CORRELATION BETWEEN SONOGRAPHIC RENAL DIMENSIONS, BLOOD PRESSURE AND SOME ANTHROPOMETRIC PARAMETERS AMONGST STUDENTS OF AHMADU BELLO UNIVERSITY, ZARIA

BY:

Tasiu IBRAHIM, MBBS. (ABU) 2010
P13MDHA8026

DEPARTMENT OF HUMAN ANATOMY
FACULTY OF BASIC MEDICAL SCIENCES
AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA.

JULY, 2018

CORRELATION BETWEEN SONOGRAPHIC RENAL DIMENSIONS AND BLOOD PRESSURE, SOME ANTHROPOMETRIC PARAMETERS AMONGST STUDENTS OF AHMADU BELLO UNIVERSITY, ZARIA

BY

Tasiu IBRAHIM, MBBS. (ABU) 2010
P13MDHA8026

A RESEARCH DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERISTY, ZARIA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE IN HUMAN ANATOMY

DEPARTMENT OF HUMAN ANATOMY,
FACULTY OF BASIC MEDICAL SCIENCES
AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA

JULY, 2018

DECLARATION

I Ibrahim, Tasiu hereby declare that the work in this Dissertation titled **"*Correlation between Sonographic Renal Dimensions, Blood Pressure and some Anthropometric Parameters Amongst Students of Ahmadu Bello University, Zaria*"** was performed by me in the Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Health Sciences, ABU, Zaria, under the supervision of Dr. A.A. Buraimoh, Dr. A.A. Adamu and Prof. S.O. Ojo. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this Dissertation was previously presented for another degree at any institution.

…………………………………. …………………………

Ibrahim, Tasiu Date

CERTIFICATION

The thesis entitled **"*Correlation between Sonographic Renal Dimensions, Blood Pressure and some Anthropometric Parameters Amongst Students of Ahmadu Bello University, Zaria*"** by Tasiu IBRAHIM meets the regulations governing the award of the degree of Master of Science in Ahmadu Bello University, Zaria and is approved for its′ contribution to knowledge and literary presentation.

……………………… ………………………
Dr. A. A. Buraimoh (B.Sc., M.Sc., Ph.D.) Signature Date
Chairman, Supervisory Committee
Department of Human Anatomy,
Kaduna State University, Kaduna

……………………… ………………………
Dr. A. A. Adamu (MD, PhD) Signature Date
Member, Supervisory Committee,
Department of Radiology,
Ahmadu Bello University Teaching Hospital, Zaria

……………………… ………………………
Prof. S. O. Ojo (DVm., MSc., PhD., FCVSN) Signature Date
Member, Supervisory Committee
Department of Veterinary Anatomy,
Faculty of Veterinary Medicine
Ahmadu Bello University, Zaria

……………………… ………………………
Dr. (Mrs.) Z. M. Bauchi (B.Sc., M.Sc., Ph.D) Signature Date
The Head
Department of Human Anatomy,
Faculty of Basic Medical Sciences
College of Health Sciences
Ahmadu Bello University, Zaria

……………………… ………………………
Prof. S. Z. Abubakar (B.E., MSc., MBA, PhD) Signature Date
Dean School of Postgraduate Studies
Ahmadu Bello University, Zaria

DEDICATION

This work is solely dedicated to the memory of my late mother, Salamatu Usman may her soul rest in peace.

AKNOWLEDGEMENTS

All glory and gratitude belong to Almighty Allah the disposer of all affairs. It is by His Grace that we are able to accomplish anything we set out for.

I could not have any letter guide than the one I received from my supervisors, Dr. A. Buraimoh Dr. A.A. Adamu and Prof. S.O. Ojo. You did not only serve as my compass but you also showed me parental empathy. May God bless you.

To all my lecturers and colleagues too numerous to mention, I will forever remain grateful. May Allah reward you abundantly.

Dr. (Mrs.) Z.A Bauchi, my Head of Department, who did not only mentor, guide, encourage but you also create the enabling environment for me to flow and proceed. To you I say a big thank you and may Almighty Allah guide you in every endevour.

To my friends and colleagues, Drs. Musa Mustapha, Ismail Ahmed, Aliyu Isah Aliyu, A.A. Sadeeq, Abel Agbon and my ever energetic Mal. Abdulhakeem Miko, no amount of gratitude is enough for you.

I must specially mention, Mr. Iliyasu Musa Omoyine, without you, this work will remain the pipe line.

Whoever celebrates me for completing this work must know that he/she is only celebrating Drs. S.A. Musa, Dahiru Ahmadu, J.A Timbuak, Isah Sherif, Amina Lawal, Danmusa and Umar M. Umar, for you made the push to overcome any inertia.

Finally, though, I am identified with this work but the credit is not solely mine but to many others as well. My family: my wife, Maimuna Balarabe, who gave me sufficient time-leave to accomplish this and likewise my children Salma, Ahmad, Abdulrrahman and my little Imam. My friends: Mal. Mustapha Isah, Mal. Abbas Chawai and Mal. Muhammad Ahmadu Danfulani, May Allah sustain us together.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABSTRACT

Measurement of renal dimensions is essential in making decisions for renal transplant, avoiding or commencement of immunosuppressive therapy, renal biopsy and in monitoring and prognosticating disease progression or stability. The present study was designed to determine the correlation between sonographic renal dimensions and blood pressure (BP) and some anthropometric variables among apparently young healthy undergraduate medical students of Ahmadu Bello University, Zaria. The present study was conducted in the Departments of Radiology and Human Anatomy, Ahmadu Bello University Teaching Hospital, Zaria. Four hundred apparently healthy young adults (200 males and 200 females with age 22.14±3.35 years) resident in Zaria who gave their informed consent were randomly selected and recruited for the study. The ethical permit was obtained from the Ethical Committee of Ahmadu Bello University Teaching Hospital. The longitudinal length and width of the right and left kidneys were measured. In addition, the age, sex, height (Ht), weight (Wt), BMI, BSA and blood pressure of the subjects were recorded. All renal scans were done with a Mindray diagnostic ultrasound system (Model DC-3, 2010/2012, Nanshan, Shenzen, PR China) and 2.5-6 MHZ curvilinear probe. The mean right and left kidney lengths were 9.94±0.70 cm and 10.28±0.80 cm respectively. The mean kidney width was 3.96 ± 0.36 cm and 4.33 ± 0.51 cm for right and left kidney, respectively. There was no significant sexual dimorphism in the renal dimensions ($p>0.05$). The left kidney length and width were significantly greater than the right kidney ($p<0.05$). The height, weight, BMI and BSA inversely correlated with the renal dimensions and the best correlation with the renal dimensions was observed with the weight followed by BSA. Normal valuable baseline renal nomorgram have been established for the study population taking into cognizance the body parameters.

CHAPTER ONE

1.0. INTRODUCTION

1.1 Background of the Study

Fear of undergoing any invasive investigation makes the patients reluctant to undergo a test comfortably. Among all the imaging modalities, ultrasound has been regarded and preferred as an imaging technique of choice in most of the clinical surveys (Okur *et al.,* 2014). It is cheap, accessible, non-invasive, radiation free, little or no patient preparation, no use of medication or injection of contrast agent and has now become an integral part of the clinical evaluation of normal as well as diseased kidneys (Gavela *et al.,* 2006). Compared to intravenous pyelogram, ultrasonographic assessment is more accurate and does not have the disadvantage of either increase in kidney size by osmotic diuresis through iodinated contrast material or geometric magnification (Kantarci *et al.,* 2006 and Gupta *et al.,* 2013). Its portability and simplicity makes it an indispensable modality over computerized tomography (CT) and magnetic resonance imaging (MRI) (Wee and Supriyanto, 2010). Also, it has been well established as a reliable, repeatable and reproducible method of imaging (Safak *et al.,* 2005).

Renal size can play an important role in the decision for renal biopsy, renal transplant or avoiding immunosuppressive therapy (Barton *et al.,* 2000). Measurements of renal length and width are clinically relevant, serving as surrogates for renal functional reserve, and are used frequently as the basis for making clinical decisions (Raza *et al.,* 2011). Serial measurements can also provide information regarding disease progression or stability (Kang *et al.,* 2007). Also, the renal length measurement should be preferred to renal volume estimation because of lower observer variation; more over it is reliable, simple, practical, reproducible measurement of renal size (Bakker *et al.*, 1999).

Renal infections/inflammations, nephrologic disorders, diabetes mellitus and hypertension are the most important co-morbid conditions known to affect renal dimensions which may or may not be accompanied by changes to the normal organ structure (Raman *et al.*, 1998; Egberongbe *et al.*, 2010). Other factors known to show variations with renal size are age, gender, ethnic backgrounds, height, weight, body mass index (BMI) and body surface area (BSA) (Emamian *et al.*, 1993 and Okoye *et al.*, 2005).

Several studies have reported the influence of demography, anthropometry and hypertension on renal size. For instance, Gavela *et al.* (2006) reported a good correlation between kidney parameters and body parameters, with height exhibiting the best correlation. In studies by Buchholz *et al.* (2000) and Emamian *et al.* (1993) renal volume showed a significant decrease with age which probably was totally due to reduction in parenchymal volume . Some studies have reported that kidneys are larger in males than in females (Bulchoz *et al.*, 2000; Akpinar *et al.*, 2003; Kang *et al.*, 2007). Similarly, Raza *et al.* (2011) and Jovanovic *et al.* (2013) concluded from their studies that renal length have a direct relationship with body mass index and the Mean renal size is related to the side, age, gender, height and weight as well. In a similar study in Nigeria by Maaji *et al.* (2015), a positive correlation between age, height, weight and BMI was observed in reference to the renal dimensions measured.

1.2 Statement of Research Problem

The information available on the current knowledge of kidney size is largely based on Europe and North America derived standards which may not be applicable to our population. Literature on normal renal sizes estimation by ultrasonogrphy in Nigeria is scarce. Since renal size has been shown to be affected by several factors such as hypertension/diabetes mellitus, geographical location, race, ethnic groups and body size, it has now become imperative to establish normative baseline renal size data for our population which could be used to label the kidney as physiological or pathological.

1.3 Justification

It has been reported by various studies that the kidney dimensions vary with age, gender, height, weight, body mass index (BMI) and body surface area (BSA), which of course are different for different population groups. Thus the study of renal dimensions with regards to a particular population is not only important but also imperative. A sound knowledge of the dimensions of kidney is necessary to evaluate a wide variety of renal diseases which can occur with alteration in the architecture of the kidneys (as seen in cases of hypertension).

1.4 Aim and Objectives

1.4.1. Aim of the study

The aim of the study was to determine the correlation between sonographic renal dimensions with Blood pressure (BP) and some anthropometric variables among apparently young healthy undergraduate medical students of Ahmadu Bello University, Zaria.

1.4.2. Objectives of the study

The objectives of the study were to:

i. establish reference values of the normal sonographic renal dimensions in apparently healthy adults of Ahmadu Bello University, Zaria.

ii. investigate sexual dimorphism in the renal dimensions, blood pressure and other anthropometric variables.

iii. determine the effect of renal side, age, height, weight and BMI on renal dimensions.

iv. check for the correlations between renal dimensions and blood pressure, and some anthropometric parameters.

v. formulate regression equation for the estimation of renal length and width based on anthropometric variables that best correlated.

1.5 Scope of the Study

This research work focused on the determination of the correlation between sonographic renal dimensions with Blood pressure (BP) and some anthropometric indices among apparently healthy undergraduate medical students of Ahmadu Bello University, Zaria. The following anthropometric measurements (height and weight), biometric data (age and sex) and BP were taken. The renal dimensions will be determined sonographically.

1.6 Limitations of the Study

The limitations of this study include the smaller sample size as larger sample size might improve the precision of the estimates and also the generalizability of the data. The nutritional status of the subjects was not recorded and renal function test to assess the normal physiologic condition of the kidney was not done. It is anticipated that further studies will tackle these limitations.

1.7 Research Hypothesis

i. The reference values of the normal renal dimensions of the study population are dissimilar with the ones derived from other population group.

ii. There is a correlation between renal dimensions and the anthropometric indices such as age, sex, height, weight, body mass index (BMI), body surface area (BSA) and blood pressure.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Kidney: Anatomy, Embryology and Physiology

2.1.1 Gross anatomy

The kidneys are pear-shaped organs. They are retroperitoneal organs that lie on the either side of the posterior abdominal walls, well behind the peritoneal space (Ryan *et al.,* 2004). Their upper poles extend to the level of the 11-12th thoracic vertebra (T11-T12) while their lower poles extend to the level of the 3rd Lumbar (L3) vertebra, with the right slightly lower than the left due to the considerable weight and space occupied by the liver (Wilson, 1981) .The kidney measures between 10-15cm in length in the adult subject, with the left being about 1.5cm longer (Ryan *et al.,* 2004). The left is also slightly narrower and more medial. Both kidneys are held in place by a mass of fatty tissue known as peri-renal fat (Wilson, 1981). A fibro-elastic sheath of 20 tissue termed the renal fascia encloses both kidneys. The kidneys in neonates and children appear more vertical, whereas in adults, they (kidneys) are slightly oblique (Eze, 2004). In sonography, the fibro -elastic sheath (the renal fascia) is strongly reflective around the renal cortex (a feature that distinguishes the renal cortex from the relatively hypoechoic renal pyramids). The strong reflective echo of the renal cortex is more pronounced in children than in adults (Ryan *et al.,* 2004).

2.1.1.1 Relations of the kidneys

The anatomical relations of the kidneys are as follows.

Relations of the right kidney are;

i. Superior relations: Right adrenal gland.

ii. Anterior relation: Right lobe of liver, duodenum, right colic flexure of the large intestine.

iii. Posterior relation: Diaphragm, muscles of the posterior abdominal wall (Quadratus Lumborum and psoas).

iv. Medial relations- Inferior Vena Cava (IVC), lymph nodes and ureters.

Relations of the left kidney

i. Superior relations-Left adrenal gland

ii. Anterior relations; spleen, stomach, Pancreas, Jejunum, left colic flexure of the large intestine.

iii. Posterior relations: Diaphragm, Posterior abdominal wall muscles

iv. Medial relations: Aorta, Lymph nodes, Ureters 21

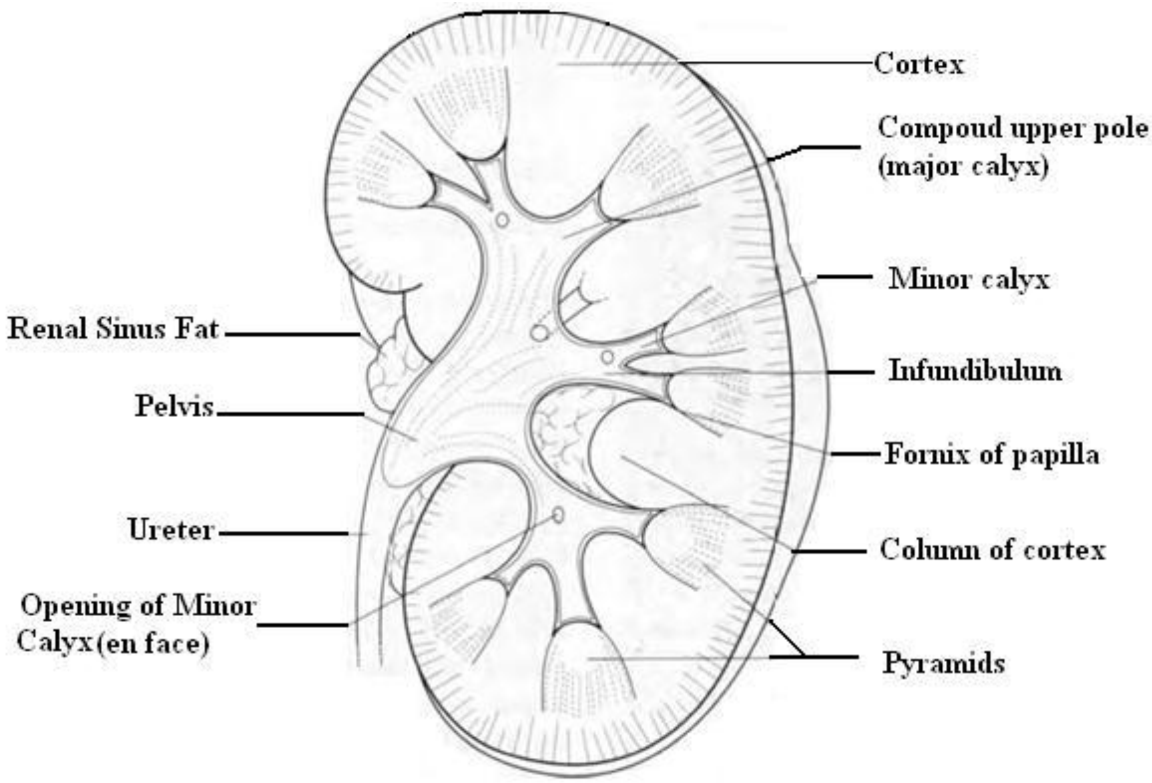

Figure 2.1: Internal structure of the kidney (Ryan *et al.*, 2004; Anatomy for diagnostic imaging; Philadelphia: Saunders books).

On a coronal section, the kidney has three layers;

i. The renal capsule: this is the outermost layer. This forms the fibrous tissue that surrounds the kidneys.

ii. Cortex: this is the inner layer. It is a reddish brown tissue that has extensions into the innermost layer.

iii. Medulla: This is the innermost layer that contains the conical-shaped renal pyramids.

The kidney has an outer cortex and an inner medulla. The cortex forms extensions into the pyramids called the Column of Bertin (Ryan *et al.,* 2004). Apices of the pyramids extend into the renal calyces to form the papillae. Seven pairs of minor calyces unite to form major calyces. These, in turn, unite to form the renal pelvis that ends in the ureters. A gap in between the renal substance and the pelvis is called the renal sinus. This site is usually filled with fat (Ryan *et al.,* 2004). The hilum of the kidney lies medially. At the hilum, the pelvis is posteriorly sited while the renal vein is anterior. In between the two is the renal artery. Lymph nodes and nerves also enter and leave the kidneys through the renal hilum. Urine is formed in the pyramids, and passes through the papillae to the calyces. From the calyces, urine then passes into the renal pelvis. From the pelvis, it passes into the ureters and finally into the urine bladder.

2.1.2 Embryology

The glomerular and the proximal ductal system of the definitive kidney are derived from the metanephros (Ryan *et al.,* 2004).The collecting ducts, calyces, pelvis and ureters are derived from the metanephric duct. The kidneys are formed in the pelvis by about twelve distinct lobules. The kidneys assume their positions in the adult by differential growth of the ureters relative to the trunk. Earlier in their development, blood supply to the kidneys is from branches of the iliac artery. However, later supply is from a series of arteries from the abdominal artery, each of which disappears as the kidneys develop a new permanent blood supply system.

2.1.3 Physiology

The Physiological functions of the kidneys are:

i. Filtration and excretion of excess water and waste products of metabolism.
ii. Regulation of blood pressure.
iii. Secretion of hormones.

Primarily, the kidneys filter the blood of excess water and eliminate metabolic waste products and electrolytes from the body (Beers *et al.*, 2003) Urine formation is essentially the duty of the nephron. Such waste products excreted by the kidney include sodium, bicarbonates, potassium and glucose. The kidneys regulate blood pressure by maintaining sodium and potassium concentrations in the blood. The release or absorption of sodium is controlled by aldosterone-a hormone produced by the adrenal gland.

2.2 Evaluation of the Kidneys

Diagnosis of renal diseases can be made clinically, through laboratory procedures or through diagnostic imaging modalities. Clinical assessment of the kidneys may be successful among infants and children but very vague among adults (Beers *et al.,* 2003). Even when grossly enlarged kidneys may be palpable especially in thin subjects, quantitative statements about the size of such enlarged kidneys cannot be accurately made (Beers *et al.,* 2003). Laboratory procedures such as urinalysis, urine cultures and kidney function test may reveal the cause and nature of renal diseases. Laboratory tests, however, cannot be relied on for renal size assessments. Imaging modalities, on the other hand, can be relied on for assessing renal sizes as well as real time diagnosis of renal disorders. In fact, imaging modalities are tools for making quantitative statements concerning renal sizes (Beers *et al.,* 2003). Such imaging modalities that may be useful in renal size assessment are as follows:

2.2.1 Plain abdominal X-Ray

Radiography is usually performed first in most cases as it is relatively cheap and easy to do. Radiography allows a global view of the abdomen and it is often as easy (or easier) to determine size and position of organs on radiographs with more advanced imaging techniques. The abdominal radiograph allows assessment the abdominal boundaries and vertebrae which may be involved in abdominal pathology e.g. metastases of prostatic tumors. The main problems with abdominal radiography are poor soft tissue contrast and difficulties with interpretation due to superimposition. In the presence of significant ascites, radiography is usually unhelpful due to complete loss of serosal detail; the same is often true for severely emaciated animals. Many diseases involving the small organs such as adrenal glands, pancreas, lymph nodes are not visible radiographically. Despite relatively poor soft-tissue contrast, radiographs are good at showing relatively small volumes of free abdominal gas and alterations of gas patterns within the gastrointestinal tract. Radiographs are also reasonably good for demonstrating areas of mineralization e.g. ureteric calculi and radiopaque foreign bodies. Since plain films are magnified, attempts at measuring renal sizes from plain abdominal radiographs are less than optimal (Beers *et al.,* 2003).

2.2.2 Intravenous urography (IVU)

This is the X-ray investigation of the kidneys and the entire renal system following the intravenous injection of iodine based contrast medium. From the immediate post contrast film in the urography series (nephrogram film), renal sizes can be assessed. Even as cholesterol stones are easily diagnosed during IVU, renal sizes measured from nephrogram films are not reliable as nephrogram films are magnified just as plain films (Beers *et al.,* 2003).

2.2.3 Ultrasonography

Diagnostic ultrasound, also called Sonography, uses pulses and high-frequency sound waves to form images of the body. The speed of sound depends on the type and interfaces between tissues which act as total or partial reflectors of the ultrasound waves. The travel time of the ultrasound waves is interpreted by using a range of frequencies, distance to the different interface, pulse and amplitudes in conjunction with advanced signal processing, two-, three- and even four-dimensional image data can be reconstructed (Von-Herby *et al.,* 2004). Health risks associated with exposure to diagnostic ultrasound are unknown, but thanks to its real-time imaging capacity with high temporal and spatial resolution used in most areas of the body (Furuse *et al.,* 2003). Though, the image quality is partial by total reflection via air- or gas-containing organs, skeletal or other calcified structures and by the depth of the object to examine. Diagnostic ultrasound is considered more operator-dependent than other modalities. In upper abdominal imaging, it is an efficient means of examining the pancreas, gallbladder, liver and biliary ducts. The introduction of ultrasound contrast media in the last decade has increased its accuracy and applications, e.g. in liver characterization and lesion detection, especially where small lesions are undetected by MRI or CT (Furuse *et al.,* 2003). Contrast-enhanced ultrasound (CEUS) adds functional information on pathological and normal vascular structures on tissue perfusion in real time, which MR and CT cannot provide at temporal resolution or equal spatial (Morin *et al.,* 2007).

2.2.4 Computed tomography (CT) scan

Here, multiple slice images are taken when a beam of X-rays is directed at the region or organ of interest and detectors on the opposite side record the transmitted radiation which a computer uses to build up an image (Simon and Wightman, 1983). Renal sizes may be measured accurately with CT scan. However, like in plain radiography, ionizing radiation is involved, and therefore CT cannot be relied on for routine and replicate renal size measurement.

2.2.5 Other modalities

Other imaging modalities that may be of use in renal size assessment include magnetic resonance imaging (MRI) and radionuclide imaging. Magnetic resonance imaging can accurately be used in renal size measurement and does not involve the risk of ionizing radiation; therefore it has a high potential in renal size assessment in children. This modality is, however, relatively new in the developing countries especially Nigeria, so it is not easily accessible and is very costly where it is available. Renal size measurement from radionuclide images is also associated with ionizing radiation, so it is not of routine use and finds more specific use in functional studies (Beers *et al.*, 2003).

2.6 Sonographic Assessment of the Kidneys

Diagnostic ultrasound, which operates within a frequency range of 1-20 megahertz (MHz), is generated by transducers that transform electrical energy into ultrasonic energy and vice versa (Krebs *et al.*, 1993). Ultrasound can penetrate soft tissues, and can also be partly reflected at tissue interfaces. The reflected signals can be recorded and from the information received, a spatial reconstruction of the deep tissues can be built up and displayed on a viewing monitor (Simon and Wightman; 1983). To produce pulses of ultrasound electrically, the transducer is rocked to and fro or moved over the skin to obtain echoes from underlying tissues of interest. These echoes are detected by the transducer as in-coming information. This information is processed and displayed as a gradation of shadows from near white to near black (grey scale) depending on the strength of these echoes from different tissues (Simon and Wightman, 1983). During the sonographic assessment of the kidney the following measurements may be obtained: maximal length and parenchyma border width. These measurements should be done in longitudinal section. Both left and right kidney should be compared (Nahm and Ritz, 2007). The American institute for ultrasound in medicine (AIUM) practice guide for the performance of abdominal sonography and or retro-peritoneum suggest that all renal sonographic examinations should include long-axis and transverse views of the upper and lower poles of the kidney. While the AIUM advocates that both the cortex and renal pelvises be assessed, it also insists that maximum measurements of renal length, width and thickness should be obtained. While renal length and width are to be measured from the long-axis view of the kidney, thickness may be measured from the short axis view (AIUM Practice Guideline, 2008). The guideline also opined that decubitus or prone positioning may provide better images of the kidney especially in children. In order to avoid or reduce measurement errors, Nahm and Ritz (2000) also advocate that all sonographic measurements should be made with the patient in the side position (decubitus) with the transducer swept from the dorsal direction. The authors are of the opinion that supine or prone position may be easier to maintain, though measurements taken from these positions tend to cause false low values because the parenchyma width near the renal hilum is smaller in the supine or prone position than in the decubitus position. Since the decubitus position may, however, be difficult to maintain in children, the authors advocate the supine position in the sonography of infants and children.

2.7 Relationship between Renal Dimensions and Anthropometric Parameters

2.7.1 Relationship between renal dimensions and BMI

A study in Nigeria showed that kidney dimensions (bipolar length) correlated best with BMI (body mass index) by Udoaka *et al.* (2013). The aim of the study was to determine the normal organ (liver, spleen, kidneys) dimensions in relation with anthropometric parameters of healthy adult Nigerians. A total number of 723 subjects were screened ultrasonographycally and their anthropometric measurements were also recorded. BMI was calculated for every subjects in kg/m^2. Bipolar length (BPL) and transverse diameter (TD) were viewed in prone position of both kidneys in every subject. Mean bipolar length in left kidney was (10.31 ± 1.10) cm and in right kidney was (10.02 ± 0.97) cm. It was concluded by the author that BMI has strongest correlation with renal dimensions than other organs like liver and spleen.

Healthy 215 Sudanese school aged children (7-13) years underwent USG examination to correlate kidney length with anthropometric measurements by Ayad *et al.* (2015) and renal length was measured in supine and contralateral decubitus positions for respective kidneys. Maximal longitudinal renal length was measured in sagittal plane. The study revealed that left kidney length was 7.9 ± 0.8 (cm), 8.1 ± 0.7 (cm) and right kidney length was 8.0 ± 0.8 (cm), 8.3 ± 0.8 (cm), for men and women respectively. Anthropometric measurements like height, weight, abdominal circumference and body mass index (BMI) were also recorded. In this study, authors had established prediction models of the kidney lengths of corresponding side in millimeters according to BMI and these are:

a) Left kidney length=0.01×child BMI+6.72, r^2=0.05

b) Right kidney length=0.08×child BMI+6.72, r^2=0.13

Eze *et al.* (2014) estimated kidney dimensions among 947 apparently healthy school age children using sonography. Kidney dimensions obtained in coronal plane passing through the renal hilum, three times and the mean values were recorded. Images were taken during deep inspiration with the subject in supine position. The mean kidney lengths were 79.6 ± 8.1 mm and 81.61 ± 8.32 mm for the right and left kidney respectively. Anthropometric data like height and weight of the study group were also recorded. Body mass index (BMI) was measured as BMI=weight in kg/height in m^2. The mean height of the study group was 140.24 ± 17.93 cm and the mean weight of the study group was 34.88 ± 12.33 kg. Mean BMI was17.10 ± 2.06 kg/m^2. Pearson correlation coefficient of kidney length with BMI was r=0.688 which showed a moderate negative correlation and weight showed a moderate positive correlation where correlation coefficient is r=0.889. They explained it on the basis of rapid body growth that occurring before the attainment of mature body morphology at adult stage.

El-Rashaid and Abdul-Fattah (2014) estimated sonographic values of renal dimensions in 252 patient aged 18-80 yrs. without any renal disease in Kuwait. Renal length was measured as the longest longitudinal diameter. Anthropometric data like height and weight were also recorded. The mean renal lengths of the study group were 10.68 ± 14 cm and 10.71 ± 1.0 cm for right and left kidney respectively. Mean height and weight of the study group were (143-193) cm and (37-124) kg respectively. The renal length showed strongest correlation with BMI (where p value $p<0.01$) and weight of the patient ($p<0.01$). Pearson correlation test also showed that renal length increased by 0.23 cm for each 10 kg increase in body weight within the range of 60-120 kg. The explanation given by the authors was that larger body size requires a larger nephron dose to meet its metabolic demands.

Srivastava *et al.* (2016) ultrasonographycally evaluated relationship between renal length and anthropometric measurements among 150 children of 1 month-14 years age group, without any renal disease. Anthropometric data were recorded. Renal lengths were obtained in sagittal view with children in supine or contralateral decubitus position, without any preparation or sedation. Taking height as the independent variable and renal length as the dependent variable, regression analysis for right and left kidney lengths were (R^2) 0.424 and 0.443 respectively. It was observed by the authors that both right and left kidney lengths moderately and significantly correlated with weight of the individual and moderately insignificant with body mass index (BMI). BMI was not related to kidney length; it is due to the fact that the sample size selected was in rapid growth stage. Srivastava *et al.* (2016) estimated relationship between renal length and anthropometric measurements among 100 adult healthy voluntary kidney donors without any renal disease. All of them underwent multi-detector computed tomography (MDCT) and CT angiography for measurements of renal length. Mean renal length was taken after obtaining renal length in three different section, that is in axial, coronal and sagittal section. Mean renal length were 99.2 ± 9.71 mm for left kidney and 95.3 ± 8.44 mm of right kidney. It was shown that there was no correlation between renal length and body weight of the individual and also no relation between BMI.

Fifty obese and 50 non-obese children and adolescent aged 1-19 years were included in a study for estimation of relationship between renal length and body mass index (BMI) by Soheilipour *et al.* (2016) 100 children and adolescent were screened ultrasonographycally and the longest longitudinal measurement in deep inspiration was taken as the kidney length. Mean height of the control group was (144.44 ± 23) cm and for obese group was (145.9 ± 22.05) cm. Mean weight of the control group was (39.20 ± 15.96) kg and for obese group was (67.02 ± 24.83) kg. Mean BMI of the control group was (17.74 ± 2.21) kg/m² and for obese group was (29.54 ± 5.14) kg/m². They recommended BMI as significant predictors of kidney length.

Myint, *et al.* (2016) established relationship between ultrasonographycally measured renal dimensions and BMI among 321 healthy students in Malaysia. The age of the study group was 19-25 years. After obtaining written consent sonographic renal measurements were carried out and these are renal length, width and renal parenchymal thickness. Anthropometric measurements were also done. According to BMI the sample size was divided into four categories and these are normal BMI (64.3%), underweight (15%), overweight (12.9%) and obese (7.8%). Mean renal length was 9.81 ± 0.75 cm in case of right side and 9.85 ± 0.58 cm in case of left side. Statistical analysis of the study revealed that renal length significantly Correlated with BMI and correspondingly increased with increased BMI which coincided with the most of the past researches.

2.7.2 Relationship between renal dimensions and height and weight

Hekmatnia *et al.* (2004) estimated sonographic measurements of absolute and relative renal length in healthy 400 Isfahani adult volunteers. Data included in the study was height, age, sex and sonographic renal length. Mean height for men and women was 171±6 cm and 159±5 cm respectively. Longest longitudinal diameter of kidney was considered as renal length. The mean renal length (absolute length) for left and right kidney was 111±9.8 mm and 109±8.4mm, respectively. Relative renal length for each kidney was considered as Kidney body-height ratio (KBR) = Absolute renal length (in millimeters)/Subjects body height (in centimeters). KBR (kidney body-height ratio) was considered a good index for estimating renal length. They found that mean KBR for left kidney was significantly higher than that for the right kidney. They concluded that there was a positive correlation between absolute renal length and subject's height which was significant.

An ultrasonographical study was conducted by Arooj *et al.* (2011) on 100 adult normal Malaysian populations to estimate the relationship between renal dimensions with anthropometric measurements. Renal dimensions included renal length as the maximal longitudinal distance in sagittal view, width as the perpendicular distance to the longitudinal length and thickness as maximum length in cross section. Ultrasonographic images were taken in two postures, in supine and lateral decubitus position in respective side after holding breath for a while. Mean left renal length for male was 10.04±0.88 cm and right renal length was 9.67±0.77 cm. In case of female, the mean left renal length was 9.8±1.03 cm and right renal length was 9.7±0.84 cm. The average height of the study group was 163.34±9.13cm. This study revealed that height of the patient was directly proportional to renal length, width and thickness.

To establish relationship between renal length and height, 514 adult patients without any renal disease underwent oblique coronal 8-slice CT scan to measure renal length. Anthropometric measurements like height, weight and age, gender and race were recorded. For each patient, the average kidney size (kidney length) was considered between right and left kidney and it ranged from 80-134mm. The average body habitus constant for male and female were 61.0 and 57.7 respectively. By regression analysis it was observed that 0.39868 units increase in kidney size (kidney length) was strongly associated with a unit increase in patient's height. A strong significant correlation was established between the anthropometric data like height and weight of the patient along with kidney size (kidney length) by the following formula: Kidney size (mm) = 49.18109+0.2065×weight (kg) +0.27360× height (cm). He also commented that a bigger body height would have a larger blood volume to flow in kidneys and thus make it larger.

Hammad *et al.* (2012) established relationship between anthropometric measurements and renal dimensions in young Saudi population of age group 19-28 years without any known clinical disease. All participants underwent ultrasonography examination in empty bladder, so that an increase in renal length caused by oral hydration can be avoided. Renal length was taken as the longest longitudinal diameter and renal width, thickness and cortical thickness were measured in longest absolute term. The mean renal length for right and left side was 10.32 cm and 10.77 cm respectively. The mean height for male and female was 1.72m and 1.57m respectively. Renal volume was measured by using ellipsoid formula: renal volume= length×width×thickness×0.5. Pearson correlation test was used to examine the relationship of renal dimensions with anthropometric measurements. They observed that both kidney lengths in young Saudi population were smaller than the same aged European population. They explained by giving reason that mean height of the young Saudi population was lower than the European population. Relationship between renal length and height was established by Abdullah *et al.* (2014) by carrying out a study on normal adult Sudanese using MRI disc summation method. 98 subjects aged 20-45 years underwent MRI for indications other than renal disease. Renal length was calculated as -Renal length= number of slices (in which kidney appeared) x slice thickness (cm). Correlation value (0.007) showed the linear relationship between the height and right kidney length and similar findings were also observed in relation to left kidney with height, where correlation coefficient was significant (0.000) in Scatter plot diagram. The mean renal length was10.18±0.46 cm for right kidney and 10.67±0.47 cm for left kidney. Following equations were derived from their study for easy reference in clinical practice: Left kidney length= 0.038x height+3.940. Right kidney length= 0.028x height + 5.202. They also commented a significant relationship between renal length and height of the patient.

Sonographic values of mean renal dimensions were compared with mean height in 477 patients aged 18-80 years without any renal disease, in Kuwait. Renal dimensions included the longest longitudinal diameter as renal length and the interval between the outer border of the renal cortex and the outer border of the medullary pyramid as renal cortical thickness. The mean renal length of the right kidney was 10.68±1.4 cm and the left kidney was 10.71±1.0 cm. Mean height of the male was 172±6.5 cm and a female was 158±6.5 cm. The Pearson correlation coefficient was used to assay the significance of linear association among different variables. They did not find any relationship between patient's height and renal length. A study was carried out with aim of correlating renal length with the height of an individual among 77 healthy participants. Renal length was measured using ultrasonography as the maximum bipolar dimension in longitudinal plane after fasting for 6 hours prior to the test, in order to reduce bowel gas, and height was measured in meters (m). The average renal length for right side was 10.15 cm and for left side was 10.33 cm. It was observed by the authors that renal length did not correlate with patient's height .While right renal parenchymal thickness showed strong positive relationship with height of patient but it failed to establish such relation on left side.

2.8 Racial Differences in Kidney Sizes

Ukoha *et al.* (2002) reported that both observer errors and racial/ ethnic differences exist in the sonographic measurement of renal dimensions in individuals without known renal diseases in a Pakistani population. Their study established some preliminary data suitable for the Pakistani population. They correlated age, sex, height, body mass index (BMI) and the presence or absence of diabetes mellitus and hypertension with renal size. The authors concluded that renal size (in the absence of renal disease, hypertension and diabetes mellitus) is related to age, sex and the individuals height and weight, stressing that population based studies are necessary to establish the normal values of renal dimension for the Pakistani population. Ozoh *et al.* (1992), Ukoha *et al.* (2002) and Eze, (2004), all agree with Ukoha *et al.* (2002). They point to the fact that racial differences do exist in renal size measurements. In, particular, Eze (2004) studied sonographic assessment of renal parenchyma thickness (RPT) in an adult Nigerian population and found that the mean 38

RPT in his study population was significantly different from the Caucasian population compared with it. Among caucasians, Miranda-Geelhoed *et al.* (2009) found that observer variability in sonographic renal size measurements ranged between 8.0- 9.2 % and 18.0-19.2 % for intra and inter observer errors respectively. It is therefore, imperative to establish our own standards and suggest upper limits of observer errors (data) that may assist in clinical/surgical decisions in our environment instead of relying on Asian and Caucasian data as universal patterns.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Location

This cross-sectional study was carried out in the Department of Human Anatomy, Ahmadu Bello University and also in the Radiology Department of Ahmadu Bello University Teaching Hospital, Zaria.

3.2 Sample Size Determination

The study group was chosen from amongst a cross-sectional sample of one thousand nine hundred and sixteen (1916) undergraduate medical students of Faculty of Medicine, Ahmadu Bello University, Zaria, Kaduna State. The minimum sample size needed for this study was three hundred and eighty-four (384), as determined according to Naing *et al.* (2006) using the formula below:

$$n = \frac{Z^2 qp}{d^2} = \frac{1.96^2 \times 0.5 \times 0.5}{0.05^2} = 384$$

n = Minimum sample size

z= Value of normal standard deviates corresponding to 1.96

p= Proportion in the target population having the particular trait (when no estimate 50% is used; i.e. 0.5)

q= Complimentary probability 1-p=1-0.5=0.5

d= Degree of accuracy (0.05 or 5%)

However, a total of four hundred subjects (400) were recruited for the study

3.3 Sampling Technique

A multistage sampling technique was employed involving the following stages:

3.3.1. Stage 1 (Selection of faculty)

Faculty of Medicine was purposively sampled. All the departments and levels were included in the sampling.

3.3.2 Stage 2 (Selection of students)

By using proportionate allocation, the number of students sampled from each department was determined as shown in Table 3.1.

Table 3.1: Determination of number of students sampled in each department

Departments	Total No. of students	Proportion	No. of students to be sampled
MBBS	525	525/1916 = 0.3	0.3 x 400 = 120
Human Anatomy	396	396/1916 = 0.2	0.2 x 400 = 80
Human Physiology	413	413/1916 = 0.2	0.2 x 400 = 80
Nursing Sciences	582	582/1916= 0.3	0.3 x 400 = 120
Total	**1916**		**400**

From table 3.2, 120, 80, 80 and 120 number of students were sampled from MBBS, Human Anatomy, Human Physiology and Nursing Sciences respectively. Also, by using equal allocation, the number of students sampled from each level of each department was determined as illustrated in the table 3.2. A list of all students in each level was made by using simple random sampling (Balloting) and the number of each student from each level was calculated was sampled.

Table 3.2: Determination of number of students in each level from each department

Departments	No. of students to be sampled	No. of levels	No. of students in each level
MBBS	120	6	120/6 = 20
Human Anatomy	80	4	80/4 = 20
Human Physiology	80	4	80/4 = 20
Nursing Sciences	120	5	120/5 = 24

3.4 Inclusion and Exclusion Criteria

3.4.1 Inclusion criteria

i. Normal arterial blood pressure measurements (<140/90);
ii. No acute or chronic disease that could lead to renal impairment;
iii. No personal or family history of renal disease
iv. Voluntary participation
v. Must be between 18-35 years of age and from faculty of medicine
vi. No imaging evidence of renal disease
vii. Non- gravid females

3.4.2 Exclusion criteria

i. Failure to meet up with the inclusion criteria.
ii. Subjects with known deformation that may affect the kidney or link to kidney disease

3.5 Methodology

3.5.1 Materials

i. Harpenden skin fold caliper with measuring accuracy of 0.05mm
ii. Standiometer with measuring accuracy of 0.1cm
iii. Precision (SECA™) weighing Scales with measuring accuracy of 50g
iv. Mecury Sphygmomanometer (ACCUSON)
v. Mindray diagnostic Ultrasound system (Model DC-3, 2010/2012, Nanshan, Shenzen, PR China) plus 2.5-6 MHzcurvilinear probe.

3.5.2 Anthropometry

The following anthropometric measurements were taken according to the standard protocol reported by International Society for Advancement of Kinanthropometry (ISAK, 2001).

i. **Stature (Height)**: Height was measured against the stadiometer with the subject standing straight, against an upright, touching the instrument with heels, butt and back. The head was oriented in the Frankfort plane (the upper edge of the ear orifice and the lower edge of the eye socket along a horizontal line) and the heels together. The subject was then instructed to stretch upward and to acquire and hold a full breath and the headboard was lowered until it firmly touched the vertex as shown in plate I.

ii. **Body mass (weight)**: The weight was measured in kilograms using a digital weighing scale while the participant is in light clothes. The participant was asked to remove any heavy objects and take off his or her shoes and all accessories and the scale was then put on a perfectly flat surface with no obstructions. The participant was then asked to stand on the scale and remain still until the readings appear. The weight in kilogram was then read to the nearest decimal place.

iii. **Body Mass Index (BMI) and Body Surface Area (BSA)**: BMI and BSA were computed from measured height and weight using the formula below:

$$BMI = \frac{Weight\ (kg)}{Height\ (m^2)} \qquad \text{(Mostelled, 2004)}$$

$$BSA = \left(\frac{Weight\ X\ Height}{3600}\right)^{\frac{1}{3}} \qquad \text{(Mostelled, 2004)}$$

Plate I: Procedure for measuring stature (height)

3.5.6 Blood pressure (BP)

BP was measured to the nearest 2 mm Hg as the first (systolic) and the fifth (diastolic) Korotkoff phases using a standard mercury sphygmomanometer. Three measurements were taken at 1-minute intervals in the sitting position after the participant had been sitting for 5 minutes. The mean of the two last readings was calculated. Participants were asked whether they had been told by a doctor or nurse that they had high BP and whether they were currently taking prescribed medication for hypertension. Participants were considered to have hypertension if they answered “yes” to both of these questions or had systolic BP _140 mm Hg and/or diastolic BP _90 mm Hg.

3.7 Scanning Technique

Before the ultrasound examination, the participants underwent physical examination to rule out any clinically visible disease that could modify renal dimension. All the sonographic examinations were done by a single trained sonographer in order to avoid inter-observer error. And all measurements were taken in duplicate with their mean values as the real measurement; this is in order to avoid intra-observer error. A pilot study was carried out where the examiner measured repeatedly the kidney sizes of ten different subjects.

Examinations was done with each subject lying prone according to the agreed scanning techniques (longitudinal and transverse) described by American Institute of Ultrasound in Medicine Proceedings, 2007 (AIUM). Following application of coupling gel on the area of interest, longitudinal scan images of each kidney will be done at deep arrested inspiration. Well defined kidney images that included both renal poles and which also clearly demonstrates the renal medulla and pyramids were captured at deep arrested inspiration. Kidney length was measured from pole to pole i.e. from the long axis (longitudinal) scan image while kidney width was measured at the widest anterior posterior (AP) diameter between the superior and inferior renal borders. Measurements of kidney length and width are demonstrated below.

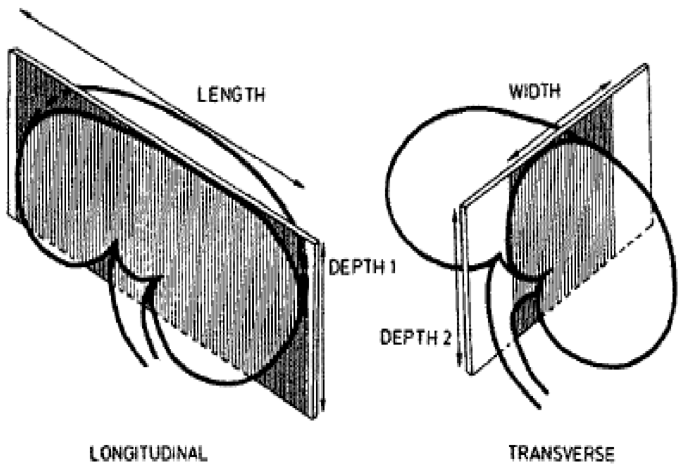

Figure 3.2: The longitudinal and transverse views of kidney (Arooj *et al.,* 2010)

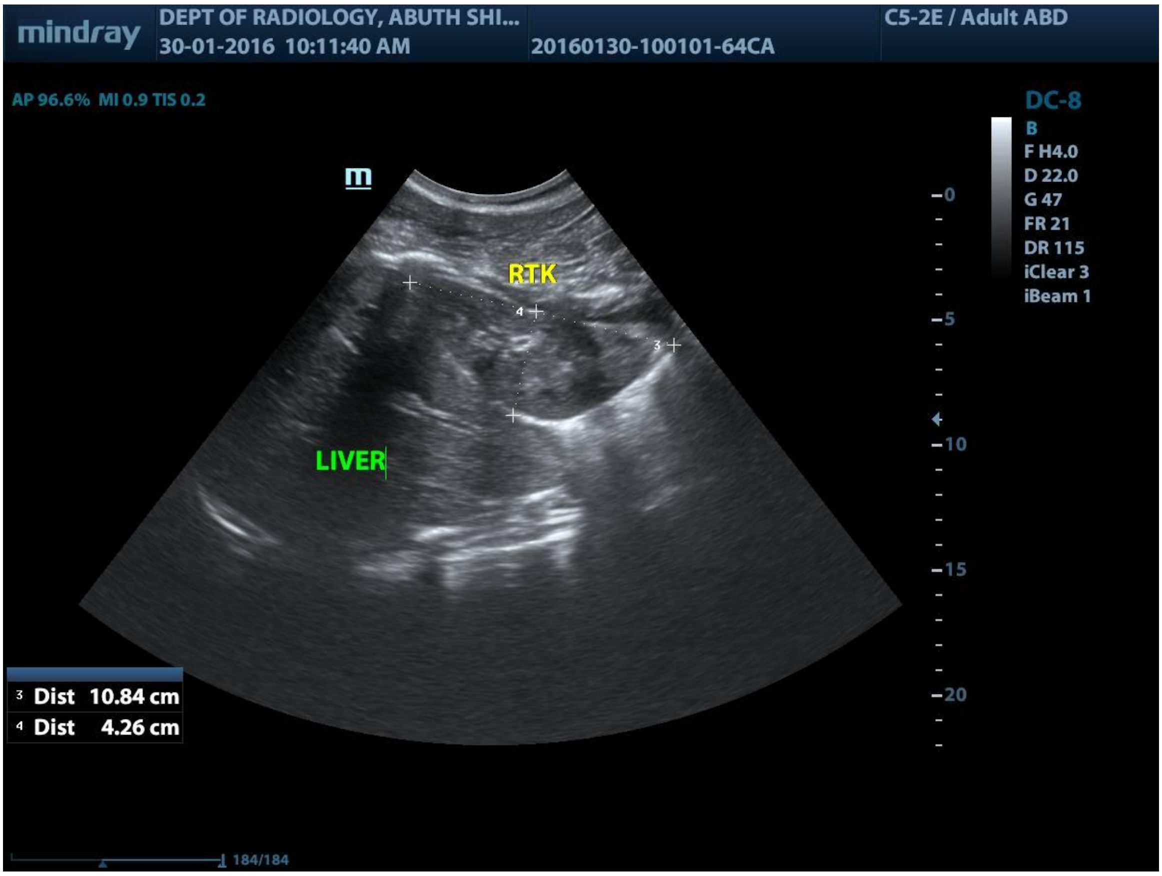

Plate 1I: Imaging procedure for the sonographic measurement of right kidney length and width

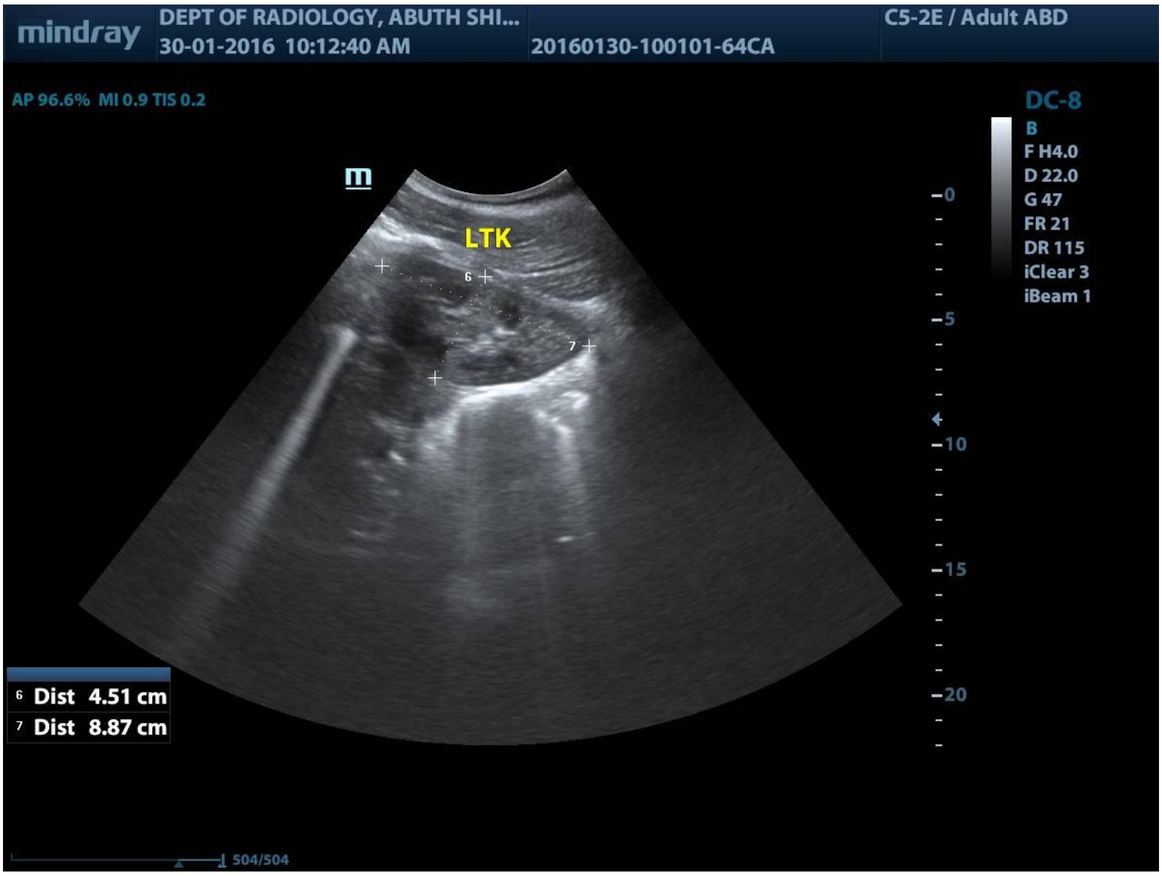

Plate III: Imaging procedure for the sonographic measurement of left kidney length and width

3.8 Ethical Approval

The ethical approval was sought according to WHO (2002) and the Helsinki Declaration (The World Medical Association) from the Ethics Committee of College of Health Sciences, Ahmadu Bello University, Zaria.

3.9 Informed Consent

All participants were informed about the aim and procedure of the study, and about the right of voluntary withdrawal from participation. Subjects were required to sign the consent form before participating.

3.10 Statistical Analysis

The descriptive statistics was expressed as mean ± SD. Student T-test was used to compare means of variables between males and females while paired t test was used to investigate the effect of side on renal dimensions. One- way ANOVA was used to determine the effects of age, Ht, Wt and BMI on the renal dimensions. Association between renal dimensions and BP, and some anthropometric variables was assessed with Pearson's correlation coefficient. Step wise Linear regression analysis was used to create models for calculating normative values for renal length and width. All statistical analyses were performed with Statistical Product and Service Solutions (SPSS) version 23.0 and the significance level was set at $p<0.05$.

CHAPTER FOUR

4.1 RESULTS

4.1 Descriptive statistics Analyses of Study Population

Descriptive statistics of the sample population is shown on Table 4.1. Four hundred students (400) participated in this study, two hundred (200) males and two hundred (200) female were used. The age range of the study subjects is 18.00 - 35.00 years, while their mean age was 22.41 ± 3.36 years. The mean age of male and female subjects was 22.85 ± 3.33 years and 21.98 ± 3.34 respectively as shown in table 4.1.

4.2 Sexual Dimorphisms of Study Population

The result from table 4.2 showed sexual dimorphisms of mean anthropometric parameters such as height, weight and body mass index, body surface area, renal dimensions such as RKDL, RKDW, LKDL, LKDW; and Blood pressure. From the results, the means age, height, weight, body surface area and systolic blood pressure of male students were significantly higher than that of female counterpart. The body mass index, and diastolic blood pressure of female students were significantly higher than that of male counterparts ($p < 0.05$). However, RKDL, RKDW, LKDL and LKDW did not indicate significant differences ($P > 0.05$) as shown in table 4.2.

Table 4.1: Descriptive statistics of renal dimensions, blood pressure and some anthropometric variables

	All (n = 400)		Male (n = 200)		Female (n = 200)	
Variables	Mean ± SD	Mix – Min	Mean ± SD	Mix - Min	Mean ± SD	Mix – Min
Age (Yrs)	22.41 ± 3.36	18 – 35	22.85 ± 3.33	18.00 - 35.00	21.98 ± 3.34	18.00 - 35.00
HT (m)	1.66 ± 0.08	1.46 - 1.91	1.70 ± 0.07	1.57 - 1.91	1.62 ± 0.07	1.46 - 1.77
WT (Kg)	60.91 ± 10.61	40.00 - 97.00	61.95 ± 9.15	46.00 - 86.00	59.86 ± 11.83	40.00 - 97.00
BMI (kg/m^{-2})	22.07 ± 3.39	15.81 - 36.13	21.34 ± 2.77	16.90 - 29.37	22.80 ± 3.78	15.81 - 36.13
BSA (m^2)	0.31 ± 0.02	0.26 - 0.36	0.31 ± 0.02	0.28 - 0.35	0.30 ± 0.02	0.26 - 0.36
RKDL (cm)	9.90 ± 0.84	7.73 - 12.61	9.94 ± 0.70	7.73 - 11.44	9.87 ± 0.96	8.03 - 12.61
RKDW (cm)	3.94 ± 0.38	3.13 - 4.85	3.96 ± 0.36	3.13 - 4.80	3.91 ± 0.39	3.13 - 4.85
LKDL (cm)	10.24 ± 0.84	7.17 - 14.10	10.28 ± 0.80	7.17 - 12.22	10.19 ± 0.89	8.63 - 14.10
LKDW (cm)	4.30 ± 0.50	3.22 - 6.65	4.33 ± 0.51	3.39 - 6.65	4.26 ± 0.48	3.22 - 5.59
SBP (mmHg)	111.10 ± 8.62	90.00 - 130.00	113.12 ± 8.38	100.00 - 130.00	109.07 ± 8.39	90.00 - 130.00
DBP (mmHg)	73.50 ± 7.34	60.00 - 90.00	72.55 ± 7.09	60.00 - 90.00	74.45 ± 7.48	60.00 - 90.00

HT: Height; WT: Weight; BMI: Body mass index; BSA: Body surface area; RKDL: Right kidney length; RKDW: Right kidney width; LKDL: Left kidney length; LKDW: Left kidney width; SBP: Systolic blood pressure; DBP; Diastolic blood pressure

Table 4.2: Sexual dimorphism in renal dimensions, blood pressure and some anthropometric variables

	Male (n = 200)	Female (n = 200)		
Variables	Mean ± SD	Mean ± SD	t-value	p-value
Age (Yrs)	22.85 ± 3.33	21.98 ± 3.34	2.597	0.010
HT(m)	1.70 ± 0.07	1.62 ± 0.07	12.581	0.001
WT(Kg)	61.95 ± 9.15	59.86 ± 11.83	1.975	0.049
BMI (kg/m^{-2})	21.34 ± 2.77	22.80 ± 3.78	-4.419	0.001
BSA	0.31 ± 0.02	0.30 ± 0.02	4.693	0.001
RKDL(cm)	9.94 ± 0.70	9.87 ± 0.96	0.795	0.427
RKDW(cm)	3.96 ± 0.36	3.91 ± 0.39	1.307	0.192
LKDL(cm)	10.28 ± 0.80	10.19 ± 0.89	1.031	0.303
LKDW(cm)	4.33 ± 0.51	4.26 ± 0.48	1.609	0.108
SBP(mHg)	113.12 ± 8.38	109.07 ± 8.39	4.831	0.001
DBP(mHg)	72.55 ± 7.09	74.45 ± 7.48	-2.607	0.009

HT: Height; WT: Weight; BMI: Body mass index; BSA: Body surface area; RKDL: Right kidney length; RKDW: Right kidney width; LKDL: Left kidney length; LKDW: Left kidney width; SBP: Systolic blood pressure; DBP; Diastolic blood pressure

4.3 Effects of Age, Height, Weight, BMI and Some Anthropometric Parameters on Renal Dimensions

Table 4.3 showed the effects of height on renal dimensions. From the result, LKDW was significantly lower in group 1.85m > when compared with other groups ($p < 0.05$). However, RKDL, RKDW and LKDL showed no significant differences across the groups ($p > 0.05$) as shown in table 4.3.

Table 4.3: Effects of height (m) on renal dimensions

	< 1.55m (n = 40)	1.56-1.65m (n = 170)	1.66-1.75m (n = 136)	1.76-1.85m (n = 50)	1.85m > (n = 4)	ANOVA	
Variables	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	F-value	p-value
RKDL(cm)	10.02 ± 1.05	9.87 ± 0.87	10.00 ± 0.71	9.70 ± 0.82	9.45 ± 1.21	1.738	0.141
RKDW(cm)	3.92 ± 0.37	3.94 ± 0.37	3.99 ± 0.38	3.83 ± 0.39	3.64 ± 0.28	2.243	0.064
LKDL(cm)	10.29 ± 0.91	10.19 ± 0.87	10.34 ± 0.80	10.10 ± 0.74	9.52 ± 1.20	1.799	0.128
LKDW(cm)	4.32 ± 0.46	4.31 ± 0.50	4.34 ± 0.50	4.14 ± 0.47	3.79 ± 0.30*	2.643	0.033

*RKDL: Right kidney length; RKDW: Right kidney width; LKDL: Left kidney length; LKDW: Left kidney width * = significantly different from normal weight. a = significantly different from overweight, b = significantly different from overweight and obese*

Table 4.4 showed the effects of weight on renal dimensions. From the result, the RKDL at weight range of 70-79kg was significantly lower than at weight range of < 50kg and 50-59kg while the RKDL at weight range of 80kg > was significantly lower than at weight range of < 50kg only. LKDL at weight range of 70-79kg was significantly lower than at weight range of < 50kg and 50-59kg. RKDW at weight range of 80kg > was significantly lower than at weight range of < 50kg and 50-59kg ($p < 0.05$). However, LKDW showed no significant differences across the groups ($p > 0.05$).

Table 4.4: Effects of weight on renal dimensions

	< 50kg (n = 31)	50-59kg (n = 181)	60-69kg (n = 95)	70-79kg (n = 71)	80kg > (n = 22)	ANOVA	
Variables	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	F-value	p-value
RKDL(cm)	10.23 ± 1.20	9.96 ± 0.79	9.96 ± 0.80	9.63 ± 0.77*	9.55 ± 0.83[a]	4.456	0.002
RKDW(cm)	4.04 ± 0.36	3.98 ± 0.37	3.95 ± 0.40	3.84 ± 0.32	3.74 ± 0.41*	3.994	0.003
LKDL(cm)	10.55 ± 1.18	10.33 ± 0.72	10.23 ± 0.92	9.96 ± 0.82*	9.93 ± 0.60	4.441	0.002
LKDW(cm)	4.41 ± 0.51	4.31 ± 0.45	4.34 ± 0.56	4.17 ± 0.51	4.18 ± 0.41	2.098	0.080

*RKDL: Right kidney length; RKDW: Right kidney width; LKDL: Left kidney length; LKDW: Left kidney width * = significantly diff from < 50 and 50-59, a = significantly diff from < 50*

Table 4.5 shows the effects of age on renal dimensions. From the result, RKDL, RKDW, LKDL and LKDW were not significantly different when compared across the age groups ($p > 0.05$).

Table 4.5: Effects of Age on renal dimensions

	18-24yrs (n = 325)	25-29yrs (n = 52)	30-35yrs (n = 23)	ANOVA	
Variables	Mean ± SD	Mean ± SD	Mean ± SD	F-value	p-value
RKDL(cm)	9.90 ± 0.86	9.95 ± 0.76	9.78 ± 0.78	0.324	0.724
RKDW(cm)	3.95 ± 0.38	3.90 ± 0.36	3.92 ± 0.42	0.375	0.687
LKDL(cm)	10.23 ± 0.85	10.30 ± 0.85	10.19 ± 0.66	0.193	0.824
LKDW(cm)	4.30 ± 0.47	4.25 ± 0.52	4.38 ± 0.72	0.576	0.563

RKDL: Right kidney length; RKDW: Right kidney width; LKDL: Left kidney length; LKDW: Left kidney width

Table 4.6 shows the effects of BMI on renal dimensions. From the result, RKDL was significantly lower in overweight subjects when compared with normal weight subjects. RKDW was significantly higher in underweight subjects when compared with overweight and obese subjects. RKDW was also significantly higher in normal weight subjects when compared with only overweight subjects. LKDL was significantly higher in normal weight subjects when compared with the overweight subjects ($p < 0.05$). However, there was no significant differences in LKDW when compared across the groups ($p > 0.05$).

Table 4.6: Effects of BMI on renal dimensions

Variables	Underweight (n = 33)	Normal weight (n = 308)	Overweight (n = 47)	Obesity (n = 12)	ANOVA	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	F-value	p-value
RKDL (cm)	9.89 ± 0.91	9.98 ± 0.82	9.56 ± 0.86*	9.36 ± 0.68	5.367	0.001
RKDW (cm)	4.11 ± 0.38[b]	3.95 ± 0.37[a]	3.78 ± 0.35[b]	3.79 ± 0.38[b]	6.066	0.001
LKDL (cm)	10.41 ± 0.93	10.27 ± 0.85[a]	9.99 ± 0.71	9.78 ± 0.53	3.162	0.025
LKDW (cm)	4.36 ± 0.49	4.29 ± 0.50	4.30 ± 0.54	4.10 ± 0.27	0.814	0.487

*RKDL: Right kidney length; RKDW: Right kidney width; LKDL: Left kidney length; LKDW: Left kidney width * = significantly different from normal weight. a = significantly different from overweight, b = significantly different from overweight and obese*

4.4 Results of Correlation Matrix

Table 4.7 shows correlation matrix of renal dimensions, some anthropometric variables and blood pressure for all Sample Population. From the result, Age was not significantly correlated with renal dimensions such as RKDL, RKDW, LKDL and LKDW. Height correlated inversely with only LKDW. However, the renal dimensions correlated inversely with weight, BMI and BSA except LKDW that was not significantly correlated with BMI. SBP correlated RKDL, LKDL and LKDW while DBP correlated with RKDW and LKDW only.

Table 4.8 shows correlation matrix of renal dimensions, some anthropometric variables and blood pressure of male and female subjects of sample population. From the result, Age correlated with LKDW only in male while age was not significantly correlated with any of the renal dimensions in female. Height correlated inversely with RKDL, RKDW, and LKDW except LKDW in male while in female height correlated inversely with LKDW only. Weight correlated inversely with RKDL, RKDW and LKDL in male while in female weight correlated inversely with LKDL only. BMI correlated inversely with all the renal dimensions in male while in female BMI correlated inversely with RKDW and LKDL only. BSA correlated inversely with all the renal dimensions in male while in female BSA correlated inversely with LKDL and LKDW only. SBP correlated inversely with LKDW only in male while in female SBP correlated directly with all the renal dimensions. DBP correlated directly with LKDL only in male while in female DBP correlated directly with RKDW and LKDW.

Table 4.7: Correlation matrix of renal dimensions, some anthropometric parameters and blood pressure for all sample population

All	AGE	HT (m)	WT(Kg)	BMI (Kgm^{-2})	BSA	RKDL(cm)	RKDW(cm)	LKDL(cm)	LKDW(cm)	SBP(mmHg)	DBP(mmHg)
AGE	-										
HT (m)	0.128^{*}	-									
WT(Kg)	0.151^{**}	0.486^{**}	-								
BMI (Kgm^{-2})	0.083	-0.079	0.830^{**}	-							
BSA	0.164^{**}	0.676^{**}	0.970^{**}	0.678^{**}	-						
RKDL(cm)	-0.033	-0.077	-0.165^{**}	-0.145^{**}	-0.156^{**}	-					
RKDW(cm)	-0.001	-0.076	-0.195^{**}	-0.177^{**}	-0.184^{**}	0.193^{**}	-				
LKDL(cm)	-0.002	-0.059	-0.177^{**}	-0.170^{**}	-0.165^{**}	0.698^{**}	0.211^{**}	-			
LKDW(cm)	0.067	-0.104^{*}	-0.121^{*}	-0.076	-0.128^{*}	0.349^{**}	0.413^{**}	0.409^{**}	-		
SBP(mmHg)	-0.061	0.112^{*}	-0.056	-0.134^{**}	-0.011	0.157^{**}	0.092	0.104^{*}	0.133^{**}	-	
DBP(mmHg)	-0.102^{*}	-0.100^{*}	-0.084	-0.037	-0.095	-0.001	0.194^{**}	0.084	0.131^{**}	0.323^{**}	-

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). HT = Height, WT = Weight, BMI = Body mass index

Table 4.8: Correlation matrix of renal dimensions, some anthropometric parameters and blood pressure of female (up) and male (down)

Variables	AGE	HT (m)	WT(Kg)	BMI (Kgm^{-2})	BSA	RKDL(cm)	RKDW(cm)	LKDL(cm)	LKDW(cm)	SBP(mmHg)	DBP(mmHg)
AGE	-	0.013	0.016	0.014	0.025	-0.083	-0.025	-0.004	-0.043	-0.046	-0.031
HT (m)	0.134	-	0.531**	0.100	0.680**	-0.087	-0.032	-0.102	-0.169*	-0.027	-0.034
WT(Kg)	0.303**	0.498**	-	0.894**	0.980**	-0.111	-0.135	-0.158*	-0.135	-0.095	-0.116
BMI (Kgm^{-2})	0.257**	-0.038	0.846**	-	0.795**	-0.098	-0.148*	-0.144*	-0.077	-0.100	-0.124
BSA	0.285**	0.667**	0.977**	0.717**	-	-0.113	-0.127	-0.162*	-0.157*	-0.086	-0.109
RKDL(cm)	0.022	-0.162*	-0.272**	-0.218**	-0.267**	-	0.015	0.704**	0.258**	0.188**	-0.030
RKDW(cm)	0.007	-0.246**	-0.299**	-0.199**	-0.311**	0.452**	-	0.052	0.372**	0.190**	0.367**
LKDL(cm)	-0.014	-0.103	-0.219**	-0.195**	-0.209**	0.696**	0.395**	-	0.336**	0.166*	-0.009
LKDW(cm)	0.154*	-0.180*	-0.127	-0.040	-0.147*	0.476**	0.450**	0.485**	-	0.391**	0.220**
SBP(mmHg)	-0.144*	-0.006	-0.067	-0.072	-0.047	0.107	-0.040	0.017	-0.144*	-	0.402**
DBP(mmHg)	-0.145*	-0.041	-0.013	0.013	-0.013	0.052	0.020	0.209**	0.067	0.330**	-

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). HT = Height, WT = Weight, BMI = Body mass index

4.5 Linear and Multiple Regression Equations

Table 4.9 presents the linear regression equations for estimating RKDL, RKDW, LKDL and LKDW from WT and BSA for the sample population. The Pearson's coefficient of regression (R), coefficients of determination (R^2), and standard error of the estimate (SEE) were also depicted. The regression model revealed the relationships between the outcome and explanatory variables. WT and BSA yielded coefficient of determination (R^2) of 0.027, 0.038, 0.031 and 0.016 accounting for 2.7%, 3.8%, 3.1% and 1.6% of the respective variance in RKDL, RKDW, LKDL and LKDW percentage among the subjects.

RKDL, RKDW, LKDL and LKDW values of the subjects were then estimated using the regression equations generated in table 4.9 as shown in table 4.10. Pearson's correlation was then used to ascertain the level of significant correlation between the observed and estimated values.

Table 4.9: Stepwise Linear regression equations for estimating renal dimensions from WT and BSA for the sample population

Predictors	Predictive equation	R	R^2	SEE	P
WT	RKDL(cm) = 10.697 + (-0.013) × WT	0.165	0.027	0.83102	0.001
WT	RKDW(cm) = 4.361 + (-0.007) × WT	0.195	0.038	0.37155	0.001
WT	LKDL(cm) = 11.088 + (-0.014) × WT	0.177	0.031	0.82949	0.001
BSA	LKDW(cm) = 5.268 + (-3.171) × BSA	0.128	0.016	0.49184	0.010

WT: Weight; BSA: Body surface area; RKDL: Right kidney length; RKDW: Right kidney width; LKDL: Left kidney length; LKDW: Left kidney width SEE: Standard error of the estimate, r: Pearson's correlation coefficient, R^2 *= Coefficient of determination;*

Table 4.10: Comparison between observed renal dimensions and estimated renal dimensions using WT and BSA

	WT		WT		WT		BSA	
S/No	Obs RKDL	Est RKDL	Obs RKDW	Est RKDW	Obs LKDL	Est LKDL	Obs LKDW	Est LKDW
1	9.72	10.03	3.65	3.96	10.57	10.25	3.85	4.36
2	9.09	9.79	4.22	4.01	10.94	10.25	4.79	4.36
3	8.72	9.77	4.50	3.96	8.83	10.25	4.07	4.30
4	10.63	9.94	3.88	4.01	10.64	10.39	4.18	4.22
5	10.12	9.77	4.02	3.96	10.34	10.37	3.85	4.30
6	9.22	9.94	3.83	4.01	9.74	10.11	3.79	4.22
7	9.98	10.10	4.13	4.01	9.17	10.09	3.84	4.22
8	10.20	10.03	3.97	3.94	10.75	10.28	4.23	4.34
9	10.73	9.98	3.78	3.82	9.62	10.09	5.00	4.34
10	10.28	10.09	3.54	3.94	9.90	10.28	4.52	4.35
	r = 0.165		r = 0.195		r = 0.177		r = 0.128	
	p = 0.001		p = 0.001		p = 0.001		p = 0.010	

CHAPTER FIVE

5.0 DISCUSSION

The normal size of a kidney is variable and is affected by age, gender, BMI, as well as the side. The size provides a rough indication of the renal function. The minimal size of a fully functional kidney is 9 cm in length (Shcherbak, 1989). Decrease of size and function are seen with chronic renal failure (Guzman *et al.*, 1994), renal arterial occlusion (Shcherbak, 1989) and late stage renal venous thrombosis (Montague *et al.*, 1982). However, although kidney size seems to be related to a number of vascular diseases, there is no correlation with blood pressure (Raunan *et al.*, 1998). Physiologically, renal length decreases 0.5 cm per decade after middle age (Emamian *et al.*, 1993).

On the other hand, there is an increase in kidney size in early stage renal thrombosis (Montague *et al.*, 1982), early stage diabetes mellitus (Sehwieger and Fine, 1990; Tuttle *et al.*, 1991) and renal inflammation (Hiraoka *et al.*, 1996). A physiological increase of glomerular filtration rate and kidney size can be observed in pregnancy (Christensen *et al.*, 1989). Kidney size also increases with increased protein intake in mice (Hammon and Lanes, 1998).

In order to estimate aberrations of kidney size, normal values must be established first. Not many studies have been done on this issue. There are, as far as we know, no reliable reference tables because the measurements vary between men and women, between people of different ethnic backgrounds and even between kidneys of the same individual. Also, it has to be borne in mind that kidney size measurement with ultrasound (US), as well as with CT and MRI result in a 24% underestimation of the renal value (Bakker *et al.*, 1998).

Commonly, US is used to screen and measure the kidney. In comparison with an intravenous pyelogram, US is more accurate and suffers neither from the geometric magnification of X-raying, nor from a possible increase in kidney size by osmotic diuresis through iodinated contrast material (Brandt *et al.,* 1982). It has been analyzed as a reliable, repeatable (inter-observer variation) and reproducible (intra-observer variation) method (Ablett *et al.,* 1995).

In a study in south-east Nigeria by Okoye *et al.* (2005) the mean right and left renal length were 10.4 cm and 10.6 cm respectively, whereas in study on adults in Sokoto North-Western Nigeria by Maaji *et al.* (2015) the overall mean renal right and left kidneys lengths were 11.3 cm and 11.6 cm respectively while the right and left renal width were 4.6 cm each. Also, in a study on adults Mexican by Oyuela-Carassco *et al.* (2009) the mean right and left renal lengths were 10.4 cm and 10.5 cm respectively which is similar with the right (10.68 cm) and left (10.71 cm) renal dimensions obtained by El-Rashid and Abdul-fattah (2014) on the adults Kuwaiti. The dimensions in the aforementioned studies are slightly higher than the ones in the present study. Similar with our findings are the right and left renal lengths of 9.77 cm and 9.94 cm and right and renal width of 4.08 cm and 4.18 cm respectively obtained by Yadav *et al.* (2017) on adults Nepal. The discrepancies in the renal dimensions could be as a result of environmental, genetic and nutritional factors. Also these results have proven that we cannot use the same normogram for different ethnicity from same country.

The present study has also shown that there were no significant differences in measured renal size with respect to gender ($p > 0.05$). This finding is similar to the findings of other previous authors (Konus *et al.,* 1998; Safak *et al.,* 2005; Soyupak *et al.,* 2007; Eze *et al.,* 2014). Therefore, gender certainly is not a determining factor for kidney dimensions in adults in this population. This suggests that special tables based on gender are not necessary. Contrastingly, probably because of difference in height or body size, renal sizes were found to larger in males in some of the studies (Wang *et al.,* 1989; Emamian *et al.,* 1993; Miletic *et al.,* 1998; Akpinar *et al.,* 2003; Okoye *et al.,* 2005; Kang *et al.,* 2007).

Our study also agrees with previous studies by Fernandes *et al.* (2002), Mazzotta *et al.* (2002) and Oyuela-Carassco *et al.* (2009) that left kidney is larger than the right kidney. The difference in size may be because of; liver on the right side may have more impact on renal growth when compared to the spleen on the left side as such left kidney has more space to grow than the right kidney and the left renal artery is shorter and straighter than the right; the increased blood flow in the left renal artery may result in relatively increase in volume.

Age has an essential bearing on renal dimensions as both physiology and anatomy of the human body alters with age (Melk and Halloran, 2001). In children, there is a close relationship between linear growth and kidney length (Ameer *et al.,* 1999) that indicates that kidney length can be used as a growth parameter in children. Kidney reaches its mature size at age 20‑29 years and remains relatively unchanged until the 6th decade of life. Studies have shown that aging leads to progressive decrease in kidney size, after middle age (Akpinar *et al.,* 2003) at rate of 0.5cm per decade, especially due to a reduction of about 1% per year in blood flow after the third decade (Mclachlan and Wasserman, 1981). Post mortem studies have also shown that the weight of kidney is up to 19% lower in elderly compared with young adults (Wald, 1937). Different mechanisms including cellular senescence, glomerulosclerosis, tubulointerstitial fibrosis, vascular collapse and thickening, oxidative stress and alterations in cytokines and growth factors have been implicated in literature (Anderson and Brenner, 1986; Fliser and Ritz, 1996). In the present study, renal dimensions remained essentially unchanged in our study group between the ages of 18 to 35 years and this is suggestive of relative homogeneity throughout young adult life.

From the results of this study, height did not show significant correlations with the kidney lengths except for the LKDW which was a negative correlation. This means that taller individuals in this population will have a narrower kidney. This disagrees with the reports of studies done by Mazzotta *et al.* (2002) and Emamian *et al.* (1993) that taller individuals have longer and wider kidneys than their shorter counterparts. The disparity seen could be tied to variation in race or different ethnic origin.

Among Africans, positive correlation was documented by Gebrehiwot and Atnafu (1998) who reported that total renal length, renal surface area and renal volume had significant positive correlation with the body surface area thus estimation of renal size can be made from a knowledge of the body size factor. Similarly, Zeb *et al*. (2012) documented that body surface area was the most sensitive indicator in their study, a finding which agrees both with literature and logic since organ size is unquestionably related to body size. Zeb *et al*. (2012) infer that body habitus and built is a major predictor of renal size in healthy adults; some parameters may have greater impact than others, but it is the amalgam of these anthropometric measurements which determines kidney size in healthy individual. The significant correlation between renal length and body weight was also established in previous studies (Wang *et al.,* 1989). A probable explanation is based on Brenner's principle of right renal dosing which states that larger body size requires a larger nephron dose to meet its metabolic demands (Brenner *et al.*, 1995; Luyckx and Brenner 2010; Otiv *et al.,* 2012).

However, the present study revealed that weight, BMI and BSA inversely correlated with the renal dimensions. The best correlation with the renal dimensions was seen with the weight. For this study population it could be inferred that the larger the body habitus the smaller the renal dimensions, thus smaller drug dose are needed for the drugs metabolic demand. The implication from our study for the Nigerian ultrasound community is obvious because of possible variations in the anthropometric parameters of various populations, races and regions. It is important for Nigerians to have their own population specific normograms of the kidneys in the studied age group as American and European population data cannot be used as universal patterns. Our results could be extrapolated to the wider international community where there is need for each country to establish their own specific normograms of kidney size in adults with reference to the body parameter that shows the best correlation with kidney dimensions as weight might show variation in different ethnic origins or races.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Normal values of renal dimensions in the adult undergraduate medical students of ABU, Zaria taken into consideration the effects of height, weight and BMI have been established. These were found to be Right Kidney Length: 9.90 ± 0.84 (cm), Right Kidney Length Width: 3.94 ± 0.38 (cm), Left Kidney Length: 10.24 ± 0.84 (cm) and Left Kidney Length Width: 4.30 ± 0.50 (cm).

The present study has also shown that there were no significant differences in measured renal size with respect to gender ($p > 0.05$). The height, weight, BMI and BSA inversely correlated with the renal dimensions and the best correlation with the renal dimensions was observed with the weight followed by BSA.

6.2 Recommendations

i. Population specific normograms of the kidneys should be advocated with special reference to the body parameter that shows the best correlation with kidney dimensions in different ethnic origins or races.
ii. A multicentre study is recommended in other regions of the country as this might improve the exactness of the estimates and also the generalizability of the data

6.3 Contribution to Knowledge

i. Normative baseline sonographic renal dimensions for adults in ABU, Zaria have been established :

- Right Kidney Length: 9.90 ± 0.84 (cm)
- Right Kidney Length Width : 3.94 ± 0.38 (cm)
- Left Kidney Length : 10.24 ± 0.84 (cm)
- Left Kidney Length Width : 4.30 ± 0.50 (cm)

ii. The prediction model of the renal dimensions, have been generated according to WT/BSA in this study as a surrogate method for the sonographers:

- RKDL(cm) = 10.697 + (-0.013) × WT
- RKDW(cm) = 4.361 + (-0.007) × WT
- LKDL(cm) = 11.088 + (-0.014) × WT
- LKDW(cm) = 5.268 + (-3.171) × BSA

REFERENCES

Abdullah, M.B., Garelnabi, M.E.M., Ayad, C.E. and Abdalla, E.A. (2014). Establishment of reference values for renal length and volume for normal adult Sudanese using MRI Disc Summation Method. *Global Journal of Medical Research,* 14(2): 29-37.

Ablett, M.J., Coulthard, A. and Lee, R.E. (1995). I-low reliable are ultrasound measurements of renal length in adults? *British Journal of Radiology*, 68: 1087-89.

Akpinar, I.N., Altun, E., Avcu, S., Tuney, D., Ekinci, G. and Biren, T. (2003). Sonographic measurement of kidney size in geriatric patients. *Journal of Clinical Ultrasound,* 31: 315–8.

Ameer, S., Anjum, M.N., Rehman, M., Haider, S.I., Farooq, L. and Ijaz, M.Z. (1999). Sonographic assessment of renal length in normal Pakistani children. Mother Child, 37: 45–50.

American Institute of Ultrasound in Medicine Proceedings, (2007). 14750 Sweitzer I.n, Suite 100 Laurel, MD 20707-5906, USA.

Anderson, S. and Brenner, B.M. (1986). Effects of aging on the renal glomerulus. *American Journal of Medicine,* 80: 435-42.

Arooj, A., Lam, J., Wui, Y.J. and Supriyanto, E. (2011). Comparison of Renal Size among Different Ethnicities. *International Journal of Biology and Biomedical Engineering*, 5(4): 221-229.

Ayad, E.A., Nouri, M., Abdalla, E.A. and Kajoak, S.A. (2015). Ultrasound quantification of kidneys length and width to establish normal values in healthy Sudanese school aged children. *American Journal of Health System and Pharmacy,* 2: 84-88.

Bakker, J., Olree, M., Kaatee, R., de-Lange, E.E., Moons, K.G. and Beutler, J.J. (1999). Renal volume measurements: accuracy and repeatability of US compared with that of MR imaging. *Radiology,* 211: 623-8.

Bakker, J., Olree, M., Kaatee, R., Lange, D. and Beek, F.J. (1998). In vitro measurement of kidney size: Comparison of ultrasonography and MRI. *Ultrasound Medical Biology,* 24: 683–8.

Barton, E.N., West, W.M., Sargeant, L.A., Lindo, J.F. and Iheonunekwu, N.C. (2000). A sonographic study of kidney dimensions in a sample of healthy Jamaicans. *West Indian Medical Journal*, 49: 154-7.

Beers, M.H., Fletcher, A.J. and Jones, T.V. (2003). The manual of medical information: New York; Pocket Books; PP 749-752.

Brandt, T.D., Neiman, H.L., Dragowski, M.J., Bulawa, W. and Claykamp, G. (1982). Ultrasound assessment of normal renal dimensions. *Journal of Ultrasound Medicine,* 1: 49–52.

Brenner, B.M., Lawler, E.V. and Mackenzie, H.S. (1995). The hyperfiltration theory: a paradigm shift in nephrology. *Kidney International,* 49: 1774-1777.

Buchholz, N.P., Abbas, F., Biyabani, S.R., Afzal, M., Javed, Q. and Rizvi, I. (2000). Ultrasonographic renal size in individuals without known renal disease. *Journal of Pakistan Medical Association,* 50: 12-6.

Christensen, T., Klebe, J.G. and Bertelsen, V. (1989). Changes in renal volume during normal pregnancy. Acta Obstetricia et Gynecologica Scandinavica, 68: 541-43.

Egberongbe, A.A., Adetiloye, V.A., Adeyinka, A.O., Afolabi, O.T., Akintomide, A.O. and Ayoola, O.O. (2010). Evaluation of renal volume by ultrasonography in patients with essential hypertension in Ile-Ife, south western Nigeria. *Libyan Journal of Medicine,* 5.

El-Rashaid, W. and Abdul-Fattah, H. (2014). Sonographic assessment of renal size in healthy adults. Medical Principles and Practice, 23: 432-436.

Emamian, S.A., Nielsen, M.B., Pedersen, J.F. and Ytte, L. (1993). Kidney dimensions at sonography: correlation with age, sex, and habitus in 665 adult volunteers. The *American Journal* of Roentgenology, 160: 83-6.

Eze, C.U. (2004). Sonographic assessment of renal parenchyma thickness in an adult Nigerian population; M.Sc. Dissertation Submitted to University of Nigeria, Nsukka, P. 48-49.

Eze, C.U., Agwu, K.K., Ezeasor, D.N., Agwuna, K.K., Aronu, A.E. and Mba, E.I. (2014). Sonographic biometry of normal kidney dimensions among school-age children in Nsukka, Southeast Nigeria. *West Indian Medical Journal,* 63(1): 47

Fernandes, M.M., Lemos, C.C., Lopes, G.S., Madeira, E.P., Santos, O.R. and Dorigo, D. (2002). Normal renal dimensions in a specific population. *International Brazilian Journal of Urology,* 28: 510-5.

Fliser, D. and Ritz, E. (1996). Renal haemodynamics in the elderly. *Nephrology Dialysis Transplantation,* 11 (9): 2-8.

Furuse, J., Nagase, M., Ishii, H. and Yoshino, M. (2003). Contrast enhancement patterns of hepatic tumours during the vascular phase using coded harmonic imaging and Levovist to differentiate hepatocellular carcinoma from other focal lesions. *British Journal of Radiology,* 76: 385-92.

Gavela, T., Sánchez-Bayle, M., Gómez-Mardones, G., Gallego, S., Martínez-Pérez, J. and Moya, M.T (2006) Ecographic study of kidney size in children. *Nefrologia,* 26: 325-9.

Gebrehiwot, M. and Atnafu, A. (1998). Determination of normal renal dimensions of adult Ethiopian patients as seen by excretory urography. *Ethiopian Medical Journal,* 36(1): 27-35.

Gupta, S., Devi, N.D., Sinam, S.S., Khumukcham, S. and Singh, A.K. (2013) Ultrasonographic renal dimensions in normal adult population of northeast India. *International Journal of Medical and Health Sciences,* 2: 433-437.

Guzman, R.P., Zierler, R.E. and Isaacson, J.A. (1994). Renal atrophy and arterial stenosis. A prospective study with duplex ultrasound. *Hypertension,* 23: 346-47.

Hammad, L.F. (2012). A sonographic study of kidney dimensions in Saudi's university students. Pakistan journal of medical sciences, 28 (3): 395-399.

Hammond, K.A. and Lanes, D.N. (1998). The effect of increased protein intake on kidney size and function. *The Journal of Experimental Biology,* 21(1): 2081-82.

Hekmatnia, A., Yaraghi, M. and Yagushi, F. (2004). Sonographic Measurement of Absolute and Relative Renal Length in Healthy Isfahani Adults. *Journal of Research in Medical Sciences,* 2: 54-57.

Hiraoka, M., 1-Ion, C. and Rsuchida, S. (1996). Ultrasonographic findings of acute tubulointerstitial nephritis. The *American* Journal of *Nephrology,* 16: 154.

International Society for the Advancement of Kinanthropometry. (2001). *International Standards for Anthropometric Assessment*. The University of South Australia Holbrooks Rd, Underdale, SA, Australia.

Jovanovic, D., Gasic, B., Pavlovic, S. and Naumovis, R. (2013). Correlation of kidney size with function and anthropometric parameters in healthy subjects and patients with chronic kidney disease. Renal failure, 35(6): 896-900.

Kang, K.Y., Lee, Y.J., Park, S.C., Yang, C.W., Kim, Y.S. and Moon, I.S. (2007). A comparative study of methods of estimating kidney length in kidney transplantation donors. *Nephrology Dialysis Transplantation,* 22: 2322-7.

Kantarci, F., Mihmanli, I., Adaleti, I., Ozer, H., Gulsen, F., Kadioglu, A., Altug, A. and Uysal, O. (2006). The effect of fluid on renal length measurement in adults: *Journal of Clinical Ultrasound*, 34(3): 128-133.

Konus, O.L. and Ozdemir, A. (1998). Normal liver spleen and kidney dimensions in neonates, infants and children: Evaluation with sonography. *American Journal of Roentgenology,* 171(6):1693-1698.

Krebs, C.A., Vincent, I. and and Eisenberg, R.I. (1993). *Ultrasound atlas of Disease Processes*. Connecticut; Appleton and Lange; pp 231-236.

Luyckx, V.A. and Brenner, B.M. (2010). The clinical importance of nephron mass. *Journal of the American Society of Nephrology,* 21: 898-910.

Maaji, S.M., Daniel, O. and Adamu, B. (2015). Sonographic measurement of renal dimensions of adults in northwestern Nigeria: a preliminary report. *Sub-Saharan African Journal of Medicine,* 2: 123-7.

Mazzotta, L., Sarteschi, L.M., Carlini, A. and Antonelli, A. (2002). Comparison of renal ultrasonographic and functional biometry in healthy patients and in patients with chronic renal failure. *Archivio Italiano di Urologia e Andrologia*, 74: 206–9.

McLachlan, M. and Wasserman, P. (1981). Changes in sizes and distensibility of the aging kidney. *The British Journal of Radiology,* 54: 488-91.

Melk, A. and Halloran, P.F. (2001). Cell senescence and its implications for nephrology. *Journal of the American Society of Nephrology,* 12: 385-93.

Miletic, D., Fuckar, Z., Sustić, A., Mozetic, V., Stimac, D. and Zauhar, G. (1998). Sonographic measurement of absolute and relative renal length in adults. The *Journal* of *Clinical Ultrasound*, 26: 185–9.

Miranda-Geelhoed, J.J., Kleyburg-Linkers, V.E., Sonja, P.E.S., Lequin, M., Nauta, J., Steegers, E.A.P., Van der Heijden, A.J. and Jaddoe, V.W.V. (2009). Reliability of renal ultrasound measurements in children. *Pediatric Nephrology, 24*(7): 1345-1353.

Montague, J.P., Neuenschwander, S. and Duguet-Lannes, M.D. (1982). Renal venous thrombosis in infants. Ultrasonic findings in 7 cases. *Archives of pediatrics,* 39: 67-68.

Morin, S.H., Lim, A.K., Cobbold, J.F. and Taylor-Robinson, S.D. (2007).Use of second generation contrast enhanced ultrasound in the assessment of focal liver lesions. *World Journal of Gastroenterology,* 13: 596370.

Mostelled, R.D. (2004). Simplified calculation of body surface area (letter). *New England Journal of Medicine,* 317: 1098.

Myint, O., Myint, T., Wynn, A.A., Soe, T.T. and San, K.K. (2016). Normal ultrasonographic renal length in relation to age, sex, BMI and serum creatinine level among students in university Malaysia Sabah. *IOSR Journal of Dental and Medical Sciences*, 15: 20-25.

Nahm, A. and Ritz, E. (2000). Errors in ultrasonogaphic measurements of the kidney. *Nephrology Dialysis Transplantation,* 15(4): 549-550.

Naing, L., Winn, T. and Rusli, B.N. (2006). Medical statistics: *Archives of Orofacial Sciences*, 1: 9-14.

Okoye, I.J., Agwu, K.K. and Idigo, F.U. (2005). Normal sonographic renal length in adult southeast Nigerians. African journal of medicine and medical sciences, 34:129-31.

Okur, A., Serin, H.I., Zengin, K., Erkoc, M.F. and Tanic, S. (2014). Relationship between kidney volume and body indexes in the Turkish population determined using ultrasonography. *International Brazilian Journal of Urology,* 40: 816-822.

Otiv, A., Mehta, K., & Ali, U. (2012). Sonographic measurement of renal size in normal Indian children. *Indian Pediatrics*, 49: 533-536.

Oyuela-Carrasco, J., Rodríguez-Castellanos, F., Kimura, E., Delgado-Hernández, R. and Herrera-Félix, J.P. (2009). Renal length measured by ultrasound in adult mexican population. *Nefrologia*, 29: 30-4.

Ozoh, J.O., Okoye, I.J., Umerah, B.C., Onuigbo, M.A.C. and Nwagbo, D.F.E. (1992). Normal renal sizes in Nigeria; *West African Journal of Radiology,* 2(1): 5-10.

Raman, G.V., Clark, A., Campbell, S., Watkins, L. and Osmond, C. (1998). Is blood pressure related to kidney size and shape? *Nephrology Dialysis Transplantation,* 13: 728-30.

Raza, M., Hameed, A. and Imran- Khan, N. (2011). Ultrasonographic assessment of renal size and its correlation with body mass index in adults without known renal disease, *Journal Ayub Medical Collegiate Abbottabad*, 23(3).

Ryan, S., McNichole, M. and Eustace, S. (2004) *Anatomy for Diagnostic Imaging. Saunders Books* Philadelphia; PP 189-194.

Safak, A.A., Simsek, E. and Bahcebasi, T. (2005). Sonographic assessment of the normal limits and percentile curves of liver, spleen, and kidney dimensions in healthy school-aged children. *Journal of Ultrasound Medicine,* 24: 1359-64.

Sehwieger, J. and Fine, L.G. (1990). Renal hypertrophy. Growth factors and neprhopathy in diabetes mellitus Semin. Journal of Nephrology, 10242-43.

Shcherbak, A.l. (1989). Angriographic criteria in the determination of indications for organ preserving surgery in renal artery occlusion. Klinichna khirurhiia, 2: 5.

Simon, G. and Wightman, A.J.A. (1983) *Clinical Radiology*. England: Butterworth and Co, p 13.

Soheilipour, F., Jesmi, F., Rahimzadeh, N., Pishgahroudsari, M. and Almassinokian, F. (2016). Configuring a better estimation of kidney size in obese children and adolescents. *Iran Journal of Pediatrics*, 26: e4700.

Soyupak, S.K., Narli, N., Yapicioglu, H., Satar, M. and Sungur, E.H. (2007). Sonographic measurements of the liver, spleen and kidney dimensions in the healthy term and preterm newborns. *European Journal of Radiology,* 43: 73e8.

Srivastava, A., Chopra, J., Hiralal, B., Sehgal, G. and Sharma, P.K. (2016) Estimation of renal length in adult north Indian population: a CT study. *International Journal of Anatomy Research,* 4: 1837-1842.

Tuttle, K.R., Bruton, J.L. and l'erusek, M.C. (1991). Effect of' strict glycemic control on renal hemodynamic response to amino acids and reital enlargement in insulin-dependent diabetes uncllitus. *The New England Journal of Medicine*, 324: 1626-29.

Udoaka, A., Enyi, C. and Agi, C. (2013). Sononlogical evaluation of the liver, spleen and kidneys in an adult Southern Nigerian population. *Asian Journal of Medical and Applied Sciences*, 5: 33-36

Ukoha, U.U., Anibeze, C.I.P., Akpuaka, F.U. and Mgbor, S.O. (2002). Kidney Parameters and Age Structure among Southeast Nigerians. *Journal of Experimental and Clinical Anatomy***,** 1(1): 19-21.

Von Herbay, A., Vogt, C., Willers, R. and Haussinger, D. (2004). Real-time imaging with the sonographic contrast agent SonoVue: differentiation between benign and malignant hepatic lesions. *Journal of Ultrasound Medicine,* 23: 1557-68.

Wald, H. (1937). The weight of normal adult human kidneys and its variability. The Archives of Pathology & Laboratory Medicine, 23: 493-500.

Wang, F., Cheok, S.P. and Kuan, B.B. (1989). Renal size in healthy Malaysian adults by ultrasonography. *Medical Journal of Malaysia*, 44: 45–51.

Wee L.K. and Supriyanto, E. (2010). Automatic detection of fetal nasal bone in 2 dimensional ultrasoundimage using map matching. *12th WSEAS international conference on automatic control, modeling and simulation,* 305-9.

Wilson, K.J.W. (1981). *Foundations of Anatomy and Physiology (5th ED).* Edinburgh, *Churchill Livingstone*, P. 153.

World Health Organisation, (2002). Reducing risk, promoting healthy life. Geneva: World Health Organisation, pp. 7-14.

Yadav, S.K., Yadav, R., Chakradhar, S. and Karn, A. (2017). Measurement of Renal Length and Width in Healthy Adults and Their Association with Various Parameters, *International Journal of Current Research Review*, 9(4): 19-27.

Zeb, S., Waeem, M., Raza, S., Adil, S., Iffat, Y., and Syed, A.H. (2012). Sonographic measurement of renal dimensions in adults and its correlates. *International Journal* of Collaborative Research on *Internal Medicine* & *Public Health,* 4: 1626-41.

APPENDIX I

PROFORMA FOR THE STUDY

TITLE: CORRELATION BETWEEN SONOGRAPHIC RENAL DIMENSIONS, BLOOD PRESSURE (BP) AND SOME ANTHROPOMETRIC PARAMETERS AMONGST MEDICAL STUDENTS OF AHMADU BELLO UNIVERSITY, ZARIA.

BIODATA

1. Research ID: ....
2. Sex: ....
3. Age: ....

SOCIAL HISTORY

1. Do you consume alcoholic beverages? Yes [ ] No [ ]
2. If yes, what is the quantity and for how long? ....
3. Do you smoke cigarettes? Yes [ ] No [ ]
4. If yes, how many sticks per day and for how long? ....
5. Do you have personal history of Hypertension? Yes [ ] No [ ]
6. Do you have personal history of Diabetes mellitus? Yes [ ] No [ ]
7. Do you have personal history of Kidney disease? Yes [ ] No [ ]

ANTHROPOMETRY

1. Weight (Kg): ....
2. Height (cm): ....

   BLOOD PRESSURE (BP)

   1. Systolic......................
   2. Diastolic..........................

ULTRASONOGRAPHIC DIMENSION

1. Kidney length (cm): ....
2. Kidney width (cm): ....

APPENDIX II

HEALTH RESEARCH ETHICS COMMITTEE

AHMADU BELLO UNIVERSITY TEACHING HOSPITAL

SHIKA - ZARIA, NIGERIA.

E-mail: abuthshika@yahoo.com website: www.abuth.org

Chairman of Board: Chief. Shuaib Oyedokun Afolabi *Fnll*
Chief Medical Director: Prof. Lawal Khalid, *MBBS, FMCS, FWACS, FRCS(ED) mnl*
Chairman, Medical Advisory Committee: Prof. Abdullahi Mohammed, *MBBS, FWACP, FICS*
Director of Administration: Barr. Ishak Bello, *LL.B, BL., LL.M, PGDM, AHAN, FCAI*

Our Ref: ABUTH/HREC/TRG /36

Date: 13th. Aug. 2016

Your Ref:

ABUTH HREC FULL ETHICAL CLEARANCE CERTIFICATE

Correlation between Sonographic Renal Dimensions and Blood Pressure and Some Anthropometric Variables amongst Students of Ahmadu Bello University Zaria

ABUTH Ethics Committee assigned number:	-	ABUTHZ/HREC/P16/2016
Name of the principal Investigator:	-	Dr. Tasiu Ibrahim
Address of the Principal Investigator:	-	Dept. of Human Anatomy, ABU Zaria
Date of receipt of valid application:	-	20/5/2016
Date of meeting when final determination on ethical approval was made:	-	4th & 5th August, 2016

This is to inform you that the research described in the submitted protocol, the consent forms and other participant information materials have been reviewed and ***given full approval by the Health Research Ethics Committee.***

Please note: this approval dates from 15th August, 2016 - 15th August, 2017

No participant recruitment into this research may be conducted outside these dates.

All informed consent forms in this study must carry the ABUTH HREC number assigned to this research and the duration of ABUTH HREC approval of the study.

This HREC expects that you submit your application as well as an annual report for ethical clearance renewal 3 months prior to expiration of study dates. This is to enable you obtain renewal of your approval and avoid interruption of your research.

If there is delay in starting the research, please inform the ABUTH HREC so that starting dates can be adjusted accordingly.

No changes are permitted in the research without prior approval by ABUTH HREC, except in circumstances outlined in national code for Health Research Ethics: http://www.nhrec.net.

ABUTH HREC reserves the right to conduct compliance assessment visits to your research site without prior notification.

Prof. A. I. Mamman MBBS, FMCPath
Chairman, ABUTH HREC

APPENDIX III

ASN-BABCOCK 2017

Theme: Anatomy Act: What Next?

UAN: ASNBU2017-1-033

SONOGRAPHIC MEASUREMENT OF RENAL DIMENSIONS AND ITS CORRELATES WITH SOME ANTHROPOMETRIC PARAMETERS IN HEALTHY ADULTS IN ZARIA, NORTHWESTERN NIGERIA

IBRAHIM, T.[1*], BURAIMOH, A.A.[1], OJO, S.O.[2], ADAMU, A.A.[3], BABAYEMI, J.O.[1], MUSTAPHA, M.[1] ILIYASU, M.O.[1], ALIYU, I.A.[1], [5]AHMED, I.[1], MIKO, A.M.[1], SHEHU, A.U.[4] AND AHMED, I.M.[5]

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

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

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

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

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

[*]**Corresponding author: +2348833698669, E-mail: drtasiu@yahoo.com**

ABSTRACT

Background: Among all the imaging modalities, ultrasound has been regarded and preferred as an imaging technique of choice in most of the clinical surveys. It is cheap, accessible, non-invasive, radiation free, little or no patient preparation, no use of medication or injection of contrast agent and has now become an integral part of the clinical evaluation of normal as well as diseased kidneys. **Aim and Objectives:** To establish some normal renal dimensions data of adults' Nigerian population in Zaria, and also to determine its correlation with height, weight, body mass index (BMI) and body surface area (BSA).**Materials and Methods:** This prospective study was conducted in the Department of Radiology, Ahmadu Bello University Teaching Hospital, Zaria between January and August 2016. Four hundred apparently healthy young adults (200 males and 200 females) resident in Zaria who gave their informed consent were randomly selected and recruited for the study. The ethical permit was obtained from the Ethical Committee of the Hospital. The longitudinal length and width of the right and left kidneys were measured. In addition, the age, sex, height (Ht), weight (Wt), BMI, and BSA of the subjects were recorded. All renal scans were done with a Mindray diagnostic ultrasound system (Model DC-3, 2010/2012, Nanshan, Shenzen, PR China) plus 2.5-6 MHZ curvilinear probe. Hard copy images were taken for documentations, and all the measurements were done by a single trained radiologist to reduce inter-observer errors.**Results:** The mean age was 23.37 ± 3.55 years. The mean Ht, Wt, BMI and BSA were 1.65 ± 0.08cm, 60.02 ± 10.17kg, $22.00 \pm 3.33 kg/m^2$ and 1.66 ± 0.16 respectively. The mean kidney length was 7.01 ± 3.2 and 7.29 ± 3.09 for right and left kidney, respectively. The mean kidney width was 7.11 ± 3.21 and 3.7 ± 1.01 for right and left kidney, respectively. Renal measurements were significantly correlated with the subject's Ht, BMI, and BSA ($p< 0.05$). **Conclusion:** Normal values of renal dimensions in the adult Nigerian population in Zaria (North Western region) taken into consideration the effect of Ht, BMI and BSA has been established.

APPENDIX IV

Journal of Anatomical Sciences

Email:anatomicaljournal@gmail.com

J Anat Sci 8 (2)

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

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

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

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

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

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

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

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

ABSTRACT

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

Keywords: Sonography, Measurements, kidney dimensions, Zaria

INTRODUCTION

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

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

The information available on the current knowledge of kidney size is largely based on Western and Asian countries derived standards and this may be inappropriate for our population[12]. The dearth of