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Normal Renal Dimensions In An Adult Nigerian Population

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ABSTRACT

A total of 310 subjects were randomly selected from Southeast Nigerian adults with absence of any disease that could modify renal dimensions. Length, width and area of both kidneys were measured by Transabdominal ultrasound and correlated with gender, age, height, body weight, and body mass index (BMI). 135 (43.5%) of the subjects were males while 175 (56.5%) were females. Age ranged from 18 to 80 years old, height from 1.45 to 1.85m (1.67 ± 0.08) for men and (1.60 ± 0.08 for women), body weight from 46 to 102 kg (68.1 ± 6.0 for men and 63.5 ± 65.5 for women) and BMI from 17.3 to 40.1 kg/m^2 (24.4 ± 2.4 for men and 24.8 + 2.8 for women). There was an association (one-way ANOVA test) between length, width and area for each kidney and for both, with height ($P < 0.001$), body weight ($P < 0.001$), BMI ($P < 0.001$), and gender ($P < 0.001$). Renal lengths and area reduced with age ($P < 0.001$). Considerable reduction was noted from the 5th decade when compared to the other age ranges. Notably, kidney lengths decreased by about 0.3cm per decade from the 5th decade onwards. The left kidney was generally bigger than the right kidney ($P < 0.01$). Results suggest that the normal pattern of renal length reported by other studies is inadequate for Nigerian black population.

KEYWORDS: Kidney; Biometry, Ultrasonography.

The background knowledge of normal renal dimensions (RD) is important for the diagnostic and the prognostic of nephropathies. Kidney dimensional variations occur in nephropathies due to hypertropic process and /or atrophy (Elkin, 1980). Therefore, it is essential to establish the pattern of normal renal dimensions.

It has been postulated from necropsy studies that variation in RD and renal weight are related to gender with weight being higher in males (Moell, 1956). It is also known that the left kidney is larger than the right kidney, independent of gender (Moell, 1956;Emamian et. al; 1993). Data from necropsies are not universally accepted, since a wide variation in the dimensions is observed, and this variability has been confirmed by studies utilizing intravenous pyelographies (Moell, 1956;Braasch et. al; 1938). Studies in this field have also tried to establish a correlation between RD and age, since it was shown that a reduction of up to 40% in renal weight occurs over the years (Korenchevsky, 1942;Simon, 1964;Wald, 1937)

Notably, normal renal dimensions among Caucasians are well documented in the literature (Brandt et.al; 1983;Brown, 2003;Roger et.al; 1994). Racial differences in renal parameters have been found to exist (Ukoha et al; 2002;Mario et al; 2002). The available data for Nigerian blacks are scanty and are culled from relatively small sample sizes. There is, therefore, the need to establish normograms for the kidney dimensions in Nigerian population. Thus, the aim of this study was to evaluate the normal RD in adult Nigerian population, and to verify possible correlations with gender, age, height, body weight and BMI.

MATERIALS AND METHODS

Scope

The study was carried out at University of Nigeria Teaching Hospital, Enugu and Federal Medical centre, Abakaliki. These hospitals have the southeast geographical zone of Nigeria as their catchments area. The study took place between August 2002 and November 2003. Adults within the age range of 18 to 80 years old were included in the study.

Patient Selection

The RD of 310 subjects was measured prospectively by ultrasonography. The following criteria for patient inclusion were used:

I. No acute or chronic disease that could lead to renal impairment;

ii. No personal or family history of renal disease;
iii. Subjects aged 18 years and above, whose renal outlines were clearly visible on ultrasound scan;
iv. Non-pregnant females.

Scanning Techniques

All subjects underwent real time ultrasound scans using 3.5 mHz transducers with a Medison's Sonoace 3200 or a Siemens SL-1 machine. Longitudinal scans were performed with the patient in the lateral decubitus position or in supine oblique position. Several scans through the long axis of the kidney were made to ensure that the measurements were accurate.

Length (L), Width (W), and area of both kidneys were measured. The major distance between the renal poles (superior and inferior) was taken as the kidney length (KL). The major distance between the lateral and medial borders perpendicular to the length was taken as the kidney width (KW). Renal area (RA) was estimated through the formula used for an ellipse,

RA = - x KL x KW/4, where - is a constant (3.1416) (Mario et.al; 2002). Two operators obtained these measurements for each patient to minimize inter observer error.

Apart from the renal measurements, age, gender, height, body weight, and BMI were recorded in all subjects. BMI = Weight (kg)/ Height $(m)^2$.

Statistical Analysis

Results are reported as mean ± standard deviation (S ± SD). Comparison of KL by weight, height and BMI of subjects was done by Analysis of Variance and multiple comparisons with the Tamhane test. The differences were considered statistically significant when $P < 0.001$. Renal dimensions of left and right kidneys were compared by the paired t - test. The differences were considered statistically significant when $P < 0.01$

RESULTS

The general data for the studied population is shown in Table I. Age ranged from 18 to 80 years, height from 1.45 to 1.85m, body weight (BW) from 46 to 102 kg, and BMI from 17.3 to 40.1 kg/m^2.

Table 2 shows the normograms of RD. Generally the left kidney have larger RD. The lower limit of normal for KL is 8.6cm for both kidneys.

When RD was analyzed with respect to BW, it was shown that KL correlated to those levels (Table 3), ($P < 0.001$). Similarly, when the data was grouped according to height, this variable showed a significant association with KL (Table 4), ($P < 0.001$). Also when the data was analyzed with respect to BMI, it was shown that KL correlated to those levels but rather less strongly compared to BW and height (Table 5), ($P < 0.001$).

Table 6 presents an analysis of height with respect to BW, showing that individuals with higher mean height had higher BW.

Table 7 shows the distribution of RD by age according to decades of life. There was a considerable reduction in both KL and RA for subjects in the 5th and 6th decades compared to other decades ($P < 0.001$).

Table 8 presents the relationship between gender and mean RD. There was no significant difference among KL, KW and RA for men or women ($P > 0.001$).

DISCUSSION

Normal RD is an additional tool to study renal functions. Renal size has traditionally been measured on the intravenous urogram. Urographic measurements have the advantage of reproducibility but suffer the disadvantage of magnification, in part due to urographic technique and also due to the osmotic diuresis caused by the contrast medium (Dorph et.al; 1977). Although, ultrasonographic renal measurements are less reproducible, it is the imaging modality of choice because it is relatively cheaper, non-invasive and non-ionising. It is also less time consuming and does not produce magnification.

In the present study, we analysed renal size in terms of length and width, which are simple, reproducible, reliable and objective measurements. Data obtained by measurements of the right and left

Table I General data for the studied population (n = 310; 135 males and 175 females)

Parameter	Gender	Mean ± SD
Age (years)	Combined	3.8 ± 10.6
Patients' Height (m)	Males	1.67 ± 0.08
	Females	1.60 ± 0.08
Body Weight (Kg)	Males	68.1 ± 6.0
	Females	63.5 ± 6.5
Body Mass Index (Kg/m^2)	Males	24.4 ± 2.4
	Females	24.8 ± 2.8

Table 2 – Normograms of Renal Dimensions (X ± SD), n = 310

Renal Dimensions	Normogram	Range
Right Kidney Length (cm)	10.3 ± 0.7	8.5 – 12.5
Left Kidney Length (cm)	10.5 ± 0.6	8.6 – 12.8
Right Kidney Width (cm)	4.4 ± 0.5	3.2 – 5.6
Left Kidney Width (cm)	4.5 ± 0.5	3.4 – 5.7
Right Kidney Area (cm^2)	34.3 ± 4.3	24.1 – 50.0
Left Kidney Area (cm^2)	36.1 ± 2.7	24.7 – 51.4

Table 3 – Renal Length (X ± SD) distributed according to body weight (n = 310)

Body Weight (kg)	Length (cm)	
	Right *	Left *
< 60; n= 87	9.7 ± 0.5	9.9 ± 0.5
60 -69; n = 111	10.3 ± 0.7	10.5 ± 0.7
70 – 79; n = 72	10.7 ± 0.5	10.8 ± 0.5
> 79; n = 40	10.8 ± 0.6	10.9 ± 0.6

* P < 0.001 according to Analysis of Variance

Table 4 – Renal Length (X ± SD) distributed according to patients' height (n = 310)

Patients' Height (M)	Length (cm)	
	Right *	Left*
< 1.56; n= 90	10.0 ± 0.6	10.1 ± 0.6
1.56 -1.65; n = 138	10.2 ± 0.5	10.4 ± 0.5
1.66 – 1.75; n = 70	10.4 ± 0.6	10.7 ± 0.6
> 1.75;n = 12	10.8 ± 0.2	11.0 ± 0.2

* P < 0.001 according to Analysis of Variance

Table 5 – Renal Length (X ± SD) distributed according to Patients' Body Mass Index (n = 310)

BMI (Kg/M^2)	Length (cm)	
	Right *	Left *
< 23.0; n= 88	10.1 ± 0.3	10.2 ± 0.3
23.0 -25.9; n = 105	10.2 ± 0.5	10.3 ± 0.5
26.0 – 28.9; n = 66	10.4 ± 0.6	10.5 ± 0.6
> 28.9;n = 51	10.4 ± 0.4	10.5 ± 0.4

* P < 0.001 according to Analysis of Variance

Table 6 – Relationship between patients' Height and Weight (n = 310)

Weight (kg) *	Height (M) *
< 60; n = 88	1.56 (0.006)
60 – 69; n = 111	1.62 (0.006)
70 – 79; n = 72	1.63 (0.006)
> 79; n = 39	1.68 (0.008)

* P < 0.001 according to Analysis of Variance

Table 7 – Renal Dimensions (X ± SD) distributed by age (grouped by decade of life); n = 310

Decade	Kidney length (cm)		Kidney Width (cm)		Kidney Area (cm^2)	
	RK *	LK *	RK*	LK*	RK*	LK*
2nd; (n = 125)	10.8 ± 0.3	10.9 ± 0.4	4.2 ± 0.1	4.3 ± 0.2	36.9 ± 3.3	38.1 ± 3.3
3rd; (n = 77)	10.7 ± 0.5	10.8 ± 0.5	4.1 ± 0.2	4.2 ± 0.2	36.8 ± 2.2	38.0 ± 2.2
4th; (n = 42)	10.6 ± 0.5 10.3 ±	10.7 ± 0.5	4.2 ± 0.2	4.4 ± 0.2	35.0 ± 2.2	37.0 ± 3.3
5th; (n = 32)	0.8	10.4 ± 0.8	4.3 ± 0.3	4.4 ± 0.1	34.1 ± 6.6	36.6 ± 3.3
6th; (n = 34)	10.0 ± 0.9	10.2 ± 0.9	4.2 ± 0.4	4.3 ± 0.2	33.4 ±5.5	34.5 ± 6.6

* P < 0.001 according to Analysis of Variance; RK = right kidney; LK = left kidney.

Table 8 Relationship Between Gender and Renal Dimensions (Mean), n = 310;135 males and 175 females

Renal Dimensions	Gender Male (n = 135)	Female (n = 175)
Right Kidney length (cm)	10.36	10.23
Right Kidney width (cm)	4.46	4.24
Left Kidney length (cm)	10.67	10.38
Left Kidney width (cm)	4.55	4.38
Right Kidney area (cm^2)	34.42	34.25
Left Kidney area (cm^2)	36.50	35.61

kidneys agreed with data from previous studies, showing that the left kidney is larger than the right (Simon, 1937;Ukoha et. al; 2002; Mario et.al; 2002;Odita 1982; Sampaio, et.al; 1989). The anthropometric profile of the sample showed a significant difference between genders. (Table 1) for BW, BMI and height. Previous study done on a Brazilian population (Mario et. al; 2002) showed similar findings.

The present study has shown that the overall mean KL of the right kidney is 10.3 $\pm$ 0.7cm (range 8.5 12.5) and of the left kidney 10.5 $\pm$ 0.6cm (range 8.6 12.8cm), (Table 2). The above findings are in agreement with the average KL of 10.3 $\pm$ 0.9 cm for right kidney and 10.7 $\pm$ 0.8cm for left kidney (n = 120) reported for a similar Nigerian black population (Ukoha et.al; 2002). Compared with Caucasian values, these observed values for Southeast Nigerians appear smaller. For instance, Brandts' study in 1983 indicated a mean KL of 10.74 $\pm$ 1.35cm and 11.0 $\pm$ 1.15cm for right and left kidneys respectively. Similarly, Brown (2003) in a recent study reported a mean value of 10.9cm for right kidney and 11.2 for the left; whereas Roger et. al; (1994) established that the overall mean length of the left kidney was 10.79 $\pm$ 1.33cm and of the right kidney 10.86 $\pm$ 1.41cm for Caucasians. Racial differences in KL have been attributed to genetic and environmental variations (Ukoha et al; 2002). The lower limit of normal for KL appears to be 8.6cm (Table 2). The Caucasian lower limit of normal for KL is generally accepted as 9cm (Brown, 2003). However, this depends on patient habitus. There is also considerable observer variability in measuring KL with difference of up to 1.85cm reported (Ablett et al; 1995). A formula for estimating renal volume of which is correlated with BMI has been published in an attempt to overcome difference in patient habitus but there has been little clinical correlation with these measurements (Derchi et.al; 1998).

The relation between BW and height in this population showed that individuals with higher BW also have higher heights (Table 6). The present data show that Nigerian blacks have a mean height between that of Asian (Wang, 1989) and European (Moell, 1956), table not shown. One study in Pakistan (Bucholz et.al; 2000) also highlights the necessity of investigating RD for each population, emphasizing that European and American populations' data cannot be used as universal patterns.

The association between RD and BW, height, and BMI showed a highly significant direct relation in the higher ranges (BW and height > BMI). In younger adults, height was the only variable correlated strongly with RD, justifying the use of this parameter in reference tables for RD. A previous study found similar data analyzing RD by ultrasound(Emamian et.al; 1993).

Renal area is not usually employed as a RD parameter. However, in the present study, RA was shown to have consistent correlation with age, decreasing as age increases (Table 7). There was a considerable reduction in size of RA in the 5^{th} and 6^{th} decades of life. We suggest, therefore, that RA is a good parameter for detecting variations in RD with respect to age, and thus may be used.

It is known that aging leads to a progressive reduction of renal size (Mclachlan and Wasserman, 1981). In this present study, from the 5^{th} decade on, KL decreases approximately 0.3cm per decade (Table 7). This conspicuous reduction in RD in the 5^{th} and 6^{th} decades is considerable compared with other age ranges. Miletic et al; (1998) also reported that this decrease tends to accelerate from the 6^{th} decade. Meyer and Bellucii (1986) suggested that this observation could be due to increased glomerular sclerosis and arteriolar vascular changes, in aging population. Previous studies established that from the 5^{th} decade on, KL decreases approximately 0.5cm per decade, especially due a reduction of about 1% per year in blood flow after the third decade (Wald, 1937; Mclachlan and Wasserman, 1981). The difference in the present study may be due to genetic and environmental variations.

There was no significant difference among KL, KW and RA for male and female (Table 8), suggesting that gender is not an independent determinant factor for RD. Therefore, special table based on gender are not necessary.

In conclusion, present data show that the mean values obtained for RD are smaller than Caucasian values. Notably, the present KL values for Southeast Nigerians show that the normal pattern defined by other studies from other races is not adequate for our population. However, multi-centre studies are advised to obtain reliable nationwide normograms.

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