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Sonographic Measurement of Renal Dimensions and its Correlates with some Anthropometric Parameters in Healthy Adults in Zaria, Northwestern Nigeria

Ibrahim T[1*], Buraimoh AA[1], Ojo SO[2], Adamu AA[3], Babayemi JO[3], Mustapha M[1] Iliyasu MO[1], Aliyu IA[1], [1]Ahmed I[1], Miko AM[1], Shehu AU[4] and Ahmed IM[5]

[1]Department of Human Anatomy, Faculty of Medicine, Ahmadu Bello University, Zaria, Nigeria.

[2]Department of Veterinary Anatomy, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, Nigeria.

[3] Department of Radiology, Ahmadu Bello University Teaching Hospital, Zaria, Nigeria

[4]Department of Anatomy, College of Medicine, Kaduna State University, Nigeria

[5]Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, Usmanu Danfodio University, Sokoto, Nigeria

Corresponding author: Ibrahim T
E-mail: drtasiu@yahoo.com; +2340833698669

ABSTRACT

Measurement of renal dimensions is essential in making decisions for renal transplant, avoiding or commencement of immunosuppressive therapy, renal biopsy and in monitoring and prognosticating disease progression or stability.The present study was designed to establish normative baseline renal size data of adults' Nigerian population in Zaria, and also to determine its correlation with height, weight, body mass index (BMI) and body surface area (BSA).This prospective study was conducted in the Department of Radiology, Ahmadu Bello University Teaching Hospital, Zaria between January and August 2016. Four hundred apparently healthy young adults (200 males and 200 females) resident in Zaria who gave their informed consent were randomly selected and recruited for the study. The ethical permit was obtained from the Ethical Committee of the Hospital. The longitudinal length and width of the right and left kidneys were measured. In addition, the age, sex, height (Ht), weight (Wt), BMI, and BSA of the subjects were recorded. All renal scans were done with a Mindray diagnostic ultrasound system (Model DC-3, 2010/2012, Nanshan, Shenzen, PR China) plus 2.5-6 MHZ curvilinear probe. The mean age was 22.41±3.35 years. The mean right and left kidney lengths were 9.94±0.70 cm and 10.28±0.80 cm respectively. The mean kidney width was 3.96 ± 0.36 cm and 4.33 ± 0.51 cm for right and left kidney, respectively. There was no significant sexual dimorphism in the renal dimensions ($p>0.05$). The left kidney length and width were significantly greater than the right kidney ($p<0.05$). Renal measurements were significantly correlated with the subject's Ht, Wt, BMI, and BSA ($p< 0.05$).The strongest correlation was seen between weight and right kidney width ($r=0.195$). Normal valuable baseline renal nomorgram have been established for the study population taking into cognizance the body parameters.

Keywords: Sonography, Measurements, kidney dimensions, Zaria

INTRODUCTION

Out of the lots of imaging modalities, ultrasound is the most preferred imaging modality in virtually all clinical surveys[1]. It is cheap, accessible, non-invasive, radiation free, requires little or no neither patient preparation, nor use of medication or routine injection of contrast agent. It has now become a fundamental part of the clinical assessment of healthy as well as pathologic kidneys[2]. Its portability and simplicity makes it an indispensable modality over magnetic resonance imaging (MRI) and computerized tomography (CT)[3]. Safak *et al.*[4] has also identified ultrasound as a reproducible, repeatable and reliable technique of imaging.

Measurement of renal dimensions is essential in making decisions for renal transplant, avoiding or commencement of immunosuppressive therapy, renal biopsy and in monitoring and prognosticating disease progression or stability[4, 5, 6]. Studies have implicated nephrologic disorders such as hypertension, diabetes mellitus and renal infections as the most important co-morbid conditions known to affect the kidney with or without resultant changes in the overall architecture of the organ[8, 9]. Other factors known to show variations with renal size are age, gender, ethnic backgrounds, weight, height, body mass index (BMI) and body surface area (BSA) [10, 11].

The information available on the current knowledge of kidney size is largely based on Western and Asian countries derived standards and this may be inappropriate for our population[12]. The dearth of documented studies on normal renal sizes determination by ultrasound in Nigeria and the fact that several factors can affect same (Ohikhokhai *et al.*[13]) makes it imperative to establish normative baseline renal size data for our population which could be used to label the kidney as physiological or pathological. The present study was designed to establish normative baseline renal size data of adults' Nigerian population in Zaria, and also to determine its correlation with height, weight, body mass index (BMI) and body surface area (BSA).

MATERIALS AND METHODS

The study was conducted in the Radiology Department of Ahmadu Bello University Teaching Hospital, Zaria between January and August 2016. Four hundred apparently healthy young adults (200 males and 200 females) resident in Zaria who gave their informed consent were randomly selected and recruited for the study. The study protocol was approved by the Ethical Committee of the Hospital and informed consent was obtained pre-participation. The subjects with any prior history of kidney disease or any condition that could modify the kidney structure or sonographic evidence of renal cyst, scarring, hydronephrosis were excluded from the study. Before the ultrasound examination, the participants were subjected to general physical examination in order to exclude any clinically apparent disease that could affect the renal dimensions. In order to avoid inter-observer and intra-observer error the sonographic measurements were done by a trained sinologist and the measurements taken in duplicate with their average values as the real measurement respectively. A pilot study involving twenty subjects was carried out by the sonologist with each subject lying in prone position according to the scanning protocols outlined by American Institute of Ultrasound in Medicine Proceedings (AIUM)[14]. The coupling gel was applied on the area of interest and a well defined kidney image that included both renal poles and which also clearly demonstrates the renal medulla and pyramids were captured at deep arrested inspiration. Kidney length was measured from pole to pole i.e. from the long axis (longitudinal) scan image while kidney width was measured at the widest anterior posterior (AP) diameter between the superior and inferior renal borders. Measurements of kidney length and width are demonstrated below (figure 1). The renal ultrasound was done with a Mindray diagnostic ultrasound system (Model DC-3, 2010/2012, Nanshan, Shenzen, PR China) plus 2.5-6 MHZ curvilinear probe. In addition, the age, sex, height (Ht), and weight (Wt) of the subjects were recorded and body mass index (BMI), and body surface area (BSA) were computed using the Mostelled[15] formula.

Descriptive statistics was expressed as mean ± standard deviation. Independent sample t-test was used to investigate sexual dimorphism in the variables and also for comparison of renal dimensions according to side. The Pearson correlation was used examine the significance of linear association between renal dimensions and anthropometric variables. All statistical analyses were performed with Statistical Product and Service Solutions (SPSS) version 23.0 and the significance level was set at $p<0.05$.

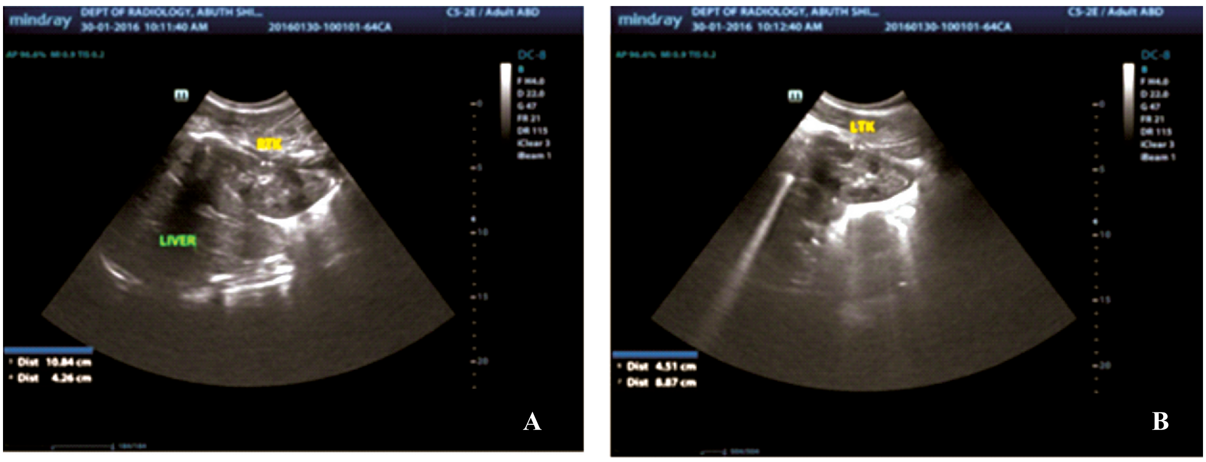

Figure 1: Sonogram demonstrating measurements of the renal length and width in the right (A) and left (B) kidneys

RESULTS

The overall age range was 18 to 35 years while the mean ages were 22.85±3.33 and 21.98±3.34 years for males and females respectively. The mean right and left kidney lengths were 9.94±0.70 cm and 10.28±0.80 cm respectively. The mean kidney width was 3.96 ± 0.36 cm and 4.33 ± 0.51 cm for right and left kidney, respectively (table 1). In table 2, there was no significant sexual dimorphism in the renal dimensions, however, mean height, weight and BSA were significantly higher in males ($p<0.05$) except for the BMI which was higher in the females ($p<0.05$). The left kidney length and width were significantly greater than the right kidney ($p<0.05$) (Table 3).

Table 4 is a Pearson correlation matrix of renal dimensions and some anthropomeric parameters. The height was negatively correlated with left kidney width only ($p<0.05$). The weight was negatively correlated with right and left kidney length and width ($p<0.05$). The BMI was negatively correlated with right and left kidney length and right kidney width whereas, BSA also showed negative correlations with right and left kidney length and width ($p<0.05$). The strongest correlation was seen between weight and right kidney width ($r=0.195$, $p<0.05$)

Table 1: Descriptive statistics of renal dimensions and some anthropometric variables

	All Subjects (400)		Male (200)		Female (200)	
Variables	Mean ± SD	**Min-Max**	**Mean ± SD**	**Min-Max**	**Mean ± SD**	**Min-Max**
AGE (years)	22.41 ± 3.55	18.00 - 35.00	22.85 ± 3.49	18.00 - 35.00	21.98 ± 3.34	18.00 - 35.00
Ht(m)	1.66 ± 0.08	1.46 - 1.91	1.70 ± 0.65	1.57 - 1.91	1.62 ± 0.07	1.46 - 1.77
WT(Kg)	60.02 ± 10.17	40.00 - 97.00	60.58 ± 8.38	46.00 - 86.00	59.46 ± 11.69	40.00 - 97.00
BMI	22.00 ± 3.33	15.81 - 36.13	21.18 ± 2.60	16.90 - 29.37	22.82 ± 3.75	15.81 - 36.13
BSA	0.31 ± 0.02	0.26 – 0.36	0.31 ± 0.17	0.26 – 0.36	0.30 ± 0.02	0.26 – 0.36
RKDL(cm)	9.90 ± 0.84	7.73 – 12.61	9.94 ± 0.7	7.73 – 12.22	9.97 ± 0.96	8.03 – 12.61
RKDW(cm)	3.94 ± 0.38	3.13 – 4.85	3.96 ± 0.36	3.10 - 4.80	3.91 ± 0.39	3.13 – 4.85
LKDL(cm)	10.24 ± 0.84	7.17 – 14.10	10.30 ± 0.80	7.17 - 12.22	10.19 ± 0.89	8.60 – 14.10
LKDW(cm)	4.30 ± 0.50	3.22 - 6.65	4.33 ± 0.51	3.39 - 6.65	4.26 ± 0.48	3.20 - 5.59

Ht: Height; WT: Weight; BMI: Body mass index; BSA: Body surface area; RKDL: Right kidney length; RKDW: Right kidney width; LKDL: Left kidney length; LKDW: Left kidney width

Table 2: Sexual dimorphism in renal dimensions and some anthropometric variables

Variables	N(male, female)	t-value
Age (years)	400(200, 200)	2.597*
Height(m)	-	12.58*
Weight(Kg)	-	1.97*
Body Mass Index (kg/m^2)	-	-4.419*
Body Surface Area	-	-4.419*
Right Kidney Length (cm)	-	0.795
Right Kidney Width (cm)	-	1.307
Left Kidney Length (cm)	-	1.031
Left Kidney Width (cm)	-	1.609

**p<0.05*

Table 3: Comparison of renal dimensions according to side

Parameters (n=400)	Side	Mean±SD	t-value
Kidney length (cm)	Right	9.90±0.84	-5.6*
	Left	10.24±0.84	
Kidney width (cm)	Right	3.94±0.38	-11.46*
	Left	4.30±0.50	

**p<0.05*

Table 4: Pearson correlation matrix of renal dimensions and some anthropometric parameters

	Kidney length (cm)		Kidney width (cm)	
Parameters	**Right**	**left**	**Right**	**Left**
Height (m)	-.077	-.059	-.076	-.104*
Weight (kg)	-.165*	-.177*	-.195*	-.121*
Body mass index (kg/m^2)	-.145*	-.170*	-.177*	-.076
Body surface area	-.156*	-.165*	-.184*	-.128*

**p<0.05*

DISCUSSION

The present study revealed the overall mean right and left kidney lengths to be 9.94±0.70 cm and 10.28±0.80 cm respectively while the mean kidney width was 3.96 ± 0.36 cm and 4.33 ± 0.51 cm for right and left kidney, respectively. However, in a study in south-east Nigeria by Okoye *et al*.[11] the mean right and left renal length were 10.4cm and 10.6cm respectively, whereas in study on adults in Sokoto North-Western Nigeria by Maaji *et al*.[12] the overall mean renal right and left kidneys lengths were 11.3cm and 11.6cm respectively while the right and left renal width were 4.6cm each. In another study on adults Mexican by Oyuela-Carassco *et al*.[16], the average right and left kidney lengths were 10.4cm and 10.5cm respectively and these is similar with the right (10.68cm) and left (10.71cm) renal dimensions obtained by El-Rashid and Abdul-fattah[17] on the adults Kuwaiti. The dimensions in the aforementioned studies are slightly higher than the ones in the present study. Similar with our findings are the right and left renal lengths of 9.77cm and 9.94cm and right and renal width of 4.08cm and 4.18cm respectively obtained by Yadav *et al*.[18] on adults Nepal. The discrepancies in the renal dimensions could be explained by the influence of genetics, nutrition and environmental factors on the different populations. Also these results have shown that it is inappropriate to use the same normogram for the same race or different ethnicity even if they are from the same country.

The present study also agrees with previous reports by fernandes *et. al*.[19], Marzotta *et.al*.[20] and Oyuela-Carassco *et al*.[16] that the right kidney is smaller than the left kidney. One likely reason for this difference, could be attributed to the smaller size of spleen than the liver, as such the left kidney has more space to grow than the right kidney whose growth is restricted by the relatively larger size of the liver. Another probable reason for the difference could be linked to the shorter and straighter length of the renal artery than the right one; these results in increased blood flow in the left artery and may ultimately cause a relative increase in the volume. The result of the present study also revealed insignificant sexual dimorphism in the renal dimensions ($p > 0.05$). This is in keeping with findings of the previous studies[4, 21, 22]. Thus, the renal dimensions in this population are not gender dependent and this overrules the need for special tables based on the gender.

In the present study, height did not show significant correlations with the kidney lengths except for the LKDW which was a negative correlation. Weight also showed negative correlations with the kidney dimensions. This means that taller and heavier individuals in this population will have a narrower and shorter kidney. This is contrary to the reports by Bucholz *et al*.[23], Mazotta *et al*.[20] and Emamian *et al*.[10] who concluded that taller and heavier individuals tend to have wider and longer kidneys than their shorter counterparts. The disparity seen could be tied to variation in race or different ethnic origin and genetics.

With regards to the body size Gebrehiwot and Atnafu[24] on Ethopian population and Zeb *et al.*[25] on Asians observed a positive correlation with the renal length and renal volume and concluded that determination of renal size should be done taking into cognizance the body size. Their finding is congruent both with literature and common logic since organ size is directly proportional to the body size especially in healthy adults. Another likely explanation could be taken from Brenner's law of correct renal dosing which states that larger body size requires a larger nephron dose to meet its metabolic demands[26, 27, 28].

However, the present study revealed that body size (BMI and BSA) was inversely correlated with the renal dimensions. Thus, it could be inferred that the larger the body habitus the smaller the renal dimensions, therefore smaller drug dose are needed for the drugs metabolic demand in this population. The take home for the Nigerian ultrasound community from this study is very clear because of the possible variations in the anthropometric variables of diverse populations, races and regions. Thus, population specific normograms of the kidneys should be advocated with special reference to the body parameter that shows the best correlation with kidney dimensions in different ethnic origins or races.

CONCLUSION

Normal valuable baseline renal nomorgram have been established for the study population taking into cognizance the body parameters. A multicentre study is recommended in other regions of the country as this might improve the exactness of the estimates and also the generalizability of the data.

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Nil

Conflicts of Interest

There are no conflicts of interest

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