africa, this is probably a reflection of the comparatively small body size of our Asian population.[22, 23]

Bernhard Glodny et al reported a significant difference ($p < 0.001$) between renal measurements of right and left kidneys. They found left kidney being longer and wider than right kidney.[9] In a study done in Brazil by Ferandes et al, it has been reported that the size of left kidney is larger than that of the right kidney and the difference in size is independent of gender.[24]Our study results are comparable to results reported in other studies as left kidney length, width, thickness and renal volume were significantly greater as compared to right kidney. The possible explanation which different studies have given is the presence of liver on the right side leading to restricted space for the right kidney to grow.[25]

A hospital based study conducted in India, reported mean renal volume of both kidneys in males was significantly greater ($p=0.04$) as compared to mean renal volume in females.11In the present study, all renal dimensions were found significantly greater ($p=0.001$) in males as compared to females (Table 2). This difference is probably due to large body size of males as compared to females. [22] Buchholz NP et al in their study reported a significant positive ($p= 0.000$) correlation in mean renal size between males and females. Similarly, in present study a weak positive correlation was observed in mean renal volume (right, $r = 0.024$; left, $r = 0.035$) between males and females.[25]

Few studies are conducted to determine the relationship between kidney dimensions and normal aging. Wang et al, in their study done on 1192 potential healthy kidney donors, reported that the volume of kidney increases during adulthood and remains stable till the age of 50 years but then subsequently declines in both genders. [10] In the present study, a gradual increase in mean renal volume of right and left kidneys was observed till the third decade. It remained almost stable during the fourth and fifth decades and then a gradual decrease was observed after 50 years of age (Table 3). A study conducted in 2011 found a weak negative correlation non significant between right and left renal length ($r = - 0.22$; $r = -0.21$, respectively) and age.[26] In our study a moderate negative significant correlation was observed between renal volume and age (Figure 1 and 2). Studies have reported that after third decade of life, progressive reduction of approximately 0.5cm in kidney length occurs with each decade, probably this is due to mechanisms like gradual reduction in renal blood flow after third decade, glomerulosclerosis, tubulointerstial fibrosis and oxidative stress with advancing age.[25, 27]

Present study provides a reference range of renal dimensions in a subset of Karachi population. Thus, this study will help clinicians, radiologist and surgeons in analysis of renal measurements and its normal variation in our local population according to age, gender and side of kidney.

CONCLUSION

It is concluded that normal value of renal dimensions varies significantly with side, gender and age of the individual. A weak positive correlation was observed between renal dimensions and gender and a moderate negative but significant correlation exists between renal dimensions and age.

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