KIDNEY CORTICO-MEDULLARY RATIO IN A NIGERIAN PATIENT COHORT IN ABA SOUTH LOCAL GOVERNMENT AREA, ABIA STATE, NIGERIA

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ABSTRACT

Background: The ratio of the renal cortical and medullary thicknesses has been reported as a strong indicator of renal function in other populations.

Aim: To determine the cortico-medullary ratio (CMR) in selected healthy adults and patients with chronic renal diseases in Aba South Local Government Area, Abia State, Nigeria.

Methods: Two-dimensional sonography was conducted to measure the cortical and medullary thicknesses of the kidney parenchyma of 483 participants comprising 405 healthy adults and 78 patients with chronic kidney disease (CKD). The CMR was calculated by dividing cortical thickness by medullary thickness. Blood samples of the participants were collected to determine the serum creatinine and urea levels, while urine samples were checked for the presence of protein.

Results: The CMR of healthy adults was 1.27 ± 0.01 for the right kidney and 1.26 ± 0.05 for the left kidney. The mean CMR for the right kidney of healthy participants was 1.27 ± 0.01 while that of CKD patients was 0.93 ± 0.07. The mean CMR for the left kidney of healthy participants was 1.26 ± 0.05 while that of CKD patients was 0.94 ± 0.08. There were significant differences between CMR values of healthy participants and patients with CKD ($p < 0.05$). There was no relationship between CMR and the anthropometric parameters of normal individuals ($p > 0.05$).

Conclusion: The mean kidney CMRs for healthy adults and patients with CKD in Aba South have been established. The CMRs in patients with CKD were significantly lower than those of their healthy counterparts suggesting the importance of CMR in sonographic investigation of CKD.

Keywords: *Kidney, Cortical thickness, Medullary thickness, Cortico-medullary ratio, Sonography, Chronic renal diseases*

INTRODUCTION

The renal cortex is the outside section of the kidney, while the medulla is the inner section. The renal cortex has a more grainy texture, while the medulla is smoother. The ratio of the cortex to the medulla is a strong indication for renal diagnosis of diseases such as nephrosis, pyelonephritis, and grading of the levels of hydronephrosis[1]. The cortico-medullary ratio also provides information on the glomerular filtration rate (GFR)[2]. The medulla/cortex ratio of females was found to be 2.5-3.5 and that of males 2.5-3.2.[2]

In nephrology, ultrasound has a crucial role. It is used in the location of renal position, assessment of renal sizes, assessment of renal parenchyma, and collecting system[3]. Very important to note, sonography has established significant facts about renal disease conditions such as inflammatory changes, obstructive nephropathy like calculus, renal masses like cysts, and, renal tumors. Ultrasound imaging has been used in the diagnosis of congenital renal abnormalities such as ectopic kidney, horseshoe kidney, and duplex collecting system.

Each kidney in a human contains about one million nephrons, each capable of forming urine.The kidney cannot regenerate new nephrons. Therefore, with renal injury, disease,and normal aging, there is a gradual decrease in nephron number. After age 40, the number of functional nephrons decreases by about 10 percent every 10 years, thus; at age 80, many people have 40 percent fewer functional nephrons than they did at age 40. This loss is not life-threatening because adaptive changes in the remaining nephrons allow them to excrete the proper amounts of water, electrolytes, and waste products. Each nephron contains a tuft of glomerular capillaries called the glomerulus, through which large amounts of fluid are filtered from the blood and a long tubule in which the filtered fluid is converted into urine on its way to the pelvis of the kidney[4]. The nephrons that have glomeruli located in the outer cortex are called cortical nephrons. They have short loops of Henle that penetrate only a short distance into the medulla. About 20 to 30 percent of the nephrons have glomeruli that lie deep in the renal cortex near the medulla and are called juxtamedullary nephrons[5].

The renal parenchyma has two components. The centrally located pyramids, or medulla are surrounded on three sides by the peripherally located cortex. In infants or thin people, a differentiation of the medulla from the cortex may be very obvious, but in other healthy adults, this separation may be undetectable[6]. Most people are familiar with one important function of the kidneys - to rid the body of waste materials that are either ingested or produced by metabolism. A second function that is especially critical is to control the volume and composition of the body fluids. For water and virtually all electrolytes in the body, the balance between intake and output is maintained in large part by the kidneys. This regulatory function of the kidneys maintains a stable environment of cells necessary for them to perform their various activities[4]. Other functions are regulation of arterial pressure, regulation of acid-base balance, secretion, metabolism and excretion of hormones, and gluconeogenesis[4].

The most frightening consequence of chronic renal disease is renal failure if adequate and correct intervention is not initiated. Chronic renal diseases lead to a reduction in renal size, a reduction in parenchymal thickness, and ultimately a reduction in nephron number (Guyton,2006). Sonographically, these changes may lead to a change in the ratio of cortical thickness to medullary thickness. It is not known yet if this change in cortico-medullary thickness ratio (CMR) is a reliable indicator of the presence of parenchymal renal disease. To the best of the researcher's knowledge, the renal cortico-medullary ratio of the study population has not been established, hence the need to carry out this study (Sanders, 2007).

MATERIALS AND METHODS

A cross-sectional sonographic study of the kidneys of 405 healthy participants and 78 patients diagnosed with chronic kidney disease was conducted. The participants and patients were purposefully selected from hospitals and radiodiagnostic centres in Aba, Abia State, Nigeria.

The sample size for the study was calculated from a population size of 50,000 inhabitants determined using the formula by Yamane[7]:

$$n = \frac{N}{1 + N(e)^2}$$

Where:
n =sample size,
N=population under the study,
e =margin of error (taken to be 0.05)
Substituting in the formula earlier quoted:

$$n = \frac{50000}{1 + 50000(0.05)^2} = 396.825$$

So, a minimum sample of 397 healthy adults was calculated but data was collected from 405 healthy adults and 78 patients with chronic kidney disease.

Ethical approval (Protocol Number:FHST/REC/024/562) for the study was obtained from the Human Research and Ethics Committee of the Faculty of Health Sciences and Technology, Nnamdi Azikiwe University, Nigeria. The study procedure was thoroughly explained to the participants and their consent was obtained using a written consent form. Both healthy participants and patients with chronic kidney disease (CKD) were 18 years and above and resided in Aba.

Three sonographers with a minimum of ten years of experience in clinical sonography participated in measuring the kidney parameters using a 2-dimensional ultrasound scanner; Zoncare -Model: ZQ-6601 equipped with a 3.5MHz curvilinear transducer. They were blinded to the aim of the study Anthropometric parameters namely height and weight were measured. The height was measured with each participant standing erect using measurement tape calibrated in meters and centimeters.The weight was measured using a weighing scale as the participant stood on the scale. The gender and age of each participant were documented.

The CMR was calculated by dividing the measured cortical thickness with medullary thickness. The body-mass index (BMI) of each participant was calculated using the formula:

$$BMI = \frac{Weight\ (Kg)}{Height(m)^2}$$

The body surface area (BSA)of each participantwas calculated using the formula of Du Bois and Du Bois[8]:

$$BSA = 0.007184\ x\ Body\ Weight^{0.424}\ x\ Body\ Height^{0.725}$$

The data collected was analyzed using theMedCalc® Statistical Software version 22.023 (MedCalc Software Ltd, Ostend, Belgium. Both descriptive statistics (mean, standard deviation, percentage, table, frequency) and inferential statistical tools (Kendall's Tau correlation,ANOVA, and independent T-test) were carried out. Statistical significance was considered at $p < 0.05$.

RESULTS

Table 1 shows that there were more female participants n = 207 (51.1%) than male participants n = 198 (48.8%) for normal subjects and more male participants n =40 (51.3%) than female participants than female participants n = 38 (48.7%) for patients with chronic kidney disease. It also showed that out of 405 normal subjects, 170 (42%) were aged 21-30 years, 59 (14.6%) were aged 61 years and above, 58 (14.3%) were within the age of 31-40 years, 56 (13.8%) were within the age of 41-50 years, 40 (9.9%) were within the age of 51-60 years and 22(5.4%) were aged 20 years and less. The mean age for normal subjects was 38.7±16.0 years. The oldest participant was 84 years and the youngest participant was 18 years as shown in Table 1. Regarding the78 participants with CKD, 70 (89.8%) were 61 years or older, 6(7.7%) were aged 51-60 years, and 2 (2.5%) were aged 31-40 years. The mean age of participants with CKD was 72.4±8.4 years. The youngest patient was 39 years and the oldest was 85 years.

Table 2 shows that for the healthy subjects, the mean height was 1.70 ± 0.07m (range: 1.60 m-1.88 m). The mean weight was 78.3±8.0Kg (range: 65 Kg -95 Kg). The mean BMI was 27.0

± 1.9Kg/m^2 (range: 21.7 Kg/m^2 – 30.9 Kg/m^2). The mean BSA was 1.90 ± 0.13m^2 (range:1.71 m^2-2.22 m^2). For participants with CKD, the mean height was 1.68 ±0.07m (range: 1.59 m-1.83 m). Themeanweight was 72.1 ± 6.5Kg (range: 63 Kg-85 Kg). The mean BMI was 25.7 ± 1.3Kg/m^2 (range: 23 Kg/m^2-28.1 Kg/m^2). The mean BSA was 1.81 ± 0.12m^2 (range: 1.65 m^2-2.07 m^2).

Table 3 shows that the mean right kidney cortical thickness (RKCT) for the healthy participants was 1.1 ± 0.2 mm and the mean right kidney medullary thickness (RKMT) was 0.9 ± 0.1 mm. The mean left kidney cortical thickness (LKCT) for the healthy participants was 1.2 ± 0.2 mm and the mean left kidney medullary thickness (LKMT) was 1.0 ± 0.2 mm. For patients with CKD, the mean RKCT was0.6 ± 0.1mm while the mean RKMT was 0.7±0.1mm. Also for the CKD patients, the mean LKCT was 0.7±0.2 mm while the mean LKMT was 0.7±0.2mm.Table 3 also shows that the CMR among the healthy adults was 1.27 ± 0.01 for the right kidney and 1.26 ± 0.05 for the left kidney. For the participants with CKD, the CMR was 0.93±0.07 for the right kidney and 0.94±0.08 for the left.

Table 4 shows that for the male healthy participants, the mean right kidney CMR was 1.26 ±0.01 for participants aged 61 years or more and those aged 20 years and less. The right kidney CMR was also 1.27 ±0.01 for participants aged 21-60 years. The mean left kidney CMR was 1.17±0.12 for participants aged 21-30 years, 1.27± 0.01 for the 20 years and less group, 31-40 years and 51-60 years, and 1.26 ±0.01 for 41-50 years and 61 years and above age groups. For the healthy female participants, the mean right kidney CMR was 1.27 ± 0.01 for the 21-30 years, 41-50 years, and 51-60 years age groups. It was 1.28 ± 0.01 in the 20 years and less and 61 years or more age groups, and 1.29 ± 0.01 in the 31-40 years age group. The mean left kidney CMR was 1.27±0.01 in the 21-60 years age group, 1.28 ± 0.01 in the 20 years and less, and 61 years and above age groups.

Table 6 shows a comparison between the cortico-medullary thickness ratio between the right and the left kidneys; for healthy volunteers, the mean cortico-medullary ratio of the right kidney was 1.27 ± 0.01 and the mean cortico-medullary ratio of the left was 1.26 ± 0.05. This implies that the cortico-medullary ratio of the right was higher than the left for healthy volunteers. Regarding participants with chronic kidney disease, while the mean cortico-medullary ratio of the right kidney was 0.93 ± 0.07, the mean cortico-medullary ratio of the left kidney was 0.94 ± 0.08. this implies that the cortico-medularry ratio of the left kidney was higher than that of the right kidney in participants with CKD.

Table 7 shows that in healthy volunteers. while the mean CMR for males was 1.26 ± 0.05, the mean CMR for females was 1.27 ± 0.02. this implies that the CMR of healthy females in this study was higher than that of males. Regarding participants with CKD, while the CMR of males was 0.96 ± 0.07, the CMR of females was 0.91 ± 0.06. this implies that the CMR of male participants with CKD was higher than the CMR of female participants with CKD.

Tabe 8 compares directly the mean CMR of Healthy Volunteers (1.27 ± 0.04) and the mean CMR of patients with CKD (0.93 ± 0.07). it showed that CMR was higher in healthy volunteers than in CKD patients.

Table 9 shows the relationship between CMR and anthropological parameters. There was no correlation between CMR and age, BMI, and BSA in the healthy participants. There was also no correlation between CMR and BMI in patients with CKD. However, there was a strong correlation between the right kidney CMR and BSA in patients with chronic kidney disease (τ= 0.714). There was also a weak correlation between left kidney CMR and BSA in patients with CKD (τ= 0.332). There was only a weak negative correlation between the right kidney CMR and age in patients with CKD (τ = -0.343). There was no correlation between the left kidney CMR and age in patients with CKD.

Table1: Distribution of the participants according to age and sex

Normal Subjects (count/percent)							
Age (years)	**20 and less**	**21-30**	**31-40**	**41-50**	**51-60**	**61 and over**	**Total**
Male	15 (3.7)	34 (8.4)	43 (10.6)	49 (12.1)	13 (3.2)	44 (10.9)	**198 (48.9)**
Female	7 (1.7)	136 (33.6)	15 (3.7)	7 (1.7)	27 (6.7)	15 (3.7)	**207 (51.1)**
Total	**22 (5.4)**	**170 (42)**	**58 (14.3)**	**56 (13.8)**	**40 (9.9)**	**59 (14.6)**	**405 (100)**
Patients with Chronic Kidney Disease (count/percent)							
Male	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	40 (51.3)	**40 (51.3)**
Female	0 (0)	0 (0)	2 (2.5)	0 (0)	6 (7.7)	30 (38.5)	**38 (48.7)**
Total	**0 (0)**	**0 (0)**	**2 (2.5)**	**0 (0)**	**6 (7.7)**	**70 (89.8)**	**78 (100)**

Table 2: Summary statistics for the anthropometric and demographic variables of healthy subjects and patients with CKD

Variable	Minimum	Maximum	Mean±SD	1st Quartile	Median	3rd Quartile
			Normal subjects (n = 405)			
Age (years)	18	84	38.7 ± 16.0	26.0	32.0	50.0
Height (m)	1.60	1.88	1.70 ± 0.07	1.65	1.69	1.74
Weight(kg)	65.0	95.0	78.3 ± 8.0	72.0	79.0	83.0
BMI (kg/m^2)	21.7	30.9	27.0 ± 1.9	26.1	27.1	28.3
BSA(m^2)	1.71	2.22	1.90 ± 0.13	1.78	1.90	1.97
			Patients with Chronic Kidney Disease (n =78)			
Age (years)	39	85	72.4 ± 8.4	69.0	74.0	77.0
Height (m)	1.59	1.83	1.68 ± 0.07	1.61	1.68	1.75
Weight(kg)	63	85	72.1 ± 6.5	65.0	72.0	79.0
BMI (kg/m^2)	23.0	28.1	25.7 ± 1.3	25.0	25.6	26.5
BSA(m^2)	1.65	2.07	1.81 ± 0.12	1.74	1.79	1.95

Table 3: Summary statistics for the renal parameters of normal subjects and patients with CKD

Variable	Minimum	Maximum	Mean±SD	1st Quartile	Median	3rd Quartile
Normal subjects (n = 405)						
RKL (mm)	10.0	13.1	11.6±0.8	11.0	11.7	12.2
RKW (mm)	3.3	5.8	4.3 ± 0.5	3.8	4.2	4.6
RKCT (mm)	0.7	1.6	1.1 ± 0.2	1.0	1.1	1.2
RKMT (mm)	0.6	1.2	0.9 ± 0.1	0.8	0.9	0.9
RKCMR	1.25	1.29	1.27 ± 0.01	1.26	1.27	1.28
LKL (mm)	10.6	14.2	12.0 ± 0.8	11.4	11.9	12.3
LKW (mm)	3.2	6.1	4.5 ± 0.6	4.1	4.3	4.8
LKCT (mm)	0.8	1.6	1.2 ± 0.2	1.2	1.2	1.4
LKMT (mm)	0.6	1.4	1.0 ± 0.2	0.9	1.0	1.1
LKCMR	1.01	1.29	1.26 ± 0.05	1.26	1.27	1.28
Patients with Chronic Kidney Disease (n =78)						
RKL (mm)	9.1	10.9	9.9 ± 0.5	9.8	9.8	10.3
RKW (mm)	2.5	4.0	3.3 ± 0.4	2.9	3.2	3.7
RKCT (mm)	0.4	0.9	0.6 ± 0.1	0.5	0.6	0.7
RKMT (mm)	0.5	1.0	0.7 ± 0.1	0.6	0.7	0.7
RKCMR	0.78	1.09	0.93 ± 0.07	0.91	0.93	0.95
LKL (mm)	9.5	11.0	10.3 ± 0.4	10.2	10.3	10.6
LKW (mm)	2.6	4.0	3.4 ± 0.5	3.1	3.4	3.9
LKCT (mm)	0.5	1.0	0.7 ± 0.2	0.5	0.7	0.8
LKMT (mm)	0.5	1.0	0.7 ± 0.2	0.6	0.6	0.8
LKCMR	0.81	1.08	0.94 ± 0.08	0.91	0.92	1.0

Table 4: Sonographic renal parameters according to sex and age of the healthy participants

Age (years)	**20 and less**	**21-30**	**31-40**	**41-50**	**51-60**	**61 and over**
Renal Parameters			**Males (n=198)**			
RKL (mm)	11.7±0.5	11.9±0.5	11.7±0.7	12.5 ±0.4	11.3±0.5	10.9 ±0.5
RKW (mm)	4.4 ±0.6	4.7 ±0.6	4.3 ±0.6	4.8 ±0.2	4.4 ±0.3	3.9 ±0.3
RKCT (mm)	1.1 ±0.3	1.3 ±0.2	1.1 ±0.1	1.3 ±0.1	1.1 ±0.0	1.0 ±0.1
RKMT (mm)	0.8 ±0.2	1.0 ±0.2	0.8 ±0.1	1.0 ±0.1	0.9 ±0.0	0.8 ±0.1
RKCMR	1.26 ±0.01	1.27 ±0.01	1.27 ±0.01	1.27 ±0.01	1.27 ±0.01	1.26 ±0.01
LKL (mm)	12.0 ±0.6	11.8±0.2	12.4 ±0.9	12.7 ±0.8	11.6±0.4	11.6±0.4
LKW (mm)	4.7 ±0.5	4.2 ±0.3	4.7 ±0.6	4.9 ±0.5	4.2 ±0.0	4.4 ±0.4
LKCT (mm)	1.3 ±0.01	1.3 ±0.1	1.3 ±0.2	1.3 ±0.3	1.2 ±0.0	1.1 ±0.2
LKMT (mm)	1.0 ± 0.0	1.0 ± 0.1	1.0 ± 0.1	1.0 ± 0.2	0.9 ± 0.0	0.9 ± 0.1
LKCMR	1.27 ± 0.01	1.17 ± 0.12	1.27 ±0.01	1.26 ±0.01	1.27 ±0.01	1.26 ±0.01
			Female (n=207)			
RKL (mm)	10.9 ±0.0	11.5±0.7	11.5±0.8	11.6±0.0	11.7±0.7	11.2±0.5
RKW (mm)	3.8 ±0.0	4.1 ± 0.5	3.9 ± 0.4	4.3 ± 0.0	4.5 ± 0.1	4.3 ± 0.3
RKCT (mm)	1.2 ±0.0	1.1 ± 0.1	1.1 ± 0.3	1.1 ± 0.0	1.0 ± 0.3	1.0 ± 0.1
RKMT (mm)	0.9 ±0.0	0.8 ± 0.1	0.9 ± 0.3	0.9 ± 0.0	0.8 ± 0.2	0.8 ± 0.1
RKCMR	1.28 ±0.00	1.27 ± 0.01	1.29 ± 0.01	1.27 ± 0.00	1.27 ± 0.01	1.28 ± 0.01
LKL (mm)	11.0±0.0	11.7±0.7	11.7±0.8	12.0 ± 0.0	13.0 ± 1.1	11.6±0.2
LKW (mm)	4.0 ± 0.0	4.3 ± 0.5	4.3 ± 0.2	4.5 ± 0.0	5.0 ±0.5	3.9 ±0.8
LKCT (mm)	1.5 ± 0.0	1.3 ± 0.1	1.2 ± 0.2	1.1 ± 0.0	1.28 ± 0.1	0.8 ± 0.1
LKMT (mm)	1.1 ± 0.0	1.0 ± 0.1	1.0 ± 0.1	1.4 ± 0.0	1.0 ± 0.1	0.7 ± 0.0
LKCMR	1.28 ± 0.00	1.27 ± 0.02	1.27 ±0.00	1.27 ± 0.00	1.27 ±0.01	1.28 ± 0.01

Table 5: Influence of anthropometric characteristics of cortico-medullary thickness ratio in healthy volunteers and patients with chronic kidney disease

HEALTHY VOLUNTEERS					
Parameter	**One-way ANOVA**			**Kruskal-Wallis Test**	
Age (years)	**Total Sum of Squares**	**F-ratio**	**Significance**	**Test Statistic**	Significance
Right Kidney	0.04127	51.985	$p < 0.001$	292.5432	$p < 0.000001$
Left Kidney	0.9585	4.498	$p < 0.001$	228.8874	$p < 0.000001$
BMI (kg/m^2)					
Right Kidney	0.04127	124.655	$p < 0.001$	335.7049	$p < 0.000001$
Left Kidney	0.9585	17.116	$p < 0.001$	337.2561	$p < 0.000001$
BSA (m^2)					
Right Kidney	0.04127	124.655	$p < 0.001$	335.7049	$p < 0.000001$
Left Kidney	0.9585	17.116	$p < 0.001$	337.2561	$p < 0.000001$
Sex					
Right Kidney	0.04127	54.223	$p< 0.001$	43.5597	$p < 0.000001$
Left Kidney	0.9585	26.363	$p < 0.001$	61.7960	$p < 0.000001$
PATIENTS WITH CHRONIC KIDNEY DISEASE					
Parameter	**One-way ANOVA**			**Kruskal-Wallis Test**	
Age (years)	**Total Sum of Squares**	**F-ratio**	**Significance**	**Test Statistic**	Significance
Right Kidney	0.3461	2.674×10^{30}	$p < 0.001$	75.1100	$p < 0.000001$
Left Kidney	0.4406	3.404×10^{30}	$p < 0.001$	74.4966	$p < 0.000001$
BMI (kg/m^2)					
Right Kidney	0.3461	2.674×10^{30}	$p < 0.001$	75.1100	$p < 0.000001$
Left Kidney	0.4406	3.404×10^{30}	$p < 0.001$	74.4966	$p < 0.000001$
BSA (m^2)					
Right Kidney	0.3461	2.674×10^{30}	$p < 0.001$	75.1100	$p < 0.000001$
Left Kidney	0.4406	3.404×10^{30}	$p < 0.001$	74.4966	$p < 0.000001$
Sex					
Right Kidney	0.3461	4.277	$p = 0.042$	5.7562	$p = 0.014721$
Left Kidney	0.4406	23.391	$p < 0.001$	5.7562	$p = 0.014721$

Table 6: Comparison of cortico-medullary thickness ratio between the right and left kidneys in the healthy volunteers and patients with chronic kidney disease

INDEPENDENT SAMPLES TEST				MANN-WHITNEY TEST			
Right Kidney Mean	**Left Kidney Mean**	**t-statistic**	**p-value**	**Right Kidney Median**	**Left Kidney Median**	**Z-statistic**	**p-value**
HEALTHY VOLUNTEERS							
1.27 ± 0.01	1.26 ± 0.05	-3.746	p = 0.0002*	1.27	1.27	-0.945	p = 0.34
PATIENTS WITH CHRONIC KIDNEY DISEASE							
0.93 ± 0.07	0.94 ± 0.08	1.131	p = 0.26	0.93	0.92	-0.541	p = 0.59

Table 7: Comparison of cortico-medullary thickness ratio between the males and females among the healthy volunteers and patients with chronic kidney disease

INDEPENDENT SAMPLES TEST				MANN-WHITNEY TEST			
Mean CMR for Males	**Mean CMR for Females**	**t-statistic**	**p-value**	**Median CMR for Males**	**Median CMR for Females**	**Z-statistic**	**p-value**
HEALTHY VOLUNTEERS							
1.26 ± 0.05	1.27 ± 0.02	6.384	p < 0.0001	1.27	1.28	-10.717	p < 0.0001
PATIENTS WITH CHRONIC KIDNEY DISEASE							
0.96 ± 0.07	0.91 ± 0.06	-4.842	p < 0.0001	0.92	0.93	-1.887	p = 0.0591

Table 8: Comparison of cortico-medullary thickness ratio between the healthy volunteers and patients with chronic kidney disease

INDEPENDENT SAMPLES TEST				MANN-WHITNEY TEST			
Mean CMR Healthy Volunteers	**Mean CMR for Patients with Chronic Kidney Disease**	**t-statistic**	**p-value**	**Median CMR for Males**	**Median CMR for Females**	**Z-statistic**	**p-value**
1.27 ± 0.04	0.93 ± 0.07	-88.057	p< 0.0001	1.27	0.93	-20.241	p< 0.0001

Table 9: Kendall's Tau correlation between CMR and age, BMI, and BSA in healthy volunteers and patients with chronic kidney disease

Cortico-medullary Thickness Ratio	**Age (years)**	**BMI (kg/m²)**	**BSA(m²)**
		Healthy volunteers	
Right Kidney	τ = -0.063; p =0.0601	τ=0.085; p=0.0106	τ = -0.245; p <0.0001
Left Kidney	τ = -0.2; p <0.0001	τ = -0.141; p <0.0001	τ = -0.143; p <0.0001
Cortico-medullary Thickness Ratio	**PatientswithChronicKidneyDisease**		
Right Kidney	τ = -0.343; p <0.0001	τ= 0.0349; p =0.6550	τ= 0.714; p <0.0001
Left Kidney	τ= -0.137; p =0.0742	τ= 0.0402; p =0.6056	τ= 0.332; p <0.0001

DISCUSSION

Diagnosis of renal pathologies is made easy when the mean CMR for a location or race is known. This study of 405 healthy adults has shown that both the Cortical Thickness and the Medullary Thickness of the Left kidney was higher than the right kidney. The study showed that the left kidney has larger volume than the right kidney. The size of the cortex and medulla is proportionate to the size of kidney. Hence, the kidney with the larger size would have a larger cortex and medulla. This finding establishes a standard for renal diagnosis such that when the cortex and medulla of the right kidney are higher than that of the left kidney, attention should be paid to ascertain the pathology responsible for this abnormality. This has also given us a central reference point for the sonographic assessment of the cortex and medulla of healthy adults in Aba South. The mean size of the cortex and medulla thickness gotten in this study is not the same for all location and race.

In Sonography, Chronic Kidney Disease is grossly characterized by reduced renal cortical thickness <6mm, reduced renal length, increased renal cortical echogenicity, poor visibility of renal medulla and renal sinus, marginal irregularities, papillary calcification and cysts. With the reduction in renal cortical thickness and poor visibility of renal medulla, it is obvious the Cortico-medullary ratio will be reduced in comparison to the healthy adult. From the study, there was gross reduction of cortico-medullary ratio in patients with CKD when compared to healthy volunteers (mean CMR for healthy adult was 1.27 while mean CMR for CKD was 0.94). Hence, for renal sonography of the population of this study; Aba South, CMR of values lower than 1.00 are to be evaluated further to rule out Chronic Kidney diseases.

It was rather very surprising that the study found the CMR in females to be higher than that of the males; though it was not statistically significant ($p<0.0001$). In humans, females generally have smaller kidneys and fewer nephrons, therefore should also have lesser CMR (El Rehaid,2014). Though the mean cortical thickness obtained in this study was similar to that of El-Reshaid *et al.*[9] who in their study of renal size of healthy adults in Kuwait found that the mean Right cortical thickness was 0.98 ± 0.2 for males and 0.98 ± 0.8 for females and the Left Cortical thickness was 1.02 ± 0.2 for males and 1.02 ± 0.6 for females. The finding of this study was lower and contrary to the findings of Kunhel *et al*[2] who found that the medulla/cortex ratio of females was found to be 2.5-3.5 and that of males 2.5-3.2.

Anthropometric parameters like height are known to be related to renal size positively, this implied that tall people would have notable long renal length and width, while short people would have short renal length and width). The findings from this research is in keeping with results of previous study about renal length and human's height. However, the findings of this study were also clear that anthropometric parameters (Age, BMI and BSA) had no strong relationship with corticomedullary ratio.

This study has established a reference value for the diagnosis of renal diseases in Aba South Local Government Area. The Cortico-medullary ratio of healthy adults are higher than those with Chronic kidney diseases.

COMPETING INTEREST

None

REFERENCES

1. Fransesca P, Ilaria L, Veronica M, Barbara B, Antonio B, Simonetta C. How ultrasound can be useful for staging chronic kidney disease. Ultrasound findings in 855 cases. MDPI Journals. 2020; 7 (4): 147.
2. Kuhnel L, Thomas V, Wood ST, Francis RS, Trnka P, Ellis RJ,. Relationship between cortical and medullary thickness and glomerular filtration rate among living kidney donors. *Int Med Journ.* 2023; 53(3):431-435.
3. Novick A, Gill I, Klein E, Rackley R, Ross J, Jones J."Operative Urology at the Cleveland Clinic", Urology Annals. Humana Press. 2006;8(l2):102–S108.
4. Guyton C. Text book of medical physiology. Philadelphia: Elsevier Saunders. 2006,p.307-311.
5. Sadler T. Langman's medical embryology. Philadelphia: Lippincott Williams and Wilkins. 2012, p. 321-333.
6. Sanders C. Clinical sonography, a practical guide. Baltimore: Lippincott Williams and Wilkins.2007, p. 163-167.
7. Okwuonu C, Chukwuonye I, Ademola O, Agaba E, Ojugwu L. Prevalence of chronic kidney disease and it's risk factors among adults in semi-urban communities of South-East Nigeria. Nig Postg Medi Journ. 2017;24 (2): 81-87.
8. Du Bois D, Du Bois F. A formula to estimate the approximate surface area if height and weight be known. *Arch Intern Med*. 1916;17(6):863-71.
9. El-Rehaid W. Abdul-Fattah H. Sonographic Assessment of Renal Size in Healthy Adults. Med Princ Pract. 2014 ; 23(5): 432-436.
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