Sonographic Assessment of Renal Dimensions in Hypertensives as Compared to Normotensive Adults in a Black African Population

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Abstract

Introduction: Hypertension is a sustained systolic blood pressure greater than 140mmHg or diastolic blood pressure greater than 90mmHg in patients. The kidneys play a central role in the control of high blood pressure through the renin-angiotensin system. Thus, renovascular changes of myointimal hyperplasia in the intrarenal arteries may cause increase in renal arterial impedance, reduction in renal length and cortical thickness may be noted in prolonged hypertension, and eventually cause irreversible hypertensive nephropathy .

The early detection of these renal changes using ultrasonography can provide opportunity for immediate intervention towards preventing or at least delaying the irreversible hypertensive nephropathy.

Aims and objectives: To determine and compare the renal length and cortical thickness in both healthy normotensive and hypertensive adults at St. Nicholas Hospital Lagos.

Materials and methods: A prospective comparative study of renal dimensions using ultrasound in 75 hypertensive and 75 normotensive control adults at St. Nicholas Hospital Lagos was conducted. Measurement of renal length and renal cortical thickness were done with the patient in supine and prone positions. The data was analysed with the aid of computer based SPSS 20.0 software for windows.

Results: There were 75 hypertensives and 75 normotensive subjects, their ages ranged between 35 and 80 years. The mean renal lengths were10.17 ± 0.65cm and 10.44 ± 0.72cm and the mean renal cortical thicknesses were 0.91 ± 1.49cm and 0.95 ± 1.51cm on the right and left sides, respectively in normotensive control subjects while those of hypertensive subjects were 9.61 ± 0.43cm and 9.82 ± 0.38cm for mean renal lengths, 0.82 ± 0.71cm and 0.84 ± 0.29cm for the cortical thickness, on the right and left sides respectively.

Conclusion: The renal dimensions were slightly higher in normotensives, when compared with the hypertensive subjects.

Key words: **Ultrasound, Renal dimensions, Essential Hypertension**.

I. INTRODUCTION

Hypertension is defined by the World Health Organization (WHO) as a sustained systolic pressure greater than 140mmHg or a diastolic pressure greater than 90mmHg in subjects.[1] The WHO/International Society of Hypertension (ISH) classified hypertension as follow: Mild Hypertension=141-159/91-99mmHg, Moderate Hypertension=160-179/100-109mmHg and Severe Hypertension= ≥180/≥110mmHg.[1]

Although the kidneys play a central role in the control of high blood pressure, hypertension is a significant risk factor for renal injury and end stage irreversible renal damage by inducing myointimal hyperplasia of the intrarenal arteries.[2] The early detection of its effects on the kidneys using ultrasonography may prevent or at least delay irreversible renal damage through early treatment and intervention.

The prevalence of hypertension in the United Kingdom has been reported to increase significantly from 35.8% to 41.4% among blacks and from 24.3% to 28.1% among whites over a three year period and remains significantly higher among blacks.[3] Most studies in the United Kingdom and the United States reported not only a higher prevalence but also a higher awareness of hypertension in black people than in white people.[3] Mortality from hypertension in British African-Caribbean born people is four times the national rate; with similar data being published for African American citizens.[4] Africans have a higher prevalence and incidence of hypertension than Caucasians.[5] People of African descent tend to develop hypertension at an earlier age and have lower renin activity; target organ damage also differs in black people from that in white people.[6] Black men are at greater risk than white men for developing end stage renal disease at every level of blood pressure, due to genetic variation in the renal epithelial sodium channels among the black people of African origin.[7,8]

The overall prevalence of hypertension in Nigeria (2013) was 22.7%.[9] It is more prevalent in the urban cities of Nigeria with a rate of 32.7% than in the rural areas where a prevalence rate of 12.9% was noted.[9] This may be attributable to the change in life style due to modernization which has swept across most urban cities in Nigeria. The last published report of a national survey in 1997 by Akinkugbe under the auspices of the Federal Ministry of Health showed that Lagos state was among the states with the highest prevalence of essential hypertension in Nigeria,[10] making it important to study the effect it has on the kidneys.

There are several imaging methods used to evaluate hypertensive nephropathy but gray scale sonography is often used as the initial imaging procedure which is readily available, affordable and non-invasive. The gross changes in hypertensive nephropathy are reduction in renal length and cortical thickness due to increase in renal arterial impedance leading to reduction in renal parenchymal perfusion.

It is therefore important to detect these renal changes through routine surveillance since early intervention may prevent or at least delay the renal damage. This study will assess the effects of the hypertension on the kidneys.

II. MATERIALS AND METHODS

This is a prospective comparative study carried out over twelve months period at the Radiology department of St. Nicholas Hospital Lagos in south western Nigeria. Ethical approval for the study was obtained from the institution ethical review committee.

Methodology:

Informed consent of the subjects was obtained. To ensure adequate compliance with inclusion and exclusion criteria, brief clinical history (such as history of diabetes mellitus, sickle cell disease, end-stage renal disease and pregnancy) and physical examination (such as blood pressure and pulse rate) of the subjects were taken. All the hypertensive subjects' hospital case files were crosschecked to ascertain their renal biochemistry status. Each of the subjects was psychologically reassured and the procedure comprehensively explained to them.

Subjects were scanned using a real time [Mindray DC-6 schenzhen, China] coupled with 3.5MHz transducer. The subject lay down supine on the examing couch. Scanning was done in supine and then prone positions after the application of adequate amount of coupling gel on the area of interest to permit sound conduction, with subsequent placement of the transducer. A global examination of the kidneys was performed. The echogenicity (Figure 1) was first assessed to establish its normalcy.[11] Then the renal cortical layer thickness was measured in the sagittal plane, above the medullary pyramid, perpendicularly to the capsule, in the upper and middle thirds of the kidney. The bipolar length was measured from the upper to the lower pole, in the sagittal plane. The parenchymal thickness was measured either on the upper or lower pole, depending on the degree of visualization (Figure 2).. The gray scale ultrasonography can demonstrate the intrarenal anatomy such as cortex, medulla and arcuate vessels.[11] The arcuate vessels can be recognized as a discrete high level echo at the corticomedullary junction that should not be confused for calculi.

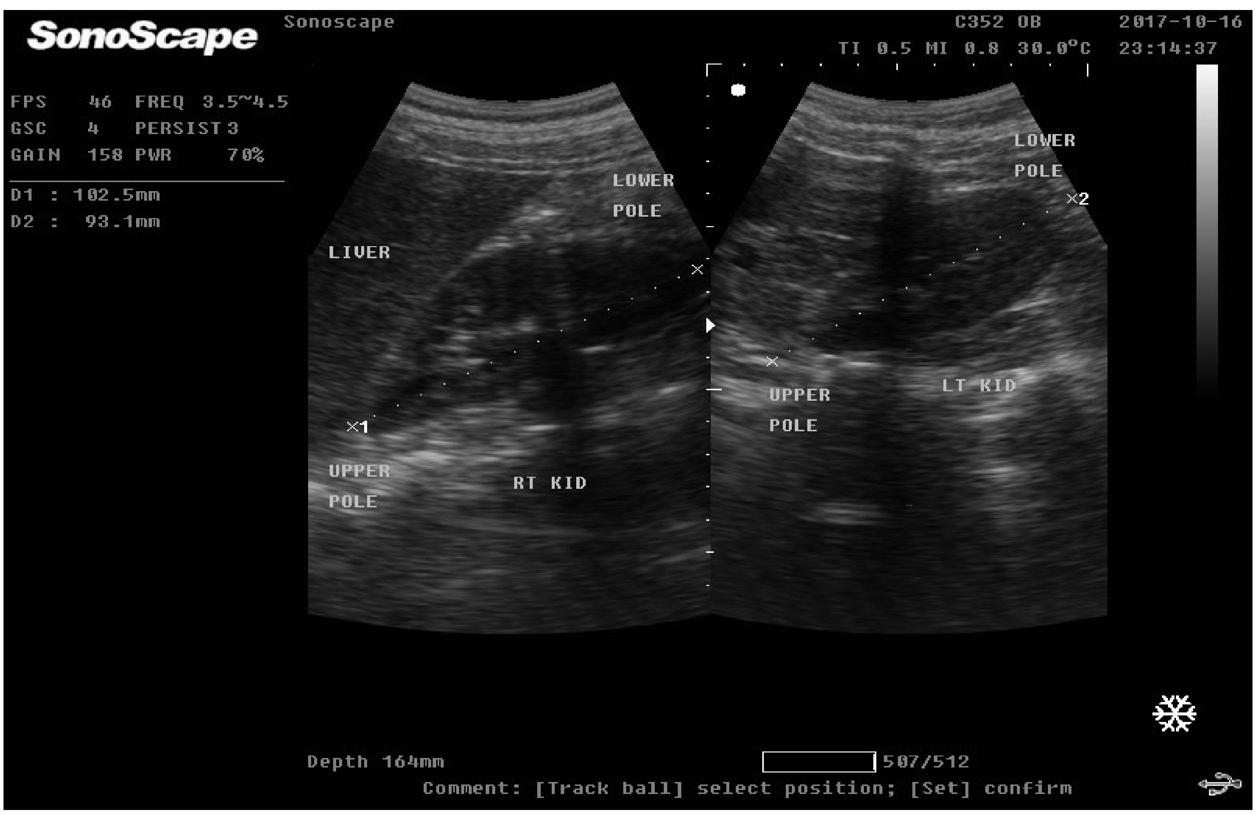

Figure 1: Longitudinal ultrasound scan of normal kidneys with their bipolar measurements.

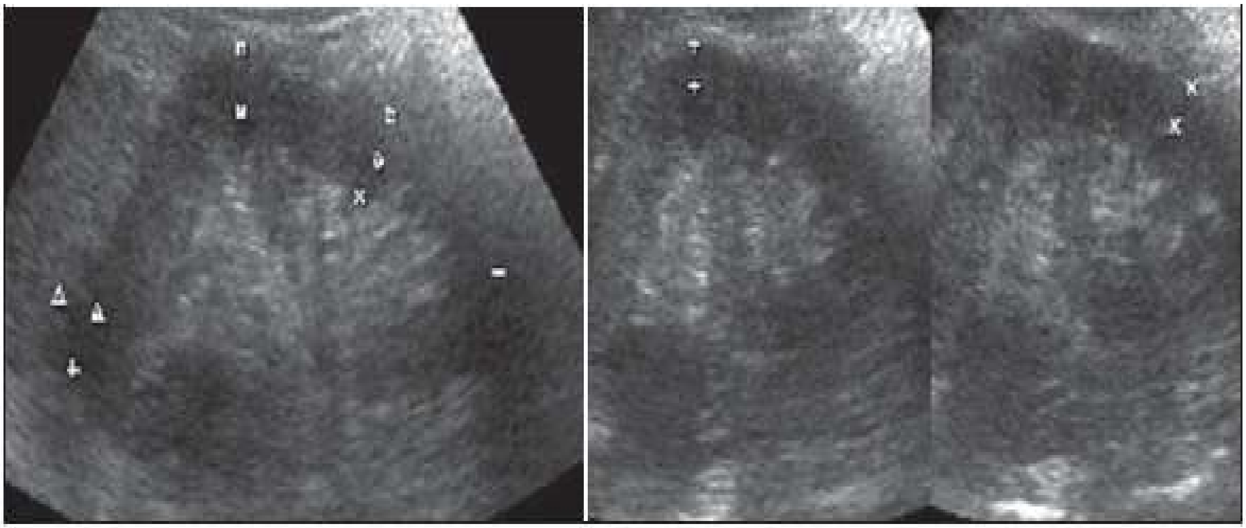

Figure 2. Sonographic images describing how renal cortex and parenchyma thicknesses were obtained

III. RESULTS

A total of 150 subjects (75 hypertensives and 75 normotensives) that fulfilled the inclusion criteria were recruited in this study (Figure 3). The age range of the subjects (hypertensive and normotensive) in this study was between 35 and 80 years. The control group (normotensive) was made up of 45 males and 30 females. The hypertensive group also consisted of 45 males and 30 females.

Majority of the hypertensive subjects (20.7%) in this study were within the age of 61 – 65 years while the majority of the normotensive (20%) were within 51 -55 years age group as illustrated in Figure 4. In both the hypertensives and normotensives, only 7.3% of the subjects were within the lower limit of 35 - 40 years. The mean (±sd) ages of both hypertensive and normotensive groups were 56.51 ± 8.71 years and 56.17 ± 7.86 years respectively. This age difference was not statistically significant (p=0.71) – Table 1

The duration of hypertension ranged between six months and 50 years with a mean of 8.7 years. Less than half of the patients (70; 46.7%) have had hypertension for more than five years, 45 (30%) have had it for 1–5 years, and 35 (23.3%) had it for less than one year -Tab 2 & Figure 4.

The mean renal lengths of the right kidneys in both normotensive and hypertensive subjects were 10.17 ± 0.65cm and 9.61 ± 0.43cm with p-value of 0.07 which was not statistically significant.

Similarly, the left mean renal length values in both groups were 10.44 ± 0.72cm and 9.82 ± 0.38cm respectively, with the difference that was not statistically significant (p=0.07) - Table 3.

As also noted in the same Table 3, both groups showed higher mean renal cortical thickness on left side than that on the right. The mean renal cortical thickness of the right kidneys in hypertensive and normotensive subjects were 0.82 ± 0.71cm and 0.91 ± 1.49cm respectively with p-value of 0.04, which was statistically significant. The left mean renal cortical thickness in both hypertensive and control groups were 0.84 ± 0.29cm and 0.95 ± 1.51cm respectively. The difference was also statistically significant with p-value of 0.04.

Table 4 also showed a positive correlation between the systolic blood pressure, diastolic blood pressure and body mass index. However, there is no correlation between the age and duration of hypertension.

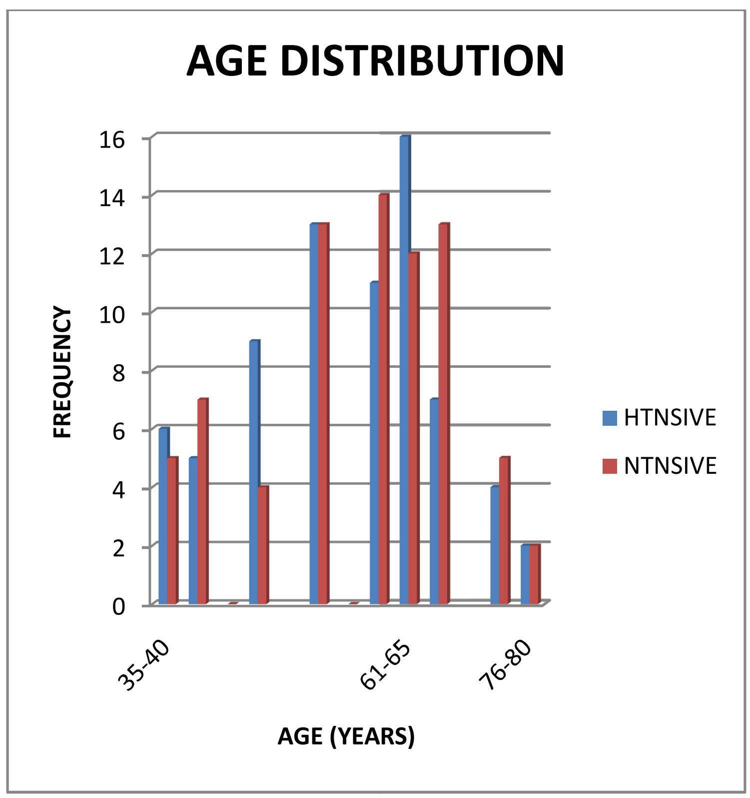

Figure 3: Histogram Showing Age Distribution Among Hypertensive (75) and Normotensive (75) Subjects.

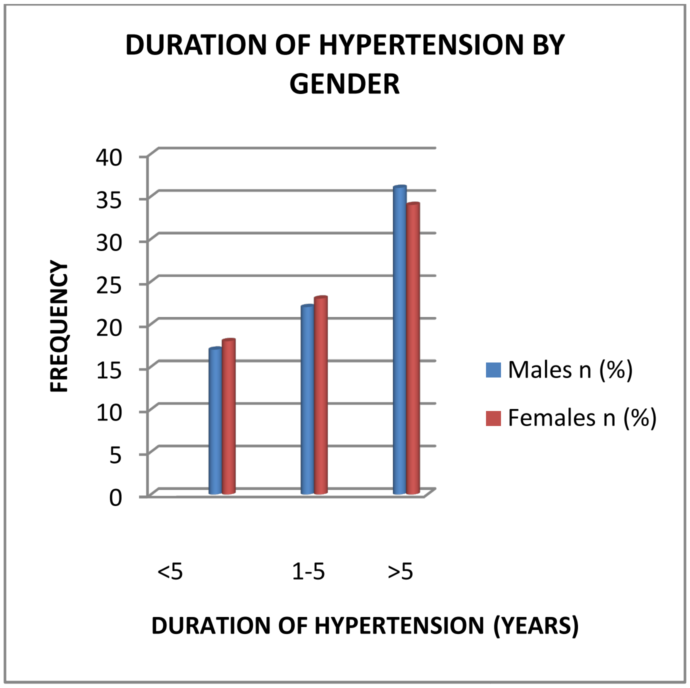

Figure 4: Histogram showing the distribution of the duration of hypertension by gender.

Table 1: Age Distribution of Subjects in the Study Groups: N=150

parameters	Frequency (%)		Mean ± sd		p-value
	Hypertensive n=75	Normotensive n=75	Hypertensive n=75	Normotensive n=75	
Age (years) 35-40	6 (8)	5(6.7)	54.21 ± 8.71	54.47 ±7.86	0.71
41-45	5(6.7)	7(9.3)			
46-50	9(12)	4(5.3)			
51-55	13(17.3)	13(17.3)			
56-60	11(14.7)	14(18.7)			
61-65	16(21.3)	12(16)			
66-70	7(9.3)	13(17.3)			
71-75	4 (5.3)	5(6.7)			
76-80	4(5.3)	2(2.7)			
TOTAL	75 (100)	75 (100)			

Table 2: Duration of hypertension by gender

Duration of hypertension (years)	Males n (%)	Females n (%)	Total n (%)
<1	17 (22.7)	18 (24)	35 (23.3)
1-5	22 (29.3)	23 (30.7)	45 (30)
>5	36 (48)	34 (45.3)	70 (46.7)
Total	75 (100)	75 (100)	150 (100)

Table 3: Ultrasonographic Renal Dimensions for the Normotensives and Hypertensives

Group: N=150.

RENAL PARAMETERS	Mean ± sd		P-VALUE
	NORMOTENSIVE	HYPERTENSIVE	
Right renal length (cm)	10.17 ± 0.65	9.61 ± 0.43	0.07
Left renal length (cm)	10.44 ± 0.72	9.82 ± 0.38	0.07
Right renal cortical thickness (cm)	0.91 ± 1.49	0.82 ± 0.71	0.04
Left renal cortical thickness (cm)	0.95 ± 1.51	0.84 ± 0.29	0.04

Table 4: The strength of association between age, BMI, SBP, DBP and duration of hypertension

Characteristics	Pearson's correlation coefficient (r)	p-value
Age	0.182	0.132 (NS)
Body Mass Index	0.301	0.031
Systolic Blood Pressure	0.204	0.002
Diastolic Blood Pressure	0.222	0.004
Duration of Hypertension	0.210	0.117 (NS)

NS= Not significant

IV. DISCUSSION

The morphology of visceral organs varies from individual to individual. The measurement of renal dimension using ultrasonography provides objective, quick, and reliable way to evaluate the kidney size.[12]

Essential hypertension is a major public health issue because of its frequent renal complications[13].

The mean renal lengths (right=10.17 ± 0.65cm and left=10.44 ± 0.72cm) in normotensive subjects found in this study are highly comparable with the findings of Okoye et al[14] and Adebayo et al[15] who reported 10.3cm and 10.6cm; and 10.0cm and 10.2cm on the right and left sides respectively. These reports from studies done in Nigeria are also similar to those of Bucholz et al[16] who documented 10.4 ± 0.08cm on each side in Pakistani and Barton et al[17] in Jamaican normotensive adults, who reported the mean renal lengths of 9.7 ± 0.07cm and 10.0 ± 0.07cm on the right and left sides respectively. The mean renal lengths from above studies were however slightly lower when compared with studies done among normotensive Caucasians by Brandt et al[18] who reported 10.74 ± 1.3cm and 11.10 ± 1.1cm on the right and left sides respectively and also Emmamian et al[19] who documented the mean renal length of 10.9cm and 11.2cm on the right and left sides respectively. These racial differences in renal lengths may be attributed to genetic and environmental variations.[20]

The index study also showed that the mean renal lengths of the hypertensives were 9.61cm and 9.82cm on the right and left sides respectively, which are slightly lower than that of the normotensives (right=10.17cm and left=10.44cm), with mean renal length differences of 0.56cm and 0.62cm on the right and left sides respectively, which were found to be statistically not significant, p=0.07 on each side. This is similar to the finding reported by Bucholz et al[16] that the hypertensive kidneys were smaller than the non-hypertensive kidneys. This mild reduction in the

renal length could be due to hypertensive induced ischaemic changes with resultant fibrosis and hyalination.[6] This study also concored with the work done by Raman et al[21] in United Kingdom which showed that blood pressure did not correlate with kidney size in the normotensive healthy adults.

In both hypertensive and normotensive subjects, it was shown in our study that the mean renal length was slightly longer on the left than on the right side. This agrees with previous studies by Emamian et al[19], Okoye et al[14] and Barton et al.[17] This mild difference in mean renal length between the right and left kidney in favour of the left could be attributed to the fact that the left main renal artery (which measures about 5-5cm in length) is apparently shorter and straighter than the right one (which measures about 6.5-8cm in length and also courses behind the inferior vena cava),therefore, increased blood flow in the left renal artery may result in the corresponding kidney being relatively larger in size.[22,23] Also accessory renal arteries are commoner on the left side, found in 30% of the population,[23] leading to increased blood flow to the left kidney with resultant relatively larger size. Although some researchers postulated this to be due to the presence of the liver on the right which does not allow comparable vertical growth and ascent of the right kidney to that which is attained by the left kidney.[19] This finding disagrees with that of Buchholz et al[16] who found no difference between mean renal lengths of both kidneys and reported mean renal length of 10.4 ± 0.08cm on both the right and left sides in Pakistani adults.

This study also showed that in the normotensive subjects, the mean renal cortical thicknesses (RCT) were 0.91 ± 1.49cm (range 0.79-0.98cm) and 0.95 ± 1.51cm (range 0.78-0.99cm) on the right and left sides respectively. These findings were not in agreement with that of Okoye et al[24] in the south eastern Nigeria who reported that the mean renal parenchymal thickness (RPT) of the right kidney was 1.91 ± 0.20cm (range 1.4-2.37cm) and that of the left was 1.95 ± 0.19cm (range 1.44-2.39cm). This is because the measurement of the RPT (from the outer renal cortical margin to the outer margin of the central sinus echoes), is different from that of the RCT (from the outer margin of the renal cortex to its inner margin, excluding the adjacent renal pyramid). So this disagreement may be attributed to difference in methodology. The findings of this study were comparable to that of Adibi et al[25] who reported the mean renal cortical thickness of 0.90cm (range 0.88-0.921cm) for the right kidney and 0.92cm (range 0.90-0.94cm) for the left kidney. Buchholz et al[16] at Karachi university, Pakistan, reported a mean ±SD RCT of 1.6 ± 2cm on both sides, which has significant difference with this study. This variation in cortical thickness is a reflection of the wide range of renal size and configuration of the collecting system. In kidneys with short and stocky infundibuli, the cortex appears thicker than in kidneys with elongated, spidery infundibuli.[11]

This study also showed that in hypertensive subjects, the mean renal cortical thickness on both sides (right=0.82cm and left=0.84cm) were slightly lower when compared with those obtained from the normotensive group (right=0.91cm and left=0.95cm). This mild reduction in the hypertensive renal cortical thickness could be due to the aforementioned ischemic changes with resultant fibrosis and hyalination.[6] This study also showed that in hypertensive group, the right mean renal cortical thickness (0.82cm) is slightly lower than that of the left mean renal cortical thickness (0.84cm) with a difference of 0.02cm in favour of the left side. Similar finding was also noted in the normotensive group of this study population. This finding is in agreement with that of Adibi et al[25] in their study.

The duration of hypertension in the subjects was calculated from the time hypertension was first diagnosed though is not easy to determine the actual duration because of the insidious on-set of the disease, which means that it can go undetected for a long time. In this study however, there was no significant correlation between renal dimensions and duration of hypertension, except that most of the patients (70; 46.7%) were in the group that has been diagnosed for more than five years. This agrees with the study done by Adedeji et al[26] which reported that renal size and duration of hypertension do not seem to be significantly correlated.

V. CONCLUSION

This study established sonographic values of mean renal length of 10.17cm and 10.44cm, and mean renal cortical thickness of 0.91cm and 0.95cm on the right and left sides respectively in normotensive subjects. These mean renal dimensions are comparable with those reported in other regions of Nigeria. Although the mean renal dimensions are slightly lower than those of Caucasians, presumably due to genetic and environmental variations.

These mean renal lengths and cortical thicknesses were slightly higher in normotensives when compared with the hypertensive patients (the mean renal length was not statistically significant while the mean renal cortical thickness was statistically significant). These showed that hypertension has significant effects on the kidneys as a result of hypertensive induced myointimal hyperplasia of the renal arterioles and wrinkling of the basement membrane, and with early detection and intervention, irreversible hypertensive renal damage may be prevented.

This study also showed a positive correlation between the systolic blood pressure, diastolic blood pressure and body mass index. However, there is no correlation between the age and duration of hypertension.

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