SONOGRAPHIC ASSESSMENT OF RENAL VOLUME AND ESTIMATED GLOMERULAR FILTRATION RATE IN NORMAL ADULTS IN CALABAR, NIGERIA.

BY

DR. NCHIEWE E. ANI (MBBCh CALABAR)

DISSERTATION SUBMITTED TO THE NATIONAL POSTGRADUATE MEDICAL COLLEGE OF NIGERIA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF FELLOWSHIP IN RADIOLOGY

NOVEMBER 2016.
DECLARATION

I hereby declare that this work was carried out by me, Dr. Nchiewe Elemi Ani, of the Department of Radiology, University of Calabar Teaching Hospital, under Supervision. This is in partial fulfillment of the requirements for the award of Fellowship of the NPMCN in radiology. It is also hereby declared that the work has not been previously submitted for the award of any degree or for publication either in parts or in its entirety.

………………………………………

Dr. Nchiewe Elemi Ani
Senior Registrar
Department of Radiology
University of Calabar Teaching Hospital,
Calabar
ATTESTATION

It is hereby declared that this work was carried out by Dr. N. E. Ani of the Department of Radiology, University of Calabar Teaching Hospital, under our Supervision.

Project Supervisors:

..............................................................
Dr. Darlene Bassey, FMCR, FWACS
Consultant Radiologist,
Department of Radiology,
University of Calabar Teaching Hospital,
Calabar.

..............................................................
Prof. G.O.G. Awosanya, FMCR; FWACS
Consultant Radiologist
Department of Radiology
Lagos State University Teaching Hospital
Lagos

..............................................................
Dr. Emmanuel Effa, FMCP
Consultant Nephrologist
Department of Internal Medicine
University of Calabar Teaching Hospital
Calabar.
CERTIFICATION

I do hereby certify that this research was carried out by Dr. N. E. Ani during the course of her Residency training in the Department of Radiology, University of Calabar Teaching Hospital, UCTH, Calabar.

Dr. Akintunde O. Akintomide, FWACS
Consultant Radiologist
Head of Department
University of Calabar Teaching Hospital, Calabar
Cross River State

TABLE OF CONTENTS
TITLE

DECLARATION - - - - - - - - - ii
ATTESTATION - - - - - - - - iii
CERTIFICATION - - - - - - - - iv
TABLE OF CONTENTS - - - - - - - - v
SUMMARY - - - - - - - - 1
INTRODUCTION - - - - - - - - 3
AIMS AND OBJECTIVES - - - - - - - - 6
JUSTIFICATION - - - - - - - - 7
ANATOMY OF THE KIDNEY - - - - - - - - 8
SONOGRAPHIC ANATOMY OF THE KIDNEY - - - - - - 12
LITERATURE REVIEW - - - - - - - - 16
MATERIALS AND METHODS - - - - - - - - 21
METHOD OF DATA ANALYSIS - - - - - - - - 32
STUDY LIMITATIONS - - - - - - - - 33
RESULTS - - - - - -- - - - 34
DISCUSSION - - - - - - - - - 67
REFERENCES - - - - - - - - - 76
APPENDICES - - - - - - - - - 82
SUMMARY

**Background:** Renal volume at sonography theoretically reflects the functional capacity of the kidney which could be equivalent to glomerular filtration rate. The increasing burden of chronic renal diseases is alarming and has assumed epidemic proportions in resource poor settings, especially Africa, Nigeria included; consequently, efforts to reduce the cost of detecting, monitoring and managing chronic renal disease are imperative. Hence, ultrasonography provides a reliable, reproducible, cost-effective and readily accessible method of evaluating renal status. This was the thrust of this study, which sought to investigate the relationship between sonographically determined renal volume and functional capacity of the kidney represented by the estimated Glomerular Filtration Rate (GFR).

**Aims and objectives:** To determine the relationship between sonographic renal volume and renal function as assessed by the estimated Glomerular Filtration Rate (eGFR) as well as the relationship between sonographic renal volume and anthropometric measurements in normal adult population in Calabar.

**Methodology:** A cross sectional prospective study design was employed, with recruitment of healthy subjects visiting or working in the University of Calabar Teaching Hospital using the simple random sampling method. Following researcher-administration of structured questionnaire with the inclusion and exclusion criteria adhered to; anthropometric data was obtained. Point of care serum creatinine values were obtained and utilized for estimation of GFR using Cockcroft Gault (CG) equation. Renal ultrasonography was then done for each of the consenting subjects.

**Results:** Data was obtained from hundred (400) subjects with a female: male ratio of 1: 0.65, and mean age of 35.2 ± 10.5 years, ranging from 18-80 years. Mean renal length was 9.81 ±0.87 and 10.34 ±0.87 cm; mean AP diameter was 3.95 ±0.40 cm and 4.28 ±0.42 cm; mean renal width was 4.99±0.51 and 5.31 ±0.47 cm and mean renal volume was 102.11 ±
22.41 cm³ and 124.07 ±25.22 cm³; Serum creatinine was 0.96 ± 0.17 and 1.10 ± 0.20 mg/dl; Mean eGFR using CG equation was 91.43 ±23.09 and 96.13 ±20.3 mL/min/1.73 m², for right and left respectively. The renal dimensions were generally larger in males than females.

**Conclusion:** This study shows a positive relationship between renal volume and eGFR, body weight and BMI with implication for diagnostic and prognostic renal evaluation in our environment, especially for Nigerian adults living in the south south region.

**Keywords:** Chronic renal disease, renal volume, Estimated Glomerular Filtration Rate, Ultrasonography
INTRODUCTION

The assessment of renal disease using biochemical assay is often carried out by the estimation of serum electrolyte, urea and creatinine (E/U/Cr) in blood and also through the determination of the amount endogenous or exogenous substances present in urine (urinalysis, 24 hours Creatinine or iohexol Clearance). Renal function can also be determined from the GFR by estimating endogenous creatinine clearance using the Cockcroft Gault equation.

Sonographic estimation of renal volume is said to have clinical utility for the Family Physician, Nephrologist and Urologist. This is because renal volume reflects renal mass or the number of surviving nephrons, hence the functional capacity of the kidneys. Alteration in kidney volume can be associated with different renal diseases. For instance, a reduction in renal volume can occur in chronic kidney disease whereas renal enlargement is seen in diabetic nephropathy. Renal volume rather than length at sonography have been proposed by most researchers as a true predictor of kidney size in states of good health and disease.

Generally, no single imaging modality is accepted by radiologists for renal volume assessment as all radiological methods have been found to be associated with prediction errors. Advanced techniques used in determining renal volume such as Computerized tomography (CT) and renal Scintigraphy may be of limited use in our environment due to cost, non-availability and exposure to radiation. Furthermore, Magnetic resonance imaging (MRI) based volumetric renal assessment, though radiation-free, is not widely available, cost higher and requires longer processing time.

Ultrasonography (US) has therefore become the standard imaging modality in the investigation of renal diseases because it is accurate, non-invasive, cost effective, easily available, convenient and provides excellent anatomical details.
requires no special patient preparation neither does it require the use of X-radiation or contrast agents which are potentially harmful.

There are few clinical data on the use of sonographic renal volume as a clinical tool. Published studies on Adult renal volume in Nigeria are few\textsuperscript{2,9,10}, and there is need to establish a normal range of values for renal volume in our adult population and also determine its relationship with renal function using eGFR.

In addition, sonographic renal dimensions published in southern Nigeria were values obtained by Okoye et al and Adebayo et al for the eastern and western regions in the south\textsuperscript{20,10}. It is an established fact that prior to this current study there has been no known study on the sonographic renal dimensions in the south south region of Nigeria.

Published literature has also stated that the use of the same data from a different geographical region or ethnicity within the same country to evaluate the renal status of another ethnic group may not ideal as variations exist due to nutritional factors, body habitus, geographical location, physical activities and genetic differences, all of which may influence the size of the kidney and result in poor assessment of the proposed renal status\textsuperscript{1,3,7,19}.

There is therefore the need to generate data typical for normal individuals living in the south-south region of Nigeria and to compare these new data with existing data for normal individuals living in the south east, south west as well as with those living in northern Nigeria. It would also interesting to know if similarity or variations in renal dimensions exist between this current study and other known renal studies carried out for normal subjects in other countries, aside from Nigeria.

It is also hoped that this study would help in the determination of sonographic renal dimensions that would aid in the diagnosis and follow up management of nephropathies and thereby prevent progression to chronic kidney diseases for Nigerians living in our locale.
Data obtained from this study could hereafter serve as controls when futures studies would be done to assess the rate of reduction or increase in renal dimensions for disease states, provided the normal dimensions were obtained as baseline for the affected individuals in south-south Nigeria.
AIMS AND OBJECTIVES

BROAD OBJECTIVES

To sonographically measure renal volume and determine its relationship with renal function as measured by the estimated Glomerular Filtration Rate (eGFR) in normal Nigerian adults who present in the University of Calabar Teaching Hospital, Calabar, South south region of Nigeria.

SPECIFIC OBJECTIVES

1. To provide a range of values of renal volume in normal adult Nigerians in Calabar.

2. To determine the relationship between renal volume and anthropometric parameters such as age, weight, height, Body Mass Index (BMI) and gender.

HYPOTHESIS

The Sonographic estimation of renal volume and the Glomerular filtration rate are important tools in the assessment of renal function.
JUSTIFICATION OF THE STUDY

The determination of renal volume and its relation to renal function is of great interest considering the fact that morbidity and mortality from chronic kidney disease is fast becoming an issue of Public health concern in Africa. Few studies have estimated renal volume using sonography and evaluated its predictability of renal function using eGFR and other body indices in normal adults. Variation in renal volume has been shown to be associated with various renal pathologies; Nephromegaly is seen in diabetic nephropathy while a reduction in renal volume is found in conditions such as hypertensive nephrosclerosis, chronic pyelonephritis and glomerulonephritis. Thus the need for image based renal evaluation cannot be over emphasized as a means of evaluating renal function as this would help the Nephrologist, Urologist and General Practitioner prevent the adverse outcome of chronic kidney disease. This study would also help develop a normogram that would serve as a template for the south-south geographical zone of Nigeria. Ultimately it is hoped that with the findings from this study the clinicians would be encouraged to know the baseline estimation of renal volume of their patients and ensure periodic, say mid-year or annual re-assessments of the patient’s renal status, such that if there are any alterations or variations from the baseline, this could be promptly detected and quick measures put in place to halt progression to chronic renal disease and renal failure.
ANATOMY OF THE NORMAL KIDNEY

EMBRYOLOGY OF THE KIDNEYS

The kidneys are mesodermal in origin. Three slightly overlapping kidney systems are formed in a craniocaudad sequence during intrauterine life in humans: the pronephros, mesonephros, and metanephros. The pronephros is rudimentary and nonfunctional; the mesonephros may function for a short time during the early fetal period while the metanephros which appears in the 5th week, forms the permanent kidney. Its excretory units develop from metanephric mesoderm in the same manner as in the mesonephric system. Collecting ducts of the permanent kidney develop from the ureteric bud, an outgrowth of the mesonephric duct close to its entrance to the cloaca. Subsequently the bud dilates, forming the primitive renal pelvis, and splits into cranial and caudal portions, the future major calyces. The kidney is formed in the pelvic region, later migrates to a more cranial position in the abdomen. This ascent of the kidney is caused by diminution of body curvature and by growth of the body in the lumbar and sacral regions.
GROSS ANATOMY OF THE KIDNEYS

The kidneys are paired bean-shaped organs which lie in the superior part of the retroperitoneum on either side of the vertebral column at approximately the levels of L1–L4 lumbar vertebrae. The kidneys rest on the lower two thirds of the Quadratus lumborum muscle, on the posterior and medial portion of the Psoas muscle and laterally on the Transversus abdominis muscle. The right kidney usually lies slightly lower than the left, due to the bulk of the liver. The kidneys move up and down by 1–2cm during deep inspiration and expiration.12,13

In the adult, each kidney measures about 9- 12 cm long, 5- 6cm wide and 3- 4cm thick. Discrepancy between right and left renal length of up to 1.5cm is within normal limits. The upper poles of the kidneys lie more medial and posterior than the lower poles. Each kidney consists of an outer cortex, an inner medulla and a pelvis. The hilum of the kidney is situated medially and transmits from front to back the: renal vein, renal artery, ureteric pelvis as well as lymphatics and sympathetic vasomotor nerves.12,13 (Fig 1).

The renal pelvis divides into two or three major calices and these, in turn, divide into minor calices which receive urine from the medullary pyramids by way of the papillae. The kidneys are surrounded by a layer of fat, the perinephric fat, which is encapsulated by the perinephric fascia (Gerota’s fascia).13

The renal artery derives directly from the aorta at the level of L2. Each renal artery divides into five segmental arteries at the hilum which, in turn, divide sequentially into lobar, interlobar, arcuate and cortical radial branches. The renal vein drains directly into the inferior vena cava. The left renal vein passes in front of the aorta immediately below the origin of the superior mesenteric artery to drain into the inferior vena cava. The right renal artery passes behind the inferior vena cava. Lymphatics drain directly to the para-aortic lymph nodes.13
Normal variants include persistent fetal lobulations, hyperplastic columns of Bertins, duplex collecting systems and accessory renal arteries.
Fig. 1: Structure of the kidney.

Adapted from Anatomy for Diagnostic Imaging by Ryan et al.\textsuperscript{13}
SONOGRAPHIC ANATOMY

Sonographically, the kidney is elliptical in shape on longitudinal section and nearly circular on transverse section. It shows an inner medulla, outer cortex, and a renal capsule. The normal kidney measures approximately 9-12 cm in length, with the left being slightly larger than the right. The parenchyma is 2.5 cm thick and the kidney is approximately 5 cm wide. Sonographically, the renal size is not magnified and so is smaller than on radiographs. The kidneys have a convex lateral edge and a concave medial edge called the hilum. The arteries, veins and ureter enter the hilum. The renal hilum appears hyperechoic due to the presence of fat. The kidney is seen to consist of a central highly echogenic core called the renal sinus, surrounded by a comparatively less echogenic layer called the renal parenchyma. The central echo complex (or the renal sinus) includes the renal collecting systems, calyces, renal infundibula, arteries, veins, lymphatics, peripelvic fat and part of the renal pelvis. The renal parenchyma consists of the cortex and medulla. The total renal volume includes both the renal sinus and renal parenchyma\textsuperscript{1, 13, 14}. The medulla is slightly less echogenic than the cortex. Fig. 2 and Fig. 3.

In healthy adults, the renal cortex should be hypoechoic or at least isoechoic to the liver and spleen. The renal capsule is represented as a well-defined echogenic line in the adult. Renal vasculature is better appreciated on Doppler studies \textsuperscript{1, 13, 14}.

Normal Developmental variants can also be appreciated on sonography, ranging from persistent fetal lobulations, hyperplastic columns of Bertin seen to protrude from the parenchyma (and do not differ in echogenicity from the remaining renal parenchyma) to localized thickening of the cortex along the lateral aspect of the left kidney, usually just below the inferior pole of the spleen. This is found in about 10\% of patients and is referred to as splenic hump.
FIG. 2: LONGITUDINAL SONOGRAPHIC ANATOMY OF THE KIDNEY
FIG. 3: SCHEMATIC LONGITUDINAL SONOGRAPHIC ANATOMY OF THE KIDNEY.
An echogenic line of fat running from the echogenic sinus fat to the cortex may be seen. This is termed a junctional cortical defect\textsuperscript{13}.

The kidneys on CT and MRI are seen on slices from T12 to L3 vertebral levels. Posterior relations and anterior relations can be seen on axial CT images, but are very well appreciated on sagittal and coronal MR images. The kidney is seen to be surrounded by perinephric fat. This is most abundant medial to the lower pole. The renal fascia is less than 1mm thick in the normal subject and can generally be seen if it is at right-angles to the imaging plane in a subject with adequate fat\textsuperscript{13}.

The renal substance is homogeneous on plain CT images. On Magnetic Resonance imaging, the intrinsic contrast between cortex and medulla is seen on T1 –and T2-weighted images. On T1-weighted images the renal cortex has a slightly higher signal than the medulla. On T2-weighted images the renal cortex is slightly lower in signal than the medulla\textsuperscript{13}. 
LITERATURE REVIEW

Renal volume is an important parameter in clinical evaluation and management of patients with kidney diseases such as congenital anomalies, renal cystic diseases, kidney stones, renal artery stenosis, recurrent urinary tract infections, vesicoureteral reflux, chronic kidney disease, kidney tumors and kidney transplants both in the paediatric and adult population 1,3,15.

On serial sonographic evaluation, a change in renal volume (reduction or increase) from one examination to the next may be an important indicator of the presence or progression of disease. Of several indices of kidney size, kidney length was traditionally used because it can conveniently be measured using US but when the complexity of the kidney shape is considered, length cannot appropriately represent kidney mass. It is also prone to inter-observer variability and poor repeatability 1,2,3.

Studies have shown that renal volume is influenced by factors such as age, ethnicity, gender, position, weight and height 1,2,3,7. According to Emamian et al, renal volume gives the most exact measurement of renal mass and better correlates with body surface area. Renal length on the other hand correlates with body height. The kidney becomes shorter and thicker with age, almost entirely due to parenchymal reduction 3. More so, renal volume is said to be stable with minimal change as one age 2. Jones and Widjaja stated that renal volume is a more sensitive measure of detecting renal abnormality than any single linear measurement and better correlates with renal mass and eGFR respectively 7,8. Griffiths on the other hand observed that renal length best estimates renal mass while Emamian insisted that this was only acceptable for routine clinical evaluation 3,16. In autopsy studies, renal volume has been shown to correlate well, although indirectly with the number of functional nephrons 17.
Renal function is conventionally assessed by serum creatinine levels which rise in progressive renal failure. It provides a measure of overall combined renal function and may remain normal even in the presence of severe renal artery disease giving rise to severe damage to the kidney. However, serum creatinine levels are influenced by the muscle mass and nutritional status of the individual. These limitations severely restrict the value of creatinine measurements and therefore eGFR alone in assessing renal function. There is therefore the need to correlate eGFR with sonographic renal volume for optimal assessment of renal function in the patient.

The gold standard to assess renal function is the measurement of Glomerular filtration rate (GFR). The GFR describes the flow rate of filtered fluid through the kidney and has a potential to monitor renal disease progression, prognosis, drug dosing and follow up. It cannot be measured directly, but can be assessed by renal clearance of filtration markers which may be endogenous (serum creatinine) or exogenous (Iohexol, Cystatin). For practical reasons, renal function is often evaluated from serum creatinine and GFR is predicted from it. The total kidney GFR is the sum of the filtration rates of all single functional nephrons. In pathological conditions affecting the kidneys, an individual’s GFR may not proportionally decrease due to compensatory mechanism until about 50% of the renal functional capacity is lost. This suggests its highly dynamic and adaptive nature despite initial structural damage of the renal parenchyma (that is reduction in the number of functional nephrons) hence, the need for sonographic evaluation of the kidney for early detection of renal morphologic derangements.

Glomerular Filtration Rate (GFR) can be predicted using the Cockcroft and Gault (CG) formula. The simplified CG formula is said to be the best for estimating GFR in healthy individuals, since it uses simple mathematical formulations and has high bedside
applicability. It however should be used with caution in patients with low muscle mass (cachetic/cirrhotic) and normal individuals with high muscle mass as seen in Blacks and muscular individuals. The simplified Modification of Diet in Renal Disease (MDRD) formula can also be used but it has been said to underestimate GFR by 29% in healthy individuals.

In the past, several studies have evaluated renal dimensions with emphasis on renal length 19, 20, using various imaging modalities (radiography 21-23, Sonography 12, 19, 20, computerized imaging and Magnetic resonance imaging 1) and comparing it to various anthropometric parameters. However, very few studies have assessed renal volume especially in Nigeria 2, 9, 10.

The normal sonographic renal length in south eastern Nigeria, according to Okoye et al 19 is 10.33 ± 0.70cm and 10.45 ± 0.63cm for the right and left sides respectively. Whereas in the south western zone of Nigeria, Adebayo et al 10 measured 10.0 ± 0.8 cm and 10.2± 0.7cm for the right and left kidney, respectively . In Danish populace 3, renal length was given as 11.2cm (left) and 10.9cm (right) whereas in the American population 20 it was said to be 10.74 ± 1.35 cm and 11.1 ± 1.15cm on the right and left sides, respectively.

For normal renal volume estimation, Emamian et al recorded mean renal volumes of 146cm³ and 134cm³ in the left and right kidney respectively in Danish subjects 3. It was however smaller in Pakistanis Adults 24 with a value of 99.8 ± 37.2cm³ and 124.4 ± 41.3 cm³ for the right and left kidneys respectively. In south western Nigeria, renal volume was given as 125.5 ± 35.1cm³ and 118 ± 33.3cm³ on the left and right side respectively.

Emamian et al stated that renal volume decreased with age; almost entirely because of parenchyma reduction and also that the kidneys become relatively wider and thicker with age. They gave a possible explanation for these to be the relaxation of the abdominal wall with age, so that the kidneys are squeezed less in older persons. This would also explain the broadening that becomes most pronounced for the right kidney, which has been squeezed
more because of the liver. In their study renal length correlated best with body height\(^3\). In all age groups, the parenchyma volume of the right kidney was significantly smaller than that of the left. The explanation is that the left renal artery is shorter and straighter than the right one and hence increased blood flow in the left artery may result in relatively increased volume \(^3\).

Brandt et al discussed sonographic renal dimensions and effects of change in position in 62 subjects \(^21\). The subjects were measured in the prone, supine oblique and in the supine positions. They concluded that for the right kidney, measurements in the prone and supine oblique positions were not statistically different when compared with the left kidney that had a longer length in the prone position than in supine oblique position. However, other authors have agreed that there is no statistical difference between prone and supine oblique positions \(^3, 20, 25, 26\).

The strongest correlation with renal volume was found to be the total body surface area; the correlation coefficient was 0.576 (\(p < 0.001\)) in studies by Zeb et al \(^27\). This indicates that renal parenchyma volume varies to meet metabolic demand and is closely linked to renal function.

Most studies of renal dimensions in infants and children showed no sex difference, unlike in the adult population. In children, there is a close relationship between linear growth and kidney length \(^27\) that indicates that kidney length can be used as a growth parameter in children. The kidney reaches its mature size at age 20–29 years when it now remains relatively unchanged until the 6th decade of life. Studies have shown that aging leads to progressive decrease in kidney size, after middle age at a rate of 0.5 cm per decade, due to a reduction of about 1% per year in blood flow after the third decade \(^15, 26, 28\). Buchholz et al concluded that kidney size increases till the third decade and remains stable through middle age and then declines \(^29\).
Despite the fact that renal volume is regarded as the most precise indicator of kidney size, an excellent predictor of renal function and the best correlation with body indices as well as eGFR, it has received little attention in literature as a parameter for clinical assessment and follow-up. It is also rarely included as an indication for intervention, it is therefore imperative to establish the value for normal renal volume in our locale as this would aid in the management of Nephropathies.
MATERIALS AND METHODS

STUDY DESIGN
This is a prospective study of Sonographic measurement of renal volume and relating these values to estimated GFR in normal healthy adults without any renal disease. Serum creatinine was measured during the period of contact with each subject to confirm normal renal excretory function (normal serum creatinine is between 0.3 -1.5mg/dl). The study was carried out in the Ultrasound Unit of the Department of Radiology, University of Calabar Teaching Hospital, Calabar, Nigeria over a duration of six months period after obtaining ethical approval from the Hospital Health Research and Ethics committee.

STUDY POPULATION
Subjects recruited into this study were randomly selected (by a toss of die) volunteer healthy adults within the University of Calabar Teaching Hospital (UCTH). These individuals included medical students, members of staff, as well as individuals who came into the hospital for routine medical screening; whose serum creatinine was found to be within normal range (0.3 – 1.5mg/dl).

STUDY SETTING
Calabar is the State capital of Cross River State in the South–South geopolitical zone of Nigeria. It is an educational town, a quiet peace full place, where many people from the neighboring states within the same geopolitical zone reside and carry out their educational career and businesses. It has an area of 406km² and a population of 371,022 at the 2006 census. The hospital serves the entire state as well as neighboring states like Akwa Ibom and Abia State.
ETHICAL CONSIDERATION

Ethical clearance for the proposed study was obtained from the Health Research and Ethics committee of the University of Calabar Teaching Hospital, UCTH, Calabar (Appendix III).

Written informed consent was obtained from each subject recruited into the study (Appendix I).

INCLUSION CRITERIA

1. Adult Nigerian aged 18-80 years who gave consent for the procedure.
2. Absence of any history of renal disease, malignant or systemic illness that may modify renal dimensions.
3. Arterial normotensive blood pressure of <140/90 mmHg.
4. Adults with normal renal function confirmed by normal serum creatinine <1.5 mg/dl and normal eGFR.
5. Adults with BMI <30 kg/m², as obesity is seen to modify renal volume.

EXCLUSION CRITERIA

The following individuals were excluded from the study

1. Incidental renal cyst, renal tumours, chronic renal disease, hypertensives, diabetics, chronic illness, malignant illness and obstructive uropathy with features like hydronephrosis.
2. Pregnant women or post-partum women (within the last 12 months). This is because there could be an apparent increase in renal length, due to pressure from the growing fetus.
3. Participants in whom the entire renal outline was not properly visible in prone position during US, despite deep breathing exercises.
4. Subjects above 80 years and below 18 years of age, respectively.
5. 
EQUIPMENT

1. ULTRASOUND machine ALOKA (2008)
2. 3.5MHz transducer
3. Ultrasound acoustic gel
4. Weighing scale for weight measurement
5. Stadiometer for measurement of standing height
6. Hand held creatinine monitoring device(NOVA)
7. Serum creatinine strips
SAMPLE SIZE

Sample size is usually calculated from the Fischer’s statistical formula when the population is greater than 10,000.

\[ n = \frac{z^2 \cdot pq}{d^2} \]

Where:

- \( n \) = the desired sample size (when population is greater than 10,000)
- \( z \) = the standard normal deviation, usually set at 1.96, which corresponds to the 95% confidence level.
- \( p \) = estimate of key proportions to be measured, set at 0.5
- \( q \) = 1.0 - \( p \)
- \( d \) = degree of accuracy desired, usually set at 0.05.

Calculation:

\[ n = \frac{(1.96)^2 \cdot (0.50) \cdot (0.50)}{(0.05)^2} \]

\[ = 384 \]

400 patients were however recruited so as to make for possible incomplete data of some subjects.

TECHNIQUE

The procedure was explained to all the subjects, and informed consent was obtained.

History was taken for each adult, including age (as at last birthday), gender, level of education and the presence of any illness (acute/chronic) excluded.
Blood pressure (BP) of all the subjects was measured with a mercury column sphygmomanometer after they had relaxed for five minutes. The first and fifth phases of Korotkoff sounds were taken as systolic BP and diastolic BP respectively.

Anthropometric measurement was taken using the following procedure.

**STANDING HEIGHT**

This was measured in meter using a stadiometer with a fixed vertical board and an adjustable head piece. Shoes, hair ornaments and jewelry were removed during assessment. The subjects stood erect against the backboard with the weight evenly distributed and both feet on the platform with the heels together and toes apart. The back of the head, shoulder blades, buttocks and heels made contact with the backboard.

**WEIGHT**

The subjects were weighed in kilograms using a weighing scale. They wore minimal clothing and no shoes. The subject stood in the Centre of the scale platform, facing the recorder, hands at the side and looking straight ahead.

**BODY MASS INDEX**

Body mass index $^{31}$ was calculated from the height and weight measurements using the formula: weight/height$^2$ (kg/m$^2$).
ESTIMATION OF RENAL FUNCTION

The thumb was cleaned using cotton wool dipped in methylated spirit and then finger capillary blood obtained by a single needle prick.

Serum creatinine and eGFR was estimated using a hand held Nova creatinine monitoring device (range 0.3-1.5mg/dl).

**eGFR** was calculated using the Cockcroft Gault (CG) equation\(^4,5,6\):

\[
eGFR = (140 - \text{age}) \times (\text{Weight in kg}) \times (0.85 \text{ if female}) / (72 \times \text{Cr})
\]

In males, \(eGFR = (140 - \text{age}) \times (\text{Weight in kg}) \times (72 \times \text{Cr})\)

Where Cr is Creatinine.
SONOGRAPHIC MEASUREMENT OF RENAL DIMENSIONS

All sonograms were done by the researcher under supervision to eliminate intra observer variations. Real-time grey scale ultrasound examination was performed with Aloka (2008) Ultrasound machine using the 3.5 MHz curvilinear probe. Subjects were scanned in a prone position with the urinary bladder empty.

Acoustic gel was applied to the skin (to obliterate the air interface between the probe and skin). The kidney was clearly identified as having a brightly echogenic renal capsule with a central (sinus) echogenicity. The superior and inferior poles were clearly identified and marked in the longitudinal scan of the kidney, the renal length (L) was taken as the longest distance between the poles using an electronic caliper. The anterio-posterior diameter (AP) (thickness) was measured on longitudinal scan, and the maximum distance between the anterior and posterior walls at the mid-third of the kidney was taken as AP diameter. The renal width (W) was measured on transverse scan, and the maximum transverse diameter was taken at the hilum as the renal width. (Fig 4 and Fig.5). Mean of two readings were taken for each of them to minimize intra observer error. The unit of measurement was centimeter (cm).

The examination took about 10-15 minutes.

Renal volume was calculated using the formula: \( L \times W \times AP \times 0.523 \) \(^{1, 9, 10, 32}\).
Fig. 4a: Longitudinal Sonogram of the right kidney

AB = Renal Length (L)

CD = Anterioposterior diameter
Fig. 4b: Schematic longitudinal Sonogram of the right kidney

AB = Renal Length (L), CD = Anterioposterior diameter
Fig. 5a: Transverse Sonogram of the right kidney: EF = Renal Width (W)
Fig. 5b: Schematic Transverse Sonogram of the right kidney
EF = Renal Width (W)
METHOD OF DATA ANALYSIS

Data was recorded in the participant’s ultrasound data sheet and transferred into Microsoft Excel (Microsoft Corporation, USA) and Statistical Package for Social Science for windows (SSPS Inc Chicago IL, USA) version 20.0 and double checked to ensure accuracy of entry. Mean and standard deviation were calculated for each parameter for age. The data has been stored in an encrypted format with a password.

Pearson’s correlation coefficient and Student T test were used to assess the relationship between anthropometric parameters and renal length/volume and between renal lengths/volume and eGFR.

Tables, bar charts and scatter diagrams were used where necessary.
STUDY LIMITATIONS

1. Ultrasound is operator dependent; therefore intra observer variations may have occurred. However, a mean of two readings was taken for each measurement to minimize this error.

2. There is paucity of local data hence there are few local standards for appropriate comparison.

3. There were few patients, aged greater than 60 years; hence this study had a wider range of younger people than older people. However this did not impact significantly on the study; moreover the global life expectancy is on the decline.

4. Only healthy subjects were recruited into the study.
RESULTS

4.1. SOCIODEMOGRAPHIC CHARACTERISTICS OF THE STUDY POPULATION

A total of 400 (four hundred) subjects were systematically and randomly selected for this study. There were 177 (44.25%) males and 223 (55.25%) females. The age range of the subjects were 18-70 years with a mean age 36.29(±10.25) and 34.00(±10.89) for males and females respectively.

The majority of the Participants in the male category were aged between 21-30 years (61.2%) and 31-40 years (50.3%) while the females were aged between 21-30 years (38.8%) and 31-40 years (49.7%) Table 1 displays the age group distribution of the subjects and Fig. 6a and Fig 6b shows the age distribution of males and females respectively.

Table 2 summaries the sociodemographic characteristics of the sample population. The mean weight for females (68.6 ± 10.19 Kg) is lower than that of males (71.8 ± 9.88 Kg). More so, the mean height for females (1.64 ± 0.06m) was also seen to be lower than in the males (1.70 ±0.07m). The mean body mass index (BMI) for females (25.47 ±3.33 Kg/m²) was however greater than for males (24.71 ±4.5 Kg/m²).

The differences noticed in all the measured parameters between the male and female were found to be statistically significant (P< 0.05).
Table 1: Age distribution of subjects aged 18-80 years

<table>
<thead>
<tr>
<th>Age group (year)</th>
<th>Class total</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-20</td>
<td>13</td>
<td>11 (84.6%)</td>
<td>2 (15.4%)</td>
</tr>
<tr>
<td>21-30</td>
<td>139</td>
<td>85 (61.2%)</td>
<td>54 (38.8%)</td>
</tr>
<tr>
<td>31-40</td>
<td>143</td>
<td>72 (50.3%)</td>
<td>71 (49.7%)</td>
</tr>
<tr>
<td>41-50</td>
<td>65</td>
<td>36 (55.4%)</td>
<td>29 (44.6%)</td>
</tr>
<tr>
<td>51-60</td>
<td>34</td>
<td>16 (47.1%)</td>
<td>18 (52.9%)</td>
</tr>
<tr>
<td>61-70</td>
<td>6</td>
<td>3 (50.0%)</td>
<td>3 (50.0%)</td>
</tr>
<tr>
<td>71-80</td>
<td>0</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Total</td>
<td>400</td>
<td>223 (55.7%)</td>
<td>177 (44.3%)</td>
</tr>
</tbody>
</table>
FIG 6a: Percentage Distribution of age group of male subjects
FIG 6b: Percentage distribution of age group of female subjects
Table 2: Socio-demographic characteristics of the subjects

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sex</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>Male (n = 177)</td>
<td>19.00</td>
<td>69.00</td>
<td>36.29</td>
<td>10.25</td>
<td>0.037</td>
</tr>
<tr>
<td></td>
<td>Female (n = 223)</td>
<td>18.00</td>
<td>69.00</td>
<td>34.00</td>
<td>10.89</td>
<td></td>
</tr>
<tr>
<td>Height (m)</td>
<td>Male (n = 177)</td>
<td>1.51</td>
<td>1.88</td>
<td>1.70</td>
<td>0.07</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Female (n = 223)</td>
<td>1.46</td>
<td>1.88</td>
<td>1.64</td>
<td>0.06</td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>Male (n = 177)</td>
<td>52.00</td>
<td>95.00</td>
<td>71.80</td>
<td>9.88</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>Female (n = 223)</td>
<td>41.00</td>
<td>88.00</td>
<td>68.62</td>
<td>10.19</td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>Male (n = 177)</td>
<td>16.23</td>
<td>29.73</td>
<td>24.71</td>
<td>3.01</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>Female (n = 223)</td>
<td>17.02</td>
<td>29.75</td>
<td>25.47</td>
<td>3.33</td>
<td></td>
</tr>
</tbody>
</table>
4.2. CLINICAL CHARACTERISTICS OF THE SUBJECTS.

Table 3 highlights the clinical characteristics of the study population.

There was a significant difference between the systolic blood pressure of the males and females with a significant P-value of 0.001. However, there was no significance difference (p-value = 0.454) between the diastolic blood pressure of females (72.51 ±8.90 mmHg) and males (73.16 ±8.34 mmHg).

Serum creatinine values were significantly higher (p-value=0.000) in males (1.10 ± 0.20mg/dl) than in females (0.96 ±0.17mg/dl).

Furthermore, a significant difference (p-value=0.037) with eGFR was also observed, with males having a higher value (96.13 ±20.3 ml/min/1.73²) than females (91.43 ±23.09 ml/min/1.73²).
Table 3: Clinical characteristics of the subjects

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sex</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>SD</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male (n = 177)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>90.00</td>
<td>140.00</td>
<td>119.83</td>
<td>9.86</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female (n = 223)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>90.00</td>
<td>130.00</td>
<td>116.23</td>
<td>11.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male (n = 177)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>60.00</td>
<td>90.00</td>
<td>73.16</td>
<td>8.34</td>
<td>0.454</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female (n = 223)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50.00</td>
<td>90.00</td>
<td>72.51</td>
<td>8.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male (n = 177)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCr (mg/dl)</td>
<td>0.50</td>
<td>1.49</td>
<td>1.10</td>
<td>0.20</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female (n = 223)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.46</td>
<td>1.37</td>
<td>0.96</td>
<td>0.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Male (n = 177)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>eGFR(ml/min/1.73m²)</td>
<td>51.70</td>
<td>157.32</td>
<td>96.13</td>
<td>20.33</td>
<td>0.037</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female (n = 223)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>35.20</td>
<td>176.48</td>
<td>91.43</td>
<td>23.09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.3. Family history

The number of subjects who had a positive family history of the following mentioned disease were insignificant: Polycystic kidney (1), hypertension (22), diabetes(12), Cardiac(0) pathology(2) or any other disease as they each had a P-value > 0.05. However, these individuals had normal clinical and renal parameters.
4.4 RENAL DIMENSIONS

Renal dimensions with side differences.

Table 4 summarizes the results obtained for renal dimensions for the left and right kidneys in both sexes and also for the total population.

The mean renal length for the total population was seen to be greater on the left (10.34 ± 0.87cm) than on the right (9.81 ±0.87cm) with a significant P-value of 0.001

The rest of the renal dimensions (height, AP dimension and volume) were also found to be greater on the left side in both sexes but however statistically significant (P< 0.001) in males than females.
Table 4: Sonographic renal dimensions and side differences for the subjects

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Female (Mean ±SD)</th>
<th>Male (Mean ±SD)</th>
<th>Total (Mean ±SD)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>Kidney length(cm)</td>
<td>9.73 ±0.86</td>
<td>10.28 ±0.82</td>
<td>9.92 ±0.88</td>
<td>10.42 ±0.92</td>
</tr>
<tr>
<td>Kidney A/P(cm)</td>
<td>3.91 ±0.41</td>
<td>4.32 ±0.43</td>
<td>4.00 ±0.39</td>
<td>4.34 ±0.43</td>
</tr>
<tr>
<td>Kidney width(cm)</td>
<td>4.95 ±0.53</td>
<td>5.29 ±0.49</td>
<td>5.04 ±0.50</td>
<td>5.34 ±0.43</td>
</tr>
<tr>
<td>Kidney volume(cm³)</td>
<td>99.57 ±22.26</td>
<td>121.48 ±25.44</td>
<td>105.32 ±22.24</td>
<td>127.34 ±24.63</td>
</tr>
</tbody>
</table>

- The probability values are significant at p-value (0.05)
4.5. RENAL DIMENSIONS ACCORDING TO AGE GROUP

Table 5 depicts the range of renal dimensions of the entire subject according to their age groups. The renal dimensions for both sexes were seen to increase from age group 18-20, with the highest renal dimensions observed in subjects aged 31-40 years which made up 35.8% of the total population. Thereafter, renal dimensions were seen to progressively decline in those subjects above 41 years of age.

Data obtained for age group 61-70 was statistically insufficient to draw conclusion on.
Table 5: Sonographic determination of renal size according to age group

<table>
<thead>
<tr>
<th>Age group (year)</th>
<th>Right kidney</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Left kidney</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kidney length</td>
<td>Kidney AP dimension</td>
<td>Kidney Width</td>
<td>Kidney volume</td>
<td></td>
<td>Kidney length</td>
<td>Kidney AP dimension</td>
<td>Kidney Width</td>
<td>Kidney volume</td>
</tr>
<tr>
<td>18-20 (n = 13)</td>
<td>9.59 ±0.84</td>
<td>3.63 ±0.50</td>
<td>4.85 ±0.53</td>
<td>88.94 ±19.39</td>
<td>10.08 ±0.75</td>
<td>4.14 ±0.35</td>
<td>5.09 ±0.52</td>
<td>112.11 ±22.04</td>
<td></td>
</tr>
<tr>
<td>21-30 (n = 139)</td>
<td>9.75 ±0.85</td>
<td>3.90 ±0.39</td>
<td>4.92 ±0.54</td>
<td>98.82 ±22.27</td>
<td>10.26 ±0.82</td>
<td>4.20 ±0.39</td>
<td>5.30 ±0.47</td>
<td>120.44 ±23.59</td>
<td></td>
</tr>
<tr>
<td>31-40 (n = 143)</td>
<td>9.87 ±0.90</td>
<td>4.01 ±0.39</td>
<td>5.08 ±0.52</td>
<td>106.27 ±23.04</td>
<td>10.43 ±0.90</td>
<td>4.33 ±0.45</td>
<td>5.36 ±0.46</td>
<td>128.10 ±27.35</td>
<td></td>
</tr>
<tr>
<td>41-50 (n = 65)</td>
<td>9.89 ±0.94</td>
<td>3.96 ±0.39</td>
<td>5.02 ±0.51</td>
<td>103.68 ±21.99</td>
<td>10.43 ±0.94</td>
<td>4.29 ±0.41</td>
<td>5.32 ±0.48</td>
<td>125.80 ±25.83</td>
<td></td>
</tr>
<tr>
<td>51-60 (n = 34)</td>
<td>9.73 ±0.75</td>
<td>3.92 ±0.44</td>
<td>4.88 ±0.40</td>
<td>97.75 ±18.01</td>
<td>10.21 ±0.82</td>
<td>4.35 ±0.39</td>
<td>5.21 ±0.43</td>
<td>121.54 ±19.16</td>
<td></td>
</tr>
<tr>
<td>61-70 (n = 6)</td>
<td>10.13 ±0.89</td>
<td>4.25 ±0.17</td>
<td>5.11 ±0.50</td>
<td>115.77 ±21.05</td>
<td>10.30 ±0.94</td>
<td>4.50 ±0.40</td>
<td>5.48 ±0.42</td>
<td>133.46 ±25.23</td>
<td></td>
</tr>
<tr>
<td>F-test</td>
<td>0.781</td>
<td>3.417</td>
<td>2.113</td>
<td>3.348</td>
<td>1.020</td>
<td>2.260</td>
<td>1.419</td>
<td>2.221</td>
<td></td>
</tr>
<tr>
<td>p&gt;0.05</td>
<td>p&lt;0.001</td>
<td>p&gt;0.05</td>
<td>p&lt;0.001</td>
<td>p&gt;0.05</td>
<td>p&lt;0.05</td>
<td>p&gt;0.05</td>
<td>p&gt;0.05</td>
<td>p&gt;0.05</td>
<td></td>
</tr>
</tbody>
</table>
4.6 Sonographic renal dimensions and anthropometric parameters

Table 6 shows the correlation between renal dimensions with anthropometric measurements using the Pearson’s correlation ($r$) for the left and right kidney in the total study population.

**Age Relationship versus Renal Dimensions**

For the study population, subject’s age showed no significant relationship with renal length or the renal AP dimension on either side. There was however marked correlation between the subjects age and renal width on the right ($r=0.137$) than the renal width on the left ($r=0.128$). More so, a slight correlation is observed between the subjects age and the right renal volume ($r=0.127$) however, no significant correlation was observed with the renal volume on the left ($r=0.098$).

**Height relationship versus renal dimensions**

The strongest correlation was observed between the subject’s height and renal length on both sides($r=0.316$ and $r=0.311$ for the right and left kidney respectively). The least correlation for subject’s height was with renal AP dimension($r=0.103$ and $r=0.161$ for the right and left kidney respectively).

**Weight relationship versus renal dimensions**

The strongest correlation was observed between the subject’s weight and renal volume on both sides($r=0.448$and $r=0.449$ for the right and left kidney respectively, each with p-value =<0.001). The least correlation for subject’s weight was with renal AP dimension($r=0.103$ and $r=0.161$ for the right and left kidney respectively).
BMI relationship versus renal dimensions

BMI was seen to best correlate with renal volume (p value= <0.001; r=0.318 and r= 0.323 for the right and left kidney respectively), and it correlates less with renal length (r= 0.198, p-value =<0.01) on the right and renal AP dimension (r= 0.176) on the left.
Table 6: Relationship between the anthropometric parameters and sonographic renal dimensions in the total population.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Right kidney length</th>
<th>Right kidney width</th>
<th>Right kidney AP dimension</th>
<th>Right kidney volume</th>
<th>Left kidney length</th>
<th>Left kidney width</th>
<th>Left kidney AP dimension</th>
<th>Left kidney volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>0.080</td>
<td>0.137**</td>
<td>0.077</td>
<td>0.127*</td>
<td>0.057</td>
<td>0.128*</td>
<td>0.041</td>
<td>0.098</td>
</tr>
<tr>
<td>Height (m)</td>
<td>0.316***</td>
<td>0.205**</td>
<td>0.103*</td>
<td>0.275**</td>
<td>0.311***</td>
<td>0.178*</td>
<td>0.161*</td>
<td>0.273***</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>0.368***</td>
<td>0.365***</td>
<td>0.265**</td>
<td>0.448***</td>
<td>0.427***</td>
<td>0.358***</td>
<td>0.250**</td>
<td>0.449***</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>0.198**</td>
<td>0.272**</td>
<td>0.232**</td>
<td>0.318***</td>
<td>0.274***</td>
<td>0.284**</td>
<td>0.176**</td>
<td>0.323***</td>
</tr>
</tbody>
</table>

Values indicate correlation coefficient (r)

* = correlation is significant at p<0.05

** = correlation is significant at p<0.01

*** = correlation is significant at p<0.001
4.7 Renal dimensions of subjects according to BMI classification

The Body mass index (BMI) is defined by body weight in kilograms divided by the square of the heights in meters (kg/m²). The subjects were subdivided according to the World Health Organization (WHO) classification into underweight, normal range, overweight and obese, independent of age and is the same for both sexes. However, obesity is said to modify renal dimensions\(^3\), hence obese participants were excluded.

Table 7 displays the mean renal dimensions of the subjects by the age group compared with BMI; 1.75% was under weight, 42% were normal weight and 56.25% were overweight. There was no significant difference in renal length and volume on either side in underweight individuals. Renal dimensions were greater in normal weight and largest in overweight individuals, with a significant p-value of 0.001; the left kidney dimensions were seen to be larger than the right in both normal weight and overweight individuals. Obese subjects were excluded from this study.
<table>
<thead>
<tr>
<th>BMI Classification</th>
<th>Renal length ±S.D(cm)</th>
<th>Renal volume ±S.D (cm³)</th>
<th>p-value</th>
<th>Renal length ±S.D(cm)</th>
<th>Renal volume ±S.D (cm³)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right kidney</td>
<td>Left kidney</td>
<td>p-value</td>
<td>Right kidney</td>
<td>Left kidney</td>
<td>p-value</td>
</tr>
<tr>
<td>Under weight</td>
<td>9.69 ±0.92</td>
<td>9.96 ±1.26</td>
<td>0.144</td>
<td>91.20 ±20.22</td>
<td>99.83 ±26.13</td>
<td>0.150</td>
</tr>
<tr>
<td>(n = 7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal weight</td>
<td>9.62 ±0.86</td>
<td>10.14 ±0.84</td>
<td>0.000</td>
<td>94.60 ±20.40</td>
<td>117.53 ±23.05</td>
<td>0.000</td>
</tr>
<tr>
<td>(n = 168)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over weight</td>
<td>9.97 ±0.86</td>
<td>10.50 ±0.84</td>
<td>0.000</td>
<td>108.07 ±22.17</td>
<td>129.71 ±25.22</td>
<td>0.000</td>
</tr>
<tr>
<td>(n = 225)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.8  Relationship between renal dimensions and renal function indices

Estimated glomerular filtration rate (eGFR) was seen to have the better correlation with renal volume \((r = 0.162\) on the right and 0.176 on the left, both with p-value of 0.001) than with renal length \((r=0.09\) on the right and 0.146 on the left).

Serum Creatinine (mg/dl) was seen to have the better correlation with renal length \((r = 0.177\) on the right and \(r= 0.163\) on the lefts, both with p-value of 0.001) than with renal volume \((r = 0.142,\) in the right and 0.149 on the left, both with p-value of 0.01).

Table 8 depicts the earlier described correlations.
Table 8: Relationship between sonographic renal dimensions and renal function indices in subject (N = 400)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Right kidney length</th>
<th>Right kidney width</th>
<th>Right kidney apical dimension</th>
<th>Right kidney volume</th>
<th>Left kidney length</th>
<th>Left kidney width</th>
<th>Left kidney apical dimension</th>
<th>Left kidney volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCr</td>
<td>0.177***</td>
<td>0.104*</td>
<td>0.066</td>
<td>0.142**</td>
<td>0.163***</td>
<td>0.149**</td>
<td>0.033</td>
<td>0.140**</td>
</tr>
<tr>
<td>eGFR</td>
<td>0.090</td>
<td>0.089</td>
<td>0.160***</td>
<td>0.162***</td>
<td>0.146**</td>
<td>0.058</td>
<td>0.174***</td>
<td>0.176***</td>
</tr>
</tbody>
</table>

Values indicate correlation coefficient (r)

* = correlation is significant at p<0.05

** = correlation is significant at p<0.01

*** = correlation is significant at p<0.001

SCr = serum creatinine (mg/dl), eGFR-estimated glomerular filtration rate
Figures 7-10 represent the scatter diagrams of the regression analysis of the right and left renal length and volume against the estimated glomerular filtration rate (eGFR) of subjects.

Figures 7 and 8 depict renal length versus eGFR; the points were seen to cluster almost to a horizontal level for both right and left kidneys, indicating that renal length may not be a good predictor of renal function compared with renal volume.

Figures 9 and 10 show renal volume versus eGFR; most point were seen to cluster around the line of best fit, showing a higher positive correlation ($r=0.162$ on the right and $r=0.176$ on the left) with eGFR than with renal length ($r=0.09$ on the right and 0.146 on the left); thus renal volume better predicts renal function than renal length in this population.
Fig. 7: Relationship between eGFR and the right kidney length in both male and female subjects.

\[ y = 0.0036x + 9.4755 \]

\[ r = 0.090 \]

\[ p = 0.055 \]
Fig. 8: Relationship between eGFR and the left kidney length in both male and female subjects.

\[ y = 0.0058x + 9.7935 \]
\[ r = 0.146 \]
\[ p = 0.003 \]
Fig. 9: Relationship between eGFR and right kidney volume in both male and female subjects.

\[ y = 0.1671x + 86.481 \]
\[ r = 0.162 \]
\[ p = 0.001 \]
Fig. 10: Relationship between renal volume and eGFR in both male and female subjects

\[
y = 0.2045x + 104.93 \\
r = 0.176 \\
p = 0.001
\]
4.9 Physiological variation in renal dimension of subjects

Tables 9 and 10 show the physiological variation in renal dimension of subjects.

The left kidney length was seen to be longer than the right in 152 males (85.9%) and 202 females (90.6%) whereas right kidney length was seen to be longer than the left in only 21 males (11.9%) and 16 females (7.2%). The right kidney length was the same as the left in 4 males (2.3%) and 5 females (2.2%). The results of the above analysis was not significant for the sample population (p value >0.05).

The left kidney volume was seen to be greater than the right in 173 males (97.7%) and 210 females (94.2%) whereas the right kidney volume was seen to be greater than the left in 4 males (2.3%) and 12 females (5.4%). The right kidney volume was the same as the left only in one female (0.4%). The p-value for the above analysis was > 0.05, hence not significant for the sample population.
Table 9: Physiological variation in renal length of subjects

<table>
<thead>
<tr>
<th>Relative dimensions</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left kidney length longer than right</td>
<td>152 (85.9%)</td>
<td>202 (90.6%)</td>
</tr>
<tr>
<td>Right kidney length longer than left</td>
<td>21 (11.9%)</td>
<td>16 (7.2%)</td>
</tr>
<tr>
<td>Right kidney length same size as left</td>
<td>4 (2.3%)</td>
<td>5 (2.2%)</td>
</tr>
</tbody>
</table>

*Chi value cal. = 2.593; df = 2; p > 0.05*
Table 10: Physiological variation in renal volume of subjects

<table>
<thead>
<tr>
<th>Relative dimensions</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left kidney volume larger than right</td>
<td>173 (97.7%)</td>
<td>210 (94.2%)</td>
</tr>
<tr>
<td>Right kidney volume larger than left</td>
<td>4 (2.3%)</td>
<td>12 (5.4%)</td>
</tr>
<tr>
<td>Right kidney volume same size as left</td>
<td>0 (0.0%)</td>
<td>1 (0.4%)</td>
</tr>
</tbody>
</table>

*Chi value cal. = 3.328; df = 2; p > 0.05*
4.10 Prediction of sonographic renal length and renal volume from anthropometric parameters

In emergency situations in resource poor settings where sonography may not be feasible, renal dimensions (kidney length/kidney volume) could be predicted using linear regression equations from independent variables (age, height and weight) for both females and males respectively. These equations are shown in tables 11 and 12.

The scenario where sonographic renal volume is known, eGFR could be calculated using the prediction equation as seen in Tables 13 and 14 in both females and males respectively while table 15 shows prediction equation for the total subjects.
Table 11: Prediction equation for Sonographic renal length and volume using
anthropometric parameters in female subjects (n = 223)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prediction equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right kidney length</td>
<td>$4.735 + (0.003 \times \text{Age}) + (2.266 \times \text{Height}) + (0.017 \times \text{Weight})$</td>
</tr>
<tr>
<td>Right kidney volume</td>
<td>$14.546 + (0.047 \times \text{Age}) + (13.808 \times \text{Height}) + (0.885 \times \text{Weight})$</td>
</tr>
<tr>
<td>Left kidney length</td>
<td>$6.677 - (0.001 \times \text{Age}) + (1.123 \times \text{Height}) + (0.026 \times \text{Weight})$</td>
</tr>
<tr>
<td>Right kidney volume</td>
<td>$38.756 - (0.094 \times \text{Age}) + (12.100 \times \text{Height}) + (0.963 \times \text{Weight})$</td>
</tr>
</tbody>
</table>

(Age in year; height in meter and weight in kilogram)
Table 12: Prediction equation for sonographic renal length and volume using anthropometric parameters in male subjects (n = 177)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prediction equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right kidney length</td>
<td>3.818 - (0.002 x Age) + (2.249 x Height) + (0.032 x Weight)</td>
</tr>
<tr>
<td>Right kidney volume</td>
<td>0.365 - (0.033 x Age) + (22.809 x Height) + (0.937 x Weight)</td>
</tr>
<tr>
<td>Left kidney length</td>
<td>4.090 - (0.007 x Age) + (2.158 x Height) + (0.040 x Weight)</td>
</tr>
<tr>
<td>Right kidney volume</td>
<td>-0.404 - (0.006 x Age) + (25.205 x Height) + (1.184 x Weight)</td>
</tr>
</tbody>
</table>

(Age in year; height in meter and weight in kilogram)
Table 13: Prediction equation for eGFR using Sonographic renal volume in male subjects
(n = 177)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prediction equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>eGFR</td>
<td>73.622 + (0.063 x Right renal volume) + (0.109 x left kidney volume)</td>
</tr>
</tbody>
</table>
Table 14: Prediction equation for eGFR using Sonographic renal volume in female subjects (n = 223)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prediction equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>eGFR</td>
<td>72.897 + (0.024 x Right renal volume) + (0.134 x left kidney volume)</td>
</tr>
</tbody>
</table>
Table 15: Prediction equation for eGFR using Sonographic renal volume in the subjects (n = 400)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prediction equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>eGFR</td>
<td>73.622 + (0.063 x Right renal volume) + (0.109 x left kidney volume)</td>
</tr>
</tbody>
</table>
DISCUSSION

The Sonographic assessment of renal dimensions especially renal volume is an integral tool for initial evaluation and serial follow up of suspected renal disease in adults especially in urological and nephrological clinical settings. However, few studies have depicted that sonography underestimates true renal volume thereby advocating for computerized tomography and Magnetic resonance imaging for more reliable volumetric assessment. Nonetheless, Sonographic renal size assessment remains the most reproducible, real time, tridimensional, non-invasive, non-ionizing radiation, easy, quick, most affordable and accessible modality for evaluating renal dimensions.

The overall mean renal length (right 10.4cm and left 10.6cm) in the study done by Okoye et al in South eastern Nigeria were slightly higher than those in the current study. The values for renal length were also higher in the North western Nigeria in studies done by Maaji et al., where the right kidney was 11.3 ±8.8 cm and the left 11.6 ± 9.8cm. This difference could be as a result of genetic, nutritional and environmental factors, hence the same normogram cannot be used for different ethnicities in the same country. In contrast, the study done by Adebayo et al in south western Nigeria has similar values for the right and left kidney with this current study, where the right kidney measured 10.0 ±0.8cm and the left 10.2 ±0.7cm. This similarity could probably be due to similar body habitus and type of diet of the south western and the south-southern Nigeria where most of the population is predominantly overweight and the nutritional components of our daily foods consist predominantly of carbohydrates, fat and oils.

This current study showed that mean renal lengths were lower when compared with the Caucasian study by Brandt et al and the Danish population study by Emamian et al who had a
mean renal length of 10.1±1.35cm/10.9cm on the right and 11.1±1.15cm/11.2 on the left respectively. However, the values for this current study were similar to the North western Indian and Pakistan findings by Shani et al and Raza Mujahid et al respectively34,25. Mean renal width and (AP) depth obtained in this study were slightly higher than those in the Pakistani population25.

Renal volume obtained in this study were seen to be similar to those obtained in the south western part of Nigeria and the Pakistan population10,25 while higher values were seen for the Danish(left- 146cm³, right -134cm³ )and Caucasians population(left/ right=130cm³)3,12,13. Renal volume values were lower in the North western population (119.7±32.8cm³ and 109.6±29.3 cm³ for the left and right side respectively) 32. The difference in body habitus and diets may be a plausible explanation to this effect32,35.

**GENDER**

This study showed that the left renal length were greater in males than in females; probably due to the differences in height and BMI as seen in other studies done by Emamian et al, Kang et al, okoye etal, and Brandt etal3,18,20,21. Zeb et al26 showed no gender related differences in renal length, although larger kidney sizes were seen in males.

Johnson et al like in this study observed that renal volume was lower in females than males, even when body weight and BMI were accounted for 19. Therefore, his study agrees with previous reports 3, 10, 19 that female renal dimensions are generally smaller than those in males. This difference in gender maybe due to a direct action of sex steroid on kidney growth or due to differences in physical activity3,18,29.
SIDE DIFFERENCES

Renal length and volume were seen to be larger on the left than on the right in the studied subjects as was seen in studies done by Ohikhokhai et al, Okur et al and Karim et al\textsuperscript{12,38,45}. The study by Buchholz et al\textsuperscript{29} which showed no significant side difference in renal length however agreed with this study that renal width was statistically higher on the left side than the right (p< 0.05). Unlike this study, Emamian et al and Okoye et al however reported differently that renal width and depth were higher on the right side\textsuperscript{3,20}.

However, this study established slight variations in side differences, though insignificant; a longer right kidney was seen in 9.25% of the population, and equal right and left kidneys in 2.25% of the total subjects. The right renal volume was greater in 4% of the population and equal to the left in 0.25% of the population.

The reason proposed for the longer left kidney dimension is attributable to the relatively larger hepatic mass on the right side which limits the vertical growth of the right kidney and a relatively smaller splenic size on the left side which facilitated the growth of the left kidney.\textsuperscript{19,27,45}

AGE

Renal dimensions is said to be affected by age; like in this present study, Emamian et al\textsuperscript{3} and Buchholz et al\textsuperscript{29} observed that all renal dimensions generally increased steadily until the fourth decade, with a decline after the sixth decade with the highest renal sizes occurring in the 31-40 year age group (table 6). In contrast to findings by Zeb Saeed et al\textsuperscript{27}, a fall in renal length was observed after age 70. More so, using Pearson’s correlation to compare renal sizes with anthropometric measurements, there was a weak correlation between renal volume with age for right and left kidneys respectively, in this study. This finding was unlike the study done by
Maaji et al which found a strong correlation between renal volume and age. However, there was moderate correlation between renal width and age on the right (r=0.14, p-value <0.01). According to the above mentioned comparison, the exact biological relationship between the fall in renal size with age is unknown; these studies have shown that progressive renal parenchymal volume reduction occurs at the rate of 0.5cm per decade after middle age due to a reduction of about 1% per year in blood flow after the third decade. The age related loss of renal volume is said to be due to cellular senescence, glomerulosclerosis, tubulointerstitial fibrosis, vascular collapse and thickening as well as shunting of renal blood flow from the cortex to the medulla. Other implicated factors include oxidative stress, alterations of cytokines, diet and growth factors.

**RENEAL DIMENSIONS VERSUS SUBJECTS HEIGHT AND BODY WEIGHT**

There was a strong correlation between renal length and height in this study (r= 0.316, 0.317 for the left and right side respectively), which was in agreement with studies done by Adebayo et al\(^{10}\), Gavele et al\(^{37}\), and Fernandes et al\(^{44}\) and Emamian et al\(^{3}\) (r=0.46, 0.42) for the left and right side respectively. This finding was at variance to studies done by Okoye et al., Maaji et al as well as radiographically determined renal lengths by Esbo and Ojemuyiwa, who reported that renal length best correlated with body weight\(^{19, 32, 21}\).

Renal volume in this study showed good correlation with body weight on both sides with an r value of 0.44 and 0.45 on the right and left side; this was in keeping with studies done in South Western Nigeria and in the Turkish Population\(^{10, 37}\).

The exact mechanism by which body weight affects renal volume is unknown; because additional glomeruli do not appear after birth; therefore the increase in renal volume with
increased body weight during development /weight gain is thought to result from nephron hypertrophy, presumably to meet metabolic demand\textsuperscript{18, 35, 36}.

Renal width and depth from this study also showed moderate correlation with both body height and weight.

**RENALE DIMENSIONS AND BMI**

In this study BMI showed a good correlation with both renal volume and length but better correlated with renal volume (r= 0.31/0.323). Raza Mujahid et al rather showed that renal length better correlated with BMI than renal volume \textsuperscript{24}. The study by Buccholz \textsuperscript{29} also found strong correlation between BMI with renal sizes, especially renal volume in the Pakistanis population. Udoaka et al found out that renal size increased correspondingly with an increasing BMI, as do all other organs in the body\textsuperscript{43}. Similar findings were observed with Karim et al in the Sulaimani region\textsuperscript{45}.

**RENALE DIMENSIONS AND eGFR**

The correlation between renal volume and function has not been given much attention in literature. Okur et al and Johnson et al have shown that renal volume strongly correlates with eGFR, and implied that since renal volume varies with metabolic demand, it is therefore closely linked to renal function\textsuperscript{19, 38}.

This study also showed that renal volume better correlated with eGFR, hence a better index of measurement of renal function than renal length which is the same as proposed by Moorthy et al, Chenog B et al., and Rasmussen SN et al.,\textsuperscript{1, 39, 41}. 
Gong H et al observed that renal volume best correlated with eGFR than with body height and weight with correlation coefficients of 0.615, 0.344 and 0.343 respectively, each with significant p-value of < 0.01^{40}.

**PREDICTION EQUATIONS**

Tables 14-17 show the established equations from this study that could be used to predict renal length and volume in males and females, provided the subject’s age, height and weight is known, especially in remote settings where access to sonography may be unavailable due to poor access roads or absence of an ultrasound machine/ qualified radiologist/ sonologist. However, when the subject’s height and weight is not known but renal sonography has been done, 24-hour creatinine clearance cannot be done to determine eGFR and time is of the essence, then eGFR could be calculated from the sonographically determined renal dimensions in the south-south region of Nigeria.

Few studies have attempted to draw up prediction equations in Nigeria to aid diagnosis in remote settings or emergency situations; one of such was given by Adebayo et al in South western Nigerian subjects (Renal length=6.1078 +0.0248(height) cm); similarities were observed^{10}.

These prediction equations derived in this study are standard and are recommended for this region.
CONCLUSION

Renal dimensions were generally greater on the left side than the right side and also greater in males than females. The largest renal dimensions were found between ages 31-40 years. Renal volume better correlated with body weight than BMI and best correlated with renal function (eGFR); thus the prediction of eGFR from renal volume in resource poor setting should be considered in the studied population. Sonographic assessment of renal volume rather than renal length is therefore clinically relevant and would serve as a surrogate for renal status evaluation for clinical decisions on stability, serial follow up and renal disease progression in the south - south region of Nigeria.
RECOMMENDATION

Sonographically determined renal volume should be integrated into our daily routine as Radiologist or Sonologist as this would inform the Clinicians on the functional reserve of the renal status of the individual and not just the renal length and AP dimensions as is common practice.

The prediction equations could also serve as an alternative measure for the assessment of renal dimensions in remote settings in the south-south part of Nigeria where there is no access to sonography or in busy practice where urgent renal status evaluation is required in the studied population.
LINES OF FURTHER RESEARCH

1. Sonographic renal variations in chronic kidney disease states using the MDRD formula in Calabar.

2. Conduct similar studies in infants and children.

3. Conduct similar study using Computerized tomography and Magnetic resonance imaging.

4. Multicenter study in Nigeria to draw a normogram for the whole country is encouraged.

5. An assessment of the rate of reduction in the renal indices for specific conditions may also be necessary for prognostic purposes.
REFERENCES


8. Widjaja E, Oxtoby J, Hale T, Jones P, Harden P, McCall I. Ultrasound measured renal
length versus low dose CT volume in predicting single kidney glomerular filtration rate.


45. Karim SH, Mohammed NA, Aghaways NA, Aghaways IH, Mohammed BA.


APPENDIX I

INFORMED CONSENT FORM

RESEARCH TOPIC: SONOGRAPHIC ASSESSMENT OF RENAL VOLUME AND ESTIMATED GLOMERULAR FILTRATION RATE IN NORMAL ADULTS IN CALABAR NIGERIA.

I am Dr. Ani, N. E, a Senior Registrar and the principal investigator in the above study to be conducted in University of Calabar Teaching Hospital, Calabar, Nigeria.

The goal of this research is to determine the normal kidney volume in Adults in Calabar and use it to estimate kidney function. This will help the Doctors to better manage patients with kidney diseases.

I therefore solicit your consent to allow me conduct this study. A short questionnaire will be administered to you. To help determine if your kidneys are excreting waste products properly, a substance called Creatinine would be measured. This would be done using a single needle prick to one of your fingers and blood obtained. You may experience slight discomfort during the procedure; thereafter an Ultrasound scan of your kidneys would also be performed.

Ultrasonography is a safe procedure, painless, radiation free and has no known side effect.

If we find any abnormality, you will be promptly referred to the appropriate physician after due counseling. I assure you of utmost confidentiality.

Your decision to participate in this study is voluntary and you are allowed to withdraw at any stage of the study. This will not affect how you are treated in this hospital.
If you have clearly understood this procedure with the opportunity to ask questions and given your consent; please kindly fill the consent form.

Name: …………………………………………………………………………
Address: ………………………………………………………………………
Phone No: ………………………………………………………………………
Signature: …………………………… Date……………………………………

Witness

Name: …………………………………………………………………………
Address: ………………………………………………………………………
Phone No: ………………………………………………………………………
Signature: …………………………… Date…………………………………… Thumb print
APPENDIX II:
PATIENT’S DATA SHEET

SONOGRAPHIC ASSESSMENT OF RENAL VOLUME AND ESTIMATED GLOMERULAR FILTRATION RATE IN NORMAL ADULTS IN CALABAR, NIGERIA

Patient’s Bio Data

1. Code No. ……………… (2) Sex ……………… (3) Age: ………………………

4. Nationality:

..........................................................................................................................

5. State/LGA:

..........................................................................................................................

6. Tribe:

..........................................................................................................................

7. DATA ON FAMILY HISTORY OF MEDICAL CONDITION

a. Polycystic kidney disease (Y/N) …………… Relationship………………

b. Hypertension (Y/N) ………………… Relationship………………

c. Diabetes mellitus (Y/N) ………………… Relationship………………

d. Cardiac Disease(Y/N) ………………… Relationship………………

e. OTHERS (Specify) ………………… Relationship………………

8. ANTHROPOMETRIC DATA

a. Height ……….. (m) b. Weight…… (kg)……… c. BMI……. (kg / m²)

9. B.P (mmHg)………………

10. Serum Creatinine ………….mg/dl

11. eGFr …………………………ml/min/1.73m²
12. RENAL MEASUREMENTS

<table>
<thead>
<tr>
<th></th>
<th>RIGHT</th>
<th>LEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Length (L)</td>
<td>……….. cm</td>
<td>……….. cm</td>
</tr>
<tr>
<td>b. Anterioposterior (AP)</td>
<td>……….. cm</td>
<td>……….. cm</td>
</tr>
<tr>
<td>c. Width (W)</td>
<td>……….. cm</td>
<td>……….. cm</td>
</tr>
<tr>
<td>d. Volume</td>
<td>……….. cm³</td>
<td>……….. cm³</td>
</tr>
</tbody>
</table>
APPENDIX III

ETHICAL APPROVAL

HEALTH RESEARCH ETHICS COMMITTEE
UNIVERSITY OF CALABAR TEACHING HOSPITAL
P. M. B. 1278, CALABAR, NIGERIA

CHIEF MEDICAL DIRECTOR:
Dr. Thomas U. Agan
B. Med, SC (Anat), MB, FWACS, FMCOG, FCAI

CHAIRMAN:
Prof. Martin Meremikwu
MB, BCH, MSC, FMC, Paed.

CHAIRMAN, MEDICAL ADVISORY COMMITTEE
Dr. Queeneth Kalu
MBBCH, DA (WACS), DA (WFSA)

SECRETARY:
Ededet Eyoma Esq.
BA, LLB, BL, MPA, DIP-Comp. Sc, ANIM, AIHSAN

OUR REF:
YOUR REF:

NOTICE OF FULL APPROVAL OF PROTOCOL
CORRELATING SONOGRAPHIC RENAL VOLUME WITH
ESTIMATED GLOMERULAR FILTRATION RATE IN
NORMAL ADULTS IN UCTH, CALABAR, NIGERIA

UCHTH HEALTH RESEARCH ETHICS COMMITTEE REG. NUMBER:
NHREC/07/10/2012

Health Research Ethics Committee Protocol Assigned Number:
UCHTH/HREC/33/232
NCHIEWE E. ANI

Name of Principal Investigator:
DEPT OF RADIOLOGY

Address of Principal Investigator:
12TH MARCH, 2014

Date of Receipt of Valid Application:
20TH MARCH, 2014

Date of Meeting where determination of Research was made:

This is to inform you that the Research described in the submitted protocol, the Consent Forms, and other
particant information materials have been reviewed and given full approval by the Health Research Ethics
Committee.
This approval dates from 20TH March 2014 to 19TH February, 2015. If there is delay in starting the research, please
inform the HREC so that the dates of approval can be adjusted accordingly. Note that no participant accrual or
activity related to this research may be conducted outside of these dates. In multi year research, endeavour to
submit your annual report to the HREC early in order to obtain renewal of your approval and avoid disruption of
your research.
The National Code for Health Research Ethics requires you to comply with all institutional guidelines, rules and
regulations and with the tenets of the Code including ensuring that all adverse events are reported promptly to
the HREC. No changes are permitted in the research without prior approval by the HREC except in circumstances
outlined in the Code. The HREC reserves the right to conduct compliance visit to your research site without
previous notification.

Prof. Martin Meremikwu
CHAIRMAN, UCTH HREC

16TH April, 2014

91
APPENDIX IV

RESEARCH METHODOLOGY CERTIFICATE

NATIONAL POSTGRADUATE MEDICAL COLLEGE
OF NIGERIA

RESEARCH METHODOLOGY IN MEDICINE
WORKSHOP

DATE: August, 2013

Certificate

This is to certify that

ANI, NCHIEWE ELEMI

ATTENDED AND FULLY PARTICIPATED IN THE ABOVE TRAINING PROGRAMME

DR. O.O. Ekekezie, FMCPPH
Course Coordinator

Prof. O. A. Atoyebi, FMCS
College Registrar
DATA APPENDICIES

Correlations: Over-all

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Ht</th>
<th>Wt</th>
<th>BMI</th>
<th>RKL</th>
<th>RKAD</th>
<th>RKW</th>
<th>RKV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.027</td>
<td>.591</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Ht</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.591</td>
<td>.000</td>
<td>.007</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Wt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.288</td>
<td>.482</td>
<td>.011</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.342</td>
<td>.134</td>
<td>.801</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>RKL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.080</td>
<td>.109</td>
<td>.368</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>RKAD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.103</td>
<td>.040</td>
<td>.285</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>RKW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.127</td>
<td>.011</td>
<td>.448</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>RKV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.275</td>
<td>.246</td>
<td>.318</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
### Correlations: Over-all-2

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>Ht</th>
<th>Wt</th>
<th>BMI</th>
<th>LKL</th>
<th>LKAD</th>
<th>LKW</th>
<th>LKV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Correlations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>.1</td>
<td>-.027</td>
<td>.288**</td>
<td>.342**</td>
<td>.057</td>
<td>.128*</td>
<td>.041</td>
<td>.098</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Ht</td>
<td>-.027</td>
<td>1</td>
<td>.482**</td>
<td>-.134**</td>
<td>.311**</td>
<td>.178**</td>
<td>.161**</td>
<td>.273**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>Wt</td>
<td>.288**</td>
<td>.482**</td>
<td>1</td>
<td>.801**</td>
<td>.427**</td>
<td>.358**</td>
<td>.250**</td>
<td>.448**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>BMI</td>
<td>.342**</td>
<td>-.134**</td>
<td>.801**</td>
<td>1</td>
<td>.274**</td>
<td>.284**</td>
<td>.176**</td>
<td>.323**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>LKL</td>
<td>.057</td>
<td>.311**</td>
<td>.427**</td>
<td>.274**</td>
<td>1</td>
<td>.412**</td>
<td>.383**</td>
<td>.766**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>LKAD</td>
<td>.128*</td>
<td>.178**</td>
<td>.358**</td>
<td>.284**</td>
<td>.412**</td>
<td>1</td>
<td>.336**</td>
<td>.791**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>LKW</td>
<td>.041</td>
<td>.161**</td>
<td>.250**</td>
<td>.176**</td>
<td>.363**</td>
<td>.336**</td>
<td>1</td>
<td>.724**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>LKV</td>
<td>.098</td>
<td>.273**</td>
<td>.448**</td>
<td>.323**</td>
<td>.766**</td>
<td>.791**</td>
<td>.724**</td>
<td>1</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
<td>400</td>
</tr>
</tbody>
</table>

**- Correlation is significant at the 0.01 level (2-tailed).  
*  - Correlation is significant at the 0.05 level (2-tailed).