The National Ribat University

College of graduate studies

Impact of Hypertension on Renal Morphology in Adult Sudanese Patients Using Ultrasound

A thesis Submitted for Partial Fulfillment of the Requirements of M.Sc Degree in Medical Diagnostic Ultrasound

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Chapter Two

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قال تعالى: 

"وأنزل عليك الكتاب والحكمة وعلmk ما لم تكن تعلم (النساء: 113) 

صدق الله العظيم"
Dedication

I dedicate this research to my husband (Dr.Omer), who encouraged me in this study and without his caring support, it would have not been possible.

To my loving parents, they have been my constant source of success.

To my sisters and brothers, who have never left my side.

I also dedicate this research to my little baby (Ahmed), who is my inspiration to go forward. And to my brother Dr. Mohammed Anwer who support me during this research.
Acknowledgment

My thanks and appreciation to my supervisor Dr. Raga Ahmed Abouraida for preserving with me as my advisor and for her countless hours of reading, giving notes, encouraging and most of all patience throughout the entire process.

My thanks also to the all staff on Al Salamaby hospital for their help, encouragement and support during this research.

Abstract
Ultrasound is a useful modality to document the volume and shape of the kidney.

The study conducted in Khartoum state in Alsalmaby hospital. The scope behind is a lack of estimated sonographic prevalence of effect of the essential hypertension on kidney morphology on both gender in Khartoum state.

The aim of this study is evaluation of renal morphology in patients with essential hypertension who have not developed chronic renal disease, and correlate it with age, body mass index (BMI) and duration of hypertension.

This prospective, cross-sectional, hospital-based study, including 73 patient (39 female and 37 male) referred to ultrasound department in Alsalmaby hospital-Khartoum, during a period extending from November 2015 to February 2016.

The data collected from sheet included sonographic measurements of renal volume and somatic parameters which were analyzed by computerized system using Statistical Package for Social sciences (SPSS) program.

The result of analyzed data showed that the renal size had positive relation with BMI in both genders, and negative relation with the age in essential hypertension patients.

The study showed that the renal size in males is larger than females in hypertension patients. Moreover, this study showed that there is no significant statistical correlation between renal size and shape with the duration of hypertension.

This study strongly recommended applicant of universal guidelines in sonography. And the necessary of periodic sonographic checkup for both kidneys and the blood pressure in hypertensive patients. Also, patients must do more
investigations to detect the real cause of hypertension. Further long term studies is recommended using large sample volume.
تعتبر الموجات الصوتية وسيلة تشخيصية مفيدة لمعرفة شكل وحجم الكلية.

أجريت هذه الدراسة في ولاية الخرطوم في مستشفى السلماني. الغرض من الدراسة معرفة تأثير الضغط (ضغط الدم الشرياني) على حجم وشكل الكلى لدى كلا الجنسين في ولاية الخرطوم.

هدفت هذه الدراسة إلى تقييم حجم وشكل الكليتين لمرضى الضغط الذين لا يعانون من أمراض كلية مزمنة وربطه بالعمر، وكثافة الجسم وفترة مرض الضغط.

كانت هذه الدراسة- المستقبلية التي تعطي صورة نموذجية- 73 مريضاً (39 أنثى و37 ذكر) تم تحويلهم لقسم الموجات الصوتية في مستشفى السلماني - الخرطوم، خلال فترة تمتد من نوفمبر 2015 م إلى فبراير 2016.

وضمت البيانات التي جمعت قياسات الموجات الصوتية لحجم وشكل الكلية التي تم تحليلها بنظام كمبيوتر مستخدمين حزمة إحصائية لبرنامج العلوم الاجتماعي (SPSS).

كما وضحت نتيجة تحليل البيانات أن حجم الكلية يتناسب طردياً مع وحدة حجم الجسم لكلا الجنسين، وعكسياً مع العمر لدى مرضى الضغط.

ووضحت هذه الدراسة أيضاً أن حجم الكلية لدى الذكور أكبر من الاناث المصابين بالضغط، من ناحية أخرى أظهرت هذه الدراسة أنه لا توجد علاقة ذات دلاله إحصائية بين حجم الكلية وفترة مرض الضغط.

أوصت هذه الدراسة بشدة بتطبيق مبادئ البروتوكول العالمي في الموجات الصوتية. كما أوصت بأهمية الكشف الدوري لكل الكليتين وضغط الدم لدى مرضى الضغط، بالإضافة إلى أنه على المرضى القيام بفحوصات أكثر لمعرفة السبب الأساسي لمرض الضغط.

علاوة على ذلك، نوصي بالقيام بدراسات أخرى على المدى الطويل باستخدام عينة أكبر.
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<tr>
<td>RCC</td>
<td>Renal cell carcinoma</td>
</tr>
<tr>
<td>TCC</td>
<td>Transitional cell carcinoma</td>
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<td>IVU</td>
<td>Intravenous urogram</td>
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<td>CT</td>
<td>Computerized Tomography</td>
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<td>SCC</td>
<td>Squamous cell carcinoma</td>
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<tr>
<td>AMLs</td>
<td>Angiomyolipomas</td>
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<tr>
<td>MRI</td>
<td>Magnetic Resonance imaging</td>
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<tr>
<td>MSK</td>
<td>Medullary sponge kidney</td>
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<tr>
<td>ARPKD</td>
<td>Autosomal recessive polycystic kidney disease</td>
</tr>
<tr>
<td>ADPKD</td>
<td>Autosomal dominant polycystic kidney disease</td>
</tr>
<tr>
<td>UTI</td>
<td>Urinary tract infection</td>
</tr>
<tr>
<td>MCDK</td>
<td>Multicystic dysplastic kidney</td>
</tr>
<tr>
<td>ACKD</td>
<td>Acquired cystic kidney disease</td>
</tr>
<tr>
<td>TS</td>
<td>Tuberous sclerosis</td>
</tr>
<tr>
<td>ATN</td>
<td>Acute tubular necrosis</td>
</tr>
<tr>
<td>ACN</td>
<td>Acute cortical necrosis</td>
</tr>
<tr>
<td>AIN</td>
<td>Acute interstitial nephritis</td>
</tr>
<tr>
<td>DM</td>
<td>Diabetes Mellitus</td>
</tr>
<tr>
<td>HTN</td>
<td>Hypertension</td>
</tr>
<tr>
<td>eGFR</td>
<td>estimated glomerular filtration rate</td>
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<tr>
<td>NM</td>
<td>nuclear medicine</td>
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<tr>
<td>BMI</td>
<td>Body mass index</td>
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<td>CRF</td>
<td>Chronic renal failure</td>
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Chapter one: Introduction
1-1 Introduction

The urinary system helps maintain homeostasis by removing harmful substances from the blood and regulating water balance in the body is an important part of physiology. Kidneys, which are the main part of the urinary system, are made up of millions of nephrons that act as individual filtering units and are complex structures themselves. The ureters, urethra, and urinary bladder complete this intricate system.\(^{(1)}\)

The kidneys are surrounded by three layers of tissue: The renal fascia is a thin, outer layer of fibrous connective tissue that surrounds each kidney (and the attached adrenal gland) and fastens it to surrounding structures. The adipose capsule is a middle layer of adipose (fat) tissue that cushions the kidneys. The renal capsule is an inner fibrous membrane that prevents the entrance of infections.\(^{(1)}\)

Inside the kidney, three major regions: The renal cortex borders the convex side, the renal medulla lies adjacent to the renal cortex. It consists of striated, cone-shaped regions called renal pyramids (medullary pyramids), who’s peaks, called renal papillae, face inward. The unstriated regions between the renal pyramids are called renal columns.\(^{(2)}\)

Ultrasonography is one of the well accepted and sensitive imaging modality for detecting any change in kidney morphology or cortecomедullary differentiation. Healthy kidneys produce a hormone to help the body regulate its own blood pressure. Kidney damage and uncontrolled high blood pressure each contribute to a negative spiral. As more arteries become blocked and stop functioning, the kidneys eventually fail.\(^{(3)}\) This process can happen over several years, but it can be prevented.
There are several factors that effect on kidney morphology and physiology; obesity, metabolic syndrome, insulin resistance, hypothyroidism, age, race, medication usage, genetic diseases and adrenal function. This study will focus on the characterization of hypertension (high blood pressure) on kidney morphology.\(^4\)

Blood pressure measures the force of blood against the walls of your blood vessels. Blood pressure that remains high over time is called hypertension. Extra fluid in your body increases the amount of fluid in your blood vessels and makes your blood pressure higher. Narrow or clogged blood vessels also raise your blood pressure.\(^4\)

High blood pressure makes your heart work harder and, over time, can damage blood vessels throughout your body. If the blood vessels in your kidneys are damaged, they may stop removing wastes and extra fluid from your body. The extra fluid in your blood vessels may then raise blood pressure even more.\(^5\)

1-2 Problem of the study

High blood pressure is one of the most common causes of kidney failure. That's because it can damage both the large arteries leading to the kidneys and the tiny blood vessels and tiny structure as well (glomeruli) within the kidneys. Kidneys are supplied with dense blood vessels (20-25% from cardiac output), over time, uncontrolled high blood pressure can cause arteries around the kidneys to narrow, weaken or harden. These damaged arteries are not able to deliver enough blood to the kidney tissue. Therefore the characterization of these effect is considered as significant issue of this study using ultrasound to detect these changes in kidneys vasculature due to high blood pressures in order to prevent chronic renal disease as possible.\(^5\)
1-3 Objective of the study

1-3-1 General objectives

To study the impact of essential hypertension on kidney morphology in adult Sudanese patient using ultrasound.

1-3-2 Specific objectives:

- To detect the morphological change in kidney for patient with hypertension using ultrasound.
- To develop an algorithm recognizes relation between renal volume and duration of hypertension.
- To find out the correlation between renal volume and body mass index in Hypertensive Patients.
- To correlate hypertensive patient age with the renal volume.

1-4 Justification

This study helps to reveals the ultrasound as less invasive and effective tool in term of time and cost, and accuracy of ultrasound in measurement of kidney volume and detect any change in patients with hypertension.

1-5 Overview of the study

This study will consist of five chapters; chapter one is an introduction, as well as statement of the problem and study objectives, in addition to justification and overview of the study. While chapter two will include a comprehensive scholarly literature reviews concerning the previous studies. Chapter three deals with the methodology, where it provides an outline of material and methods used to acquire
the data in this study as well as the method of analysis approach. Chapter four the results presentation and the main study finding, and chapter five include discussion of results, conclusion and recommendations followed by references and appendices.

Chapter two: Literature review and background studies

2-1 Anatomy
The kidneys are two bean-shaped organs situated in the retroperitoneum on each side of the vertebral column. Their posterior surfaces are separated from the psoas major and the quadratus lumborum muscles by the posterior pararenal space. Each kidney consists of an upper and lower pole, anterior and posterior surfaces medially, the surface is concave; the medial surface is known as the renal hilum.

The renal hilum is continuous with a central cavity called the renal sinus. Within the renal sinus are the major branches of the renal artery, major tributaries of the renal vein, and the collecting system.\(^\text{(1)}\)

The remainder of the renal sinus is packed with fat. The collecting system (renal pelvis) lies posterior to the renal vessels in the renal hilum. The long axis of the kidney runs obliquely and parallels the lateral border of the psoas major muscle. This means the upper poles are closer to midline than the lower poles. The upper poles of the kidneys are located more posterior than the lower poles. When you are scanning in the coronal plane, it is necessary to remember this orientation in order to obtain an adequate long axis scan. The medial margins of the kidneys are more anterior than the lateral margins. This means scans in the transverse plane will show the kidneys lying in an oblique plane relative to the midline of the body. The kidneys move inferiorly with inspiration and superiorly with expiration.\(^\text{(1)}\)
In the adult, each kidney measures approximately 11 cm long, 2.5 cm thick, and 5 cm wide and weighs 120 to 170 grams. Emamian et al. demonstrated that the parenchymal volume of the right kidney is smaller than that of the left kidney, possibly because of a relatively larger potential space for left renal growth (growth of right kidney inhibited by liver) or relatively increased left renal blood flow (left renal artery typically shorter than right renal artery). Renal length correlates best with body height, and renal size decreases with advancing age because of parenchymal reduction.\(^{(1,2)}\)

The left kidney usually lies 1 to 2 cm higher than the right kidney.\(^{(1)}\) The kidneys are mobile and will move depending on body position. In the supine position, the superior pole of the left kidney is at the level of the 12\textsuperscript{th} thoracic vertebra, and the inferior pole is at the level of the third lumbar vertebra.\(^{(2)}\)

2-1-1 Relationships

2-1-1-1 Anterior surface relationships of the right kidney
1. The right adrenal (suprarenal) gland sits on a small part of the anterior surface of the upper pole and upper part of the medial border. The adrenal gland is separated from the kidney by perirenal fat.
2. The right lobe of the liver covers approximately three-quarters of the anterior surface of the kidney.
3. The descending duodenum overlies a narrow area on the medial border. Other portions of the small intestine cover a small portion of the lower anterior surface between the duodenum and the hepatic flexure of the colon.
4. The hepatic flexure of the colon overlies the lower anterolateral surface of the kidney.\(^{(3)}\)

2-1-1-2 Anterior surface relationships of the left kidney
1. The left adrenal (suprarenal) gland covers a small part of the medial border of the upper pole. The adrenal gland is separated from the kidney by perirenal fat.
2. The spleen overlies a large portion of the anterolateral surface of the upper pole.
3. The stomach is related to the anterior surface of the kidney between the splenic and suprarenal areas.
4. The body/tail of the pancreas and splenic vessels are related to the middle of the anterior surface of the left kidney.
5. The splenic flexure of the colon is related to a portion of the anterolateral surface of the inferior half of the kidney.
6. The jejunum overlies the lower medial anterior surface. This is the first coil which occupies a recess between the left part of the transverse mesocolon and the left kidney. The rest of the jejunum lies in the umbilical region.\(^{(3)}\)

2-1-1-3 Posterior surface relationships of both kidneys

The posterior surfaces are embedded in fat and are devoid of peritoneum.
1. The diaphragm is related to the posterior surfaces of the upper poles of the kidneys.
A large pleural effusion located in the costodiaphragmatic recess may be demonstrated posterior to the upper pole of the kidney but separated from the kidney by the intervening diaphragm. The costodiaphragmatic potential spaces extend inferiorly as far as the renal hila.
2. The psoas major muscles have a relationship to the medial portions of the posterior surfaces of the kidneys.
3. The quadratus lumborum muscles are related to the central portions of the posterior surfaces.
4. The aponeuroses of the transversus abdominis muscles are related to the lateral portions of the posterior surfaces.
The right kidney rests upon the 12th rib and the left kidney against the 11th and 12th ribs.\(^{(3)}\)

2-1-1-4 Lateral Border Relationships

The left kidney is related to the spleen via the splenorenal ligament. The right kidney is related laterally to the right lobe of the liver.

2-1-1-5 Medial Border Relationships

1. The hilum (hilus) is a slit on the medial border opposite the level of the first lumbar vertebra. The hilum leads to a central cavity called the renal sinus.
2. The adrenal gland is related to the medial border superior to the level of the hilum.
3. The upper part of the ureter is related to the medial border below the level of the hilum.\(^{(3)}\)

2-2 Physiology

The prime function of the kidney is excretion of metabolic waste products. The kidneys do this by converting more than 1700 liters of blood per day into 1 liter of highly concentrated urine.\(^{(5)}\)

The kidney is an endocrine organ that secretes many hormones, including erythropoietin, renin, and prostaglandins. The kidneys also function to maintain homeostasis by regulating water salt and acid-base balance. The renal collecting
system, ureters, and urethra function as conduits and the bladder serves as a reservoir for urinary excretion.\(^{(5)}\)

The kidney's jobs never ends, whenever you take a drink of water or take a bite of food it will pass through the kidneys and the kidneys will filter out the unneeded particles in the blood stream.\(^{(6)}\)

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### 2-3 Pathology

#### 2-3-1 Hypertension

Hypertension is the medical term for high blood pressure. A normal blood pressure is 120/80. A blood pressure reading higher or equal to 140/90 is considered abnormally high. Blood pressure is the force of blood pushing against blood vessel walls as the heart pumps out blood, and high blood pressure, also
called hypertension, is an increase in the amount of force that blood places on blood vessels as it moves through the body.\(^{(10)}\)

Factors that can increase this force include higher blood volume due to extra fluid in the blood and blood vessels that are narrow, stiff, or clogged. Blood pressure is the force of blood pushing against blood vessel walls as the heart pumps out blood.\(^{(11)}\)

Elevated blood pressure means your heart is working harder than normal, putting both your heart and arteries under great strain. High blood pressure is serious business. On average, people with uncontrolled hypertension are:\(^{(11)}\)

- Seven times more likely to have a stroke.
- Six times more likely to develop congestive heart failure.
- Three times more likely to have a heart attack.

In 90% of cases, the cause of hypertension is unknown. This is called "essential hypertension". The other 10% of cases is called "secondary hypertension". Secondary hypertension is caused by kidney disease, severe narrowing of the aorta, tumors in the adrenal gland, or hardening of the arteries. There are many factors associated with high blood pressure, including smoking, age, race, a high-salt diet, excessive alcohol consumption, stress, and use of birth control pills, obesity, and a sedentary lifestyle.\(^{(12)}\)

If you are a man from 35 to 50, you are in a high-risk zone for hypertension, this is especially true if hypertension also runs in your family. It is less likely for women to have high-blood pressure, but the risk increases after menopause. There are usually no symptoms for hypertension. This is why it is often called the "silent killer". Actually, you could have hypertension for years and not know about
because you feel fine. But symptoms do show up if the case is severe. Some of these symptoms are:

- Headache
- Nosebleeds
- Drowsiness
- Confusion
- Dizziness
- Irregular heartbeat
- Numbness and tingling in hands and feet
- Coughing up blood
- Shortness of breath

Health Hazards: Hypertension accelerates hardening of the arteries, which may contribute to a stroke or heart attack. This can also lead to brain hemorrhage, kidney failure, heart failure, or blindness.\(^9\)

2-4 Effect of Hypertension on the kidney

High blood pressure can damage blood vessels in the kidneys, reducing their ability to work properly. When the force of blood flow is high, blood vessels
stretch so blood flows more easily. Eventually, this stretching scars and weakens blood vessels throughout the body, including those in the kidneys.\textsuperscript{(11)}

If the kidneys’ blood vessels are damaged, they may stop removing wastes and extra fluid from the body. Extra fluid in the blood vessels may then raise blood pressure even more, creating a dangerous cycle.\textsuperscript{(12)}

High blood pressure is the second leading cause of kidney failure in the United States after diabetes. In addition, the rate of kidney failure due to high blood pressure increased 7.7 percent from 2000 to 2010.\textsuperscript{(11,12)}

\textbf{2-5 Methods of diagnosis of hypertension and renal diseases}
A health care provider diagnoses high blood pressure when multiple blood pressure tests—often repeated over several visits to a health care provider’s office—show that a systolic blood pressure is consistently above 140 or a diastolic blood pressure is consistently above 90. Health care providers measure blood pressure with a blood pressure cuff. People can also buy blood pressure cuffs at discount chain stores and drugstores to monitor their blood pressure at home. Kidney disease is diagnosed with urine and blood tests.\(^{(13)}\)

2-5-1 Urine Tests

Dipstick test for albumin. A dipstick test performed on a urine sample can detect the presence of albumin in the urine. Albumin is a protein in the blood that can pass into the urine when the kidneys are damaged. A patient collects the urine sample in a special container in a health care provider’s office or a commercial facility. The office or facility tests the sample onsite or sends it to a lab for analysis. For the test, a nurse or technician places a strip of chemically treated paper, called a dipstick, into the urine. Patches on the dipstick change color when blood or protein is present in urine.\(^{(13)}\)

Urine albumin-to-creatinine ratio. A health care provider uses the albumin and creatinine measurement to determine the ratio between the albumin and creatinine in the urine. Creatinine is a waste product in the blood that is filtered in the kidneys and excreted in the urine. A urine albumin-to-creatinine ratio above 30 mg/g may be a sign of kidney disease.\(^{(13)}\)

2-5-2 Blood Test
A blood test involves having blood drawn at a health care provider’s office or a commercial facility and sending the sample to a lab for analysis. A health care provider may order a blood test to estimate how much blood the kidneys filter each minute, called the estimated glomerular filtration rate (eGFR). The results of the test indicate the following:

- eGFR of 60 or above is in the normal range
- eGFR below 60 may indicate kidney damage
- eGFR of 15 or below may indicate kidney failure

2-5-3 Imaging modalities for renal disease

The four basic examinations of the kidney are the: intravenous urogram (IVU); Computed tomography (CT); nuclear medicine (NM) or radionuclide studies and sonography.

2-5-3-1 Intravenous Urography (Intravenous Pyelography or Excretory Urography)

IVU is the radiographic examination of the kidneys, ureters and bladder after I.V. administration of a contrast medium. The IVU is only effective if the kidney are able to concentrate and excrete the contrast medium. The IVU provides both functional and anatomic information and it has the advantage of demonstrating the entire urinary tract on just a few films and it is considered an ideal method of demonstrating calculi. The major limitation of the IVU is its reliance on renal function.

2-5-3-2 Nuclear Medicine
Nuclear medicine studies of the kidneys involve administration of an I.V. radionuclide which is filtered through the kidneys at a specific rate and concentration. A series of films document the effectiveness of renal perfusion and function. The disadvantages of nuclear medicine studies are they rely on function and demonstrate only gross anatomy. (69)

2-5-4 Ultrasound
Sonography is frequently called upon to rule out hydronephrosis in patients with renal failure since ultrasound is supreme in showing fluid filled structures. It also provides information regarding retroperitoneal masses or fluid collections that may be causing the urinary problems. Sonography does not require renal function in order to be effective.

Sonography is used primarily for anatomy; the IVU and CT for anatomy and function and NM for function. (14)

2-6 Sonographic Technique for renal ultrasound:
2-6-1 Preparation

1. The patient should fast a minimum of 6 hours before the examination to limit bowel gas.
2. Position of the patient. Start with the patient lying on her \ his back (supine). Cover the right upper abdomen liberally with coupling agent. Same the left side.
3. Choice of transducer. For adults, use 4.5 MHz transducer. For children and thin adults, use 5.0 MHz transducer.
4. Setting the correct gain. Start by placing the transducer over the right upper abdomen. Angle the beam as necessary and adjust the gain to obtain the best image of the renal parenchyma.  

2-6-2 Scanning technique

The right kidney can be seen best with the patient supine, using the liver as acoustic window. Scanning is always done in deep suspending inspiration: ask the patient to take a deep breath and hold the breath in. Do not forget to tell the patient to relax and breathe normally again. Start with longitudinal scan over the right upper abdomen and then follow with a transverse scan. Next, rotate the patient to the left lateral decubitus position, to visualize the right kidney in this coronal view.

To visualize the left kidney, apply coupling agent to the left upper abdomen. Scan the left kidney in a similar sequence. If the left kidney cannot be seen (usually because of bowel gas), try the right decubitus position (lying on the right side).

Bowel gas can also be displaced if the patient drinks 3 or 4 glasses of water. The left kidney can then be visualized through the fluid-filled stomach with the patient in the supine position. If the kidneys have not been imaged adequately, scan through the lower intercostal spaces. Turn the patient prone and apply coupling agent to the left and right renal area. Perform longitudinal and transverse scans over both renal areas.
Both kidneys can also be examined with the patient sitting or standing erect. When examining any part of the renal area, compare both kidneys in different projections. Variations in size, contour and internal echogenicity may indicate an abnormality. (15)

2-7 General structure of the kidneys and its sonographic appearance in adult

The kidney is an ellipsoid structure when demonstrated in its long axis. The capsule is an echogenic white boundary separating the kidney from adjacent structures anteriorly and the musculature posteriorly.

Perirenal fat is highly echogenic. The renal cortex is homogeneous, fine textured and poorly echogenic. The cortex is equal to, or less echogenic than the normal liver. (15)

The renal columns (septal cortex or columns of Bertin) are the projections of cortex that extend between the pyramids. The columns are sonographically identical to the peripheral cortex.

The medulla consists of pyramids which are anechoic structures with their bases adjacent to the renal cortex and their apices directed towards the renal sinus.

The renal sinus is the most echogenic portion of the adult kidney. This echogenic area is called the central echo complex. In the nonhydrated state the renal pelvis is collapsed.
Figure (2-3): Normal kidney. A, Sagittal, and B, transverse, sonograms of normal anatomy with corticomedullary differentiation show relatively hypoechoic medullary pyramids, with cortex slightly less echogenic than the liver and spleen.\(^{(2)}\)
2-8 Previous studies


The study done on 672 patients have renal disease. Important results are: the Kidney size correlated closely with body size. Systolic blood pressure was correlated inversely with kidney length and kidney volume, after adjusting for age, sex.\(^{(16)}\)

2-8-2 Emamian SA, Nielsen MB, Pedersen JF, Ytte L. Kidney dimensions at sonography correlation with age, sex, and habitus. Denmark. 1993.

The study done on 665 adult volunteers. The results are: The most exact measurement of renal size is renal volume, which showed the strongest correlation with height, weight, and total body area. Clinically, measurement of renal length is most practical and can be done with the subject prone or supine.\(^{(20)}\)


The study done on 50 patients with volume overload. diabetes mellitus, myeloma, amyloidosis, or polycystic renal disease were all excluded. Important results: In hypertensive patients, right and left relative and absolute renal lengths and left renal volume were found to be significantly less than in normotensive patients. Within the hypertensive group, no significant differences were found in the parameters. There was no relationship between age, sex, height, weight, body mass index, creatinine, creatinine clearance, sodium, calcium levels, renal shape and hypertension.\(^{(21)}\)

The study done on 150 patients (75 males, 75 females) with essential hypertension and normal renal status. Results: Renal volume is higher in the left than the right kidney in hypertensive patients of both sexes and female hypertensive patients have smaller kidney size compared to males. The study also shows that volume of both kidneys decreases with age and positive correlation between renal volume and BMI. However, there is no correlation between renal size and duration of hypertension.\(^{(23)}\)
Chapter three: Methodology

3-1 Study design

This study is descriptive cross-sectional hospital based study.

3-2 Area and duration of the Study

The study is conducted in the ultrasound department of Alsalmaby hospital-Khartoum in a period from November 2015 to February 2016.

3-3 Study population, sampling and sample size

Study population are hypertensive male and female attend sonographic examination for related and unrelated symptoms of kidney disease, these have been sampled by simple random sampling technique and simple size is 73, 34 male and 39 female that they have essential hypertension from (1-20 years) collected from November 2015 to February 2016.

3-4 Study variables:

The dependent variable in this study is the kidney size, shape and duration of essential hypertension, while the independent variable are age, weight, height

3-5 Inclusion criteria: Adult patients with essential hypertension from both genders.

3-6 Exclusion criteria: children and patients not hypertensive but had other pathological condition.

3-7 Methods of data collection:

Data was collected by the observation and the interview tools.
3-7-1 For interview, a structured interview via a questionnaire is used to gather data from respondents.

3-7-2 For observation there was a check list for patient weight and height and a transabdominal sonographic technique is utilized for kidney volume measurement in both sagittal and transverse planes using three orthogonal dimensions.

**Patient preparation:**

The ability to visualize kidney by ultrasound depends on the patient’s body habitus and scanner platform. The patient should fast a minimum of 6 hours before the examination to limit bowel gas.

**Patient positioning:**

The kidneys had assessed in the transverse and coronal plane. Optimal patient positioning varies; supine and lateral decubitus positions often suffice, although Oblique and occasionally prone positioning may be necessary (e.g., obese patients).

**Equipment used:**

Siemens: made in Italy for Siemens Medical solutions 2005 probe frequency is 2-5 MHz

Toshiba: made by Toshiba Medical System Corporation in Japan 2004 probe frequency is 3.5-5 MHz
**Technical approaches:**

A combination of subcostal and intercostal approaches is required to evaluate the kidneys fully; the upper pole of the left kidney may be particularly difficult to image without a combination of approaches.

In this study TAT technique is used. Coupling gel is applied between the skin and the probe to remove air from these interfaces to ensure proper assessment and accurate measurement of the kidney. Curved abdominal probe (3.5-5 MHz), placed on right upper abdomen longitudinal and the entire kidney assessed in its long axis (from upper to lower pole), then a probe rotated 90 degree in to transverse plane. There are three measurements for each kidney; Length: Obtained from the sagittal image, measuring the largest craniocaudal length. Anterio-posterior dimension: Measured from the sagittal image measured perpendicular to the long axis. Width: Measured from a transvers image taken from the lateral margin of the kidney through the renal hilum. Finally calculated the volume of the kidney by multiply these three dimensions with each other and with 0.523.

**3-8 Data analysis:**

The data was entered a computer and analyzed by using statistic package for social sciences (SPSS). After reviewed and cleaned then the analyzed data is presented in tables and figures.
3-9 Ethical consideration:

Verbal consent was taken from respondents that the result of examination will form part of research project. No patient identification or individual patient detail will be published, and all specific information relating to patient’s identities will be protected in the same way.

The examination is performed in private room and measures for patients safety was been taken into consideration.
Chapter four: The results

Table (4-1): Distribution of study population according the gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>37</td>
</tr>
<tr>
<td>Female</td>
<td>39</td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
</tr>
</tbody>
</table>

Table (4-2): Distribution of study population according the age

<table>
<thead>
<tr>
<th>Age</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>31-40</td>
<td>30</td>
</tr>
<tr>
<td>41-50</td>
<td>20</td>
</tr>
<tr>
<td>51-60</td>
<td>15</td>
</tr>
<tr>
<td>&gt;60</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
</tr>
</tbody>
</table>
### Table (4-3): Age and somatic parameters distribution patterns in hypertensive patients

<table>
<thead>
<tr>
<th>Age(years)</th>
<th>Gender</th>
<th>BMI(Kg/m²) Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>31-40</td>
<td>M</td>
<td>26.7 _ 34.4</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>26.9 _ 31.6</td>
</tr>
<tr>
<td>41-50</td>
<td>M</td>
<td>22.9 _ 30.8</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>21.4 _ 32.8</td>
</tr>
<tr>
<td>51-60</td>
<td>M</td>
<td>21.4 _ 34.1</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>21.4 _ 32.8</td>
</tr>
<tr>
<td>&gt;60</td>
<td>M</td>
<td>21.3 _ 22.05</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>18.9 _ 27.4</td>
</tr>
</tbody>
</table>

### Table (4-4): Duration of hypertension with gender

<table>
<thead>
<tr>
<th>Duration of Hypertension (years)</th>
<th>Female</th>
<th>Male</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>15</td>
<td>11</td>
<td>26 (35.3%)</td>
</tr>
<tr>
<td>5-10</td>
<td>16</td>
<td>16</td>
<td>32 (44.7%)</td>
</tr>
<tr>
<td>&gt;10</td>
<td>8</td>
<td>7</td>
<td>15 (20%)</td>
</tr>
</tbody>
</table>
Table (4-5): Comparison between Right and Left renal volume in male and female hypertensive patients according to the Duration of Hypertension

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Gender</th>
<th>Range RT kidney Volume (cm³)</th>
<th>Range LT kidney Volume (cm³)</th>
<th>Range Duration of hypertension (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>31-40</td>
<td>M</td>
<td>101.04 _ 142.28</td>
<td>133.15 _ 193.41</td>
<td>1_13</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>87.16 _ 110.80</td>
<td>143.14 _ 187.82</td>
<td></td>
</tr>
<tr>
<td>41-50</td>
<td>M</td>
<td>103.89 _ 161.43</td>
<td>128.08 _ 198.74</td>
<td>4_20</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>76.24 _ 159.96</td>
<td>98.66 _ 205.75</td>
<td></td>
</tr>
<tr>
<td>51-60</td>
<td>M</td>
<td>101.65 _ 144.19</td>
<td>120.45 _ 180.36</td>
<td>9_18</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>82.26 _ 106.28</td>
<td>85.14 _ 163.98</td>
<td></td>
</tr>
<tr>
<td>&gt;60</td>
<td>M</td>
<td>134.21 _ 160.27</td>
<td>160.07 _ 176.62</td>
<td>14_20</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>57.71 _ 129.25</td>
<td>103.24 _ 155.51</td>
<td></td>
</tr>
</tbody>
</table>
Fig. (4-1): Distribution of study population according the age
Fig. (4-2): Scatter plot showing decrease in body mass index (BMI) as age increase in hypertensive patients.
1. Female

2. Male

Fig. (4-3): scatter plot showing renal volume is higher in female than male and renal volume is higher in left kidney than the right kidney.
Fig. (4-4): Scatter Plot Showing Decrease in Renal volume as Age Increases in Hypertensive Patient.
Fig. (4-5): scatter plot showing increase renal volume as BMI increases in hypertensive patients.
Chapter five: The discussion of the results

5-1 Discussion

This study was conducted among 73 patients had essential hypertension (34 males and 39 females) were examined. The age range was 32-68 years, with a mean of 50 years. Among the hypertensive patients, 11 (15.1%) were above 60 years of age while there were 30 (41.1%) between 41-50 years, and 20 (27.4%) at the age range 51-60 years and 12 (16.4%) at the range 31-40 years.

The importance of accurate measurement of renal size cannot be overemphasised because recent studies have suggested that the size of the allograft, or the ratio of the kidney weight to the donor body weight, have a direct positive relationship to graft survival.\(^{(18,19)}\)

This study set out to determine renal morphology represented in size and shape of the kidney in patients with essential hypertension using ultrasound, which is a volume (length x width x APx0.523) is better approximation of renal size than length measurement because the shape of the kidney varies considerably. This study corroborates the work done by Singh GR, Wendy EH in Australia, and Nielsen MB, Pedersen JF and Ytte L in Denmark in normal subjects without hypertension. Their studies found that the left kidney is larger than the right kidney, and that kidneys are larger in males than in females in hypertensive patients. The mean renal size we observed were slightly different from those reported in other studies, possibly due to differences among ethnic groups.\(^{(16,20,21)}\)

There is considerable reduction in renal size as age advances hypertensive patients. This is corroborated by other studies. The explanation for this is that the
number of nephrons per normal kidney, which varies between 400,000 and 1,000,000 nephrons per kidney, diminishes with advancing age.\(^{(17,21)}\)

The largest mean renal volumes for right and left kidney were recorded in age groups (31–40) and (41–50) years in the male and female hypertensive patients respectively, while the least mean renal volumes for right and left kidney were recorded in the age group older than 60 years in both gender. There was a significant negative correlation between age and renal size with linear relationship fitted in equations:
\[ y = 1.58 - 0.5x \]
such correlation is significant as \( R^2 = 0.042 \), so that age increases the renal volume decreases in both genders.

In patients with essential hypertension, the range of renal volume obtained was 85.14 –205.75 cm\(^3\), with a mean of 145.42 cm\(^3\) for the left kidney and 57.71 – 159.96 cm\(^3\) with a mean of 117.88 cm\(^3\) for the right kidney. The mean volumes of the right and left kidneys in males (131.235 cm\(^3\) and 159. cm\(^3\), respectively), were significantly higher than in females (108.88 cm\(^3\) and 145.44 cm\(^3\), respectively).

Reasons have been postulated for the bigger size of left kidney; one possible explanation is that because the spleen is smaller than the liver, the left kidney has more space for growth. Another explanation is that because the left renal artery is shorter and straighter than the right one, increased blood flow in the left artery may result in relatively larger size. Also study shows that males’ kidney is bigger than females’ kidneys.\(^{(21)}\)

Renal volume as already proven is the most precise measurement of renal size and tends to show the highest correlation with height, weight and BMI. The results are in accordance with this statement because we observed significant correlation between renal volume and BMI (weight/height\(^2\)) as reported in other studies.\(^{(21)}\)
The distribution of body mass index (BMI) with mean renal volume in the hypertensive patients showed that the smallest mean renal volume was in the underweight group (BMI ≤ 20), while the maximum was in the overweight group (BMI = 25–34).

The mean BMI in male patients (27.65 ± 5.49 kg/m²) was significantly higher than in female patients (24.72 ± 4.82 kg/m²).

Renal volume correlated significantly with BMI in hypertensive patients ($R^2=0.400$). If the Kidneys size increases following the BMI increment among hypertensive patients in a form of linear relationship fitted in equations:

$$y = 1.24 + 0.35x.$$ 

On other hand, this study showed negative significant correlation between age and BMI in hypertensive patient ($R^2 = 0.324$) in a form of linear relationship fitted in equations: $y = 8.55 + -1.33x$. There was recorded the least BMI (18.9-22.05 kg/m²) with a mean of 20.29 kg/m² in the patients above 60 years. And the biggest BMI (26.7-34.4 kg/m²) with a mean of 30.55 kg/m² at the age range 31-40 years. This is corroborated to study done by Adedeji A. Egberongbe and Victor A. Adetiloye in south western Nigeria. They found that Body Mass Index increased with age in hypertensive patients.\(^{(23)}\)

The duration of hypertension in this patients was calculated from the time hypertension was first diagnosed in the hospital in a patient. It is very difficult to determine the actual duration because of the insidious on-set of the disease, which means that it can go undetected for a long time.

The duration of hypertension in this study ranged between one year and 20 years with a mean of 10 years. Less than half of the patients (32; 44.7%) the duration more than five years, 26 (35.3%) 1–5 years, and 15 (20%) more than 10 years.
There was no significant statistical correlation between renal shape and size and duration of hypertension, though most patients (32; 44.7%) were in the groups that have been diagnosed for more than five years. This is disagree with study done in Turkey by Zümrütdal AO, Turan C, Cetin F and Adanali S. They showed that renal volume is smaller in hypertensive patients with chronic renal failure (CRF) when compared with non-hypertensive CRF patients, which suggests that renal volume decreases more in patients with CRF and hypertension than in CRF patients who are not hypertensive. This may imply that hypertension affects renal volume when there is a severe underlying renal parenchymal damage or compromise. None of the participants in this study had an underlying renal pathology, as indicated by their normal serum creatinine and creatinine clearance values.²²
5-2 Conclusion

As renal volume is the most precise measurement of renal size the study was assess the values of renal volume in patients with essential hypertension in our environment.

This study has shown that renal size decreases with age in hypertensive patients, and that renal size on the left is larger than on the right. Female hypertensive patients have smaller kidneys than males.

The renal volume shows significant positive correlation with body mass index (BMI). Also there is a negative correlation between BMI and patients age.

Moreover, no statistical significant correlation between renal size and shape with duration of hypertension.
5-3 Recommendation

- Application of universal guidelines in sonography strongly recommended.
- The necessary of periodic sonographic checkup for both kidneys and the blood pressure in hypertensive patients.
- Further long term studies are recommended covering large sample volume.
References


30. [PubMed]


Appendix 1:  

The National Ribat University
College of graduate studies
Data Collection Sheet

*Age  Gender  Weight  heigh  BMI  

*Comorbidities :………………………………………………

*Duration of HTN:  

*U/S findings:
  • Right Kidney:
    a) Volume
    Length  Wide  Thickness  
    b) Echogenicity
    Normal  Hypoechoic  Hyperechoic  
    c) CMD
    Normal  Poor  
  • Left Kidney:
    a) Volume
    Length  Wide  Thickness  
    b) Echogenicity
    Normal  Hypoechoic  Hyperechoic  
    c) CMD
    Normal  Poor  
Appendix: 2

Ultrasound images from the sample of the study:

Image (2-1): Sagittal sonograms of right and left kidney in female patient (33 years) with essential hypertension for 5 years.

Image (2-2): Sagittal sonograms of right and left kidney in male patient (41 years) with essential hypertension for 9 years.
Image (2-3): Sagittal sonograms of right and left kidney in male patient (38 years) with essential hypertension for 7 years.

Image (2-4): Sagittal sonograms of right and left kidney in female patient (53 years) with essential hypertension for 15 years.
Image (2-5): Sagittal sonograms of right and left kidney in male patient (60 years) with essential hypertension for 17 years.

Image (2-6): Sagittal sonograms of right and left kidney in female patient (49 years) with essential hypertension for 20 years.
Image (2-7): Sagittal sonograms of right and left kidney in female patient (51 years) with essential hypertension for 18 years.

Image (2-8): Sagittal sonograms of right and left kidney in male patient (46 years) with essential hypertension for 9 years.
Image (2-9): Sagittal sonograms of right and left kidney in male patient (38 years) with essential hypertension for 8 years.

Image (2-10): Sagittal sonograms of right and left kidney in male patient (63 years) with essential hypertension for 16 years.
Image (2-11): Sagittal sonograms of right and left kidney in female patient (56 years) with essential hypertension for 11 years.

Image (2-12): Sagittal sonograms of right and left kidney in female patient (37 years) with essential hypertension for one year.
Image (2-13): Sagittal sonograms of right and left kidney in male patient (40 years) with essential hypertension for 12 years.

Image (2-14): Sagittal sonograms of right and left kidney in female patient (58 years old) with essential hypertension for 18 years.