Sudan University of Science and Technology
College of Graduate Studies

Sonographic Measurement of Normal Kidney Volume in Adults

قياس حجم الكلية الطبيعي للبالغين بواسطة الموجات فوق الصوتية

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

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الآية

قال تعالى :-

{ فَوَجَدَا عَبْدًا مِّنْ عِبَادِنَا آتَيْنَاهُ رَحْمَةً مِنْ عِندِنَا وَعَلَّمْنَاهُ مِن لَّدُنَّا عِلْمًا }

صدق الله العظيم

سورة الكهف – الآية 65

Dedication

To my Family , Mother , Brothers, Sisters, husband and kids

Acknowledgment

Thanks for cod firstly and then I wish to express my gratitude to supervisor, Dr. Mona Ahmed Mohammad for her great helpful.

Also my thanks to Dr. Awadia Greeb Alla Suliman who help me in data analysis my thanks mast go to my colleagues in ultrasound departments whom help me to collect the data.

Abstract

This is cross sectional study was performed at Bahri teaching hospital in Al Khartoum state from (December 2018– April 2019).

The aim of the study was to measure the adults normal kidney volume and find the correlation between the volume and the age , sex and the body mass index

The study include 50 adult pts with normal renal status (25 of them males and 25 females) were evaluated by ultrasound.

The study exclude patients less than 18 years, pregnant woman, pts with chronic rend disease , congenital anomalies and patients with history of hypertension or diabetes mellitus used real time machine 3.5 Mhz to do longitudinal and transverse scanning to find the length-width and depth of the kidneys (kidneys measurements) then the volume.

The data collected by data sheet showed the variables of the study sex, age and body mass index and the kidneys volume.

Study found that kidneys volume is larger in males than females. With no significant difference. The mean volume of the right kidney is (105.87 ± 10.52 cm^3) and the mean of the left kidney volume 117.5 ± 11.64 cm^3. also there was a significant difference in both kidney volume in different age group and negative learner correlation between age and kidneys volume according to the formula $y = -0.451x+122.8$ for the right kidney and $y =-0.482x + 135.7$ for the left kidney . y: the kidney volume, x: the patient age.

The study found there are positive relation between the kidney volume and the body mass index with linear relationship between them according to the formula $y =1.927x + 55.95$ for right kidney and $y = 1.88x + 68.61$ for the left kidney y: the kidney volume, x: the body mass index.

The study recommended further study with increase number of data for more accurate results. And further study measure the normal volume of other organ's and correlate them with this study variables Assessment of the kidneys volumes should be a routine evaluation of Abdominal ultrasound investigation

المستخلص

هذه دراسة مقطعية عرضية أجريت بمستشفى بحري التعليمي في الفترة ما بين ديسمبر 2018م إلى أبريل 2019م.

الهدف من هذه الدراسة قياس حجم الكلية الطبيعي عند البالغين وإيجاد العلاقة بين حجم الكلية وكل من عمر المريض وجنسه وكتلة الجسم باستخدام الموجات فوق الصوتية .

وأجريت هذه الدراسة على عدد 50 مريض (25 من الذكور و 25 إناث).

استبعدت الدراسة كل من المرضي الذين تقل أعمارهم عن الـــ 18 عام والنساء الحوامل، المرضى الذين يعانون من أمراض الكلي المزمنة ، وأصحاب العيوب الخلقية بالكلي والمرضى الذين يعانون من مرض ضغط الدم العالي أو مرضى السكر.

وقد استخدمت أجهزة موجات فوق الصوتية 3.5 ميغاهيرز، لعمل المسح الطولي والعرضي لإيجاد طول وعرض وسمك الكلية ومن ثم حساب حجمها .

جمعت البيانات باستخدام استمارة ضمنت جميع متغيرات الدراسة (الجنس، والعمر، وكتلة الجسم، وجميع قياسات الكلية) .

وتم تحليل البيانات باستخدام برنامج التحليل الإحصائي الحزم الإحصائية للعلوم الإنسانية، وجدت الدراسة أن حجم الكلي عند الذكور أكبر من حجمها عند الإناث. حيث كان متوسط حجم الكلية اليمنى 105,87 ± 10,52 سم2 ومتوسط حجم الكلية اليسرى 117,5 ± 11,64سم2 كما أظهرت الدراسة أن هناك اختلاف واضح في حجم الكلية في الفئات العمرية المختلفة مع وجود علاقة خطية عكسية بين العمر وحجم الكلية بناءاً على المعادلة $y=-0.451x + 122.8$ للكلية اليمنى و $y=0.482x+135.7$ للكلية اليسرى حيث يمثل المتغير yحجم الكلية والمتغير x لعمر المريض.كما أوضحت أن هنالك علاقة ايجابية بين حجم الكلية وكتلة الجسم والعلاقة الخطية بينهما وفق المعادلة $y=1.927x + 55.95$ للكلية اليمنى و$y=1.880x +68.61$ حيث يمثل المتغير y حجم الكلية والمتغير x يرمز لكتلة الجسم.

أوصت الدراسة بزيادة عدد الحالات في الدراسات السابقة القادمة للحصول على نتائج أدق كما أوصت بإجراء دراسات مستقبلية توضح الحجم الطبيعي في بعض الأعضاء الأخرى ومقارنتها بمتغيرات هذه الدراسة وأيضاً أوصت بأن يكون قياس حجم الكلية تقييما روتينيا في فحص البطن بالموجات فوق الصوتية.

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Abbreviation

ADPRP	Autosmal Dominant Polycystic Renal Disease
AML	Angiomyolipoma
ARF	Acute Renal Failure
ARPRD	Autosmal Recessive Polycystic Renal Disease
CRF	Chronic Renal Failure
Fov	Field of View
L 1	Iumbar one
LKD	Left kidney depth
LKV	Left kidney volume
LKW	left kidney width
LRL	left kidney length
MBI	Body mass index
MCD	Multicystic dysplastic kidney
Pt	patient
RCC	Renal Cell Carcinoma
RKD	Right kidney depth
RKL	Right Kidney length
RKV	Right kidney volume
RKW	Right kidney width
Rtn	Acute tubular Necrosis
Spss	Statistical package For social science
T 12	Thorathic vertebrea 12
Tcc	Transitional cell carcinoma
U/s	Ultra Sound

Chapter One

Introduction

Chapter One

Introduction

1-1 Introduction:

Renal length and volume are important indicator of the presence or progression of disease. They are also important clinical parameters in the evaluation and follow up of kidney transplant recipients, patients with hypertension and renal insufficiency related to renal artery stenosis, patient with recurrent urinary infection and younger patient with vesicoureteric reflux. Because therapeutic decisions frequently are based on the result of these dimensions, accurate and reproducible methods for assessing renal length and volume are of increasing importance. In additions, an understanding of reference values of normal renal metrics is critical to assess alteration from these values (Nicholson,2000). A number of imaging methods are used for calculating the renal volume. Tomographic imaging method, such as x-ray computed tomography (CT) and magnetic resonance imaging (MRI) can acquire three dimensional data to estimate the volume of kidney. In the case of (CT) acquiring true tomographic data a long any orientation, without the constraints of ionizing radiation and nophrotoxic contrast burden. Although MRI has those previous benefits it is expensive and not available. Ultrasound is not invasive, simple and reliable method used to measure the volume of kidney in two dimension. (Mario M,2002)

The renal ultrasound is safe painless examination that use sound waves to make image of the kidneys ,during examination an ultrasound machine send sound waves into the kidney area and the images are record on a computer, the degree of blackness to the white in the image show the internal structure of the kidneys and related organs. the Kidneys measurement is one of the renal sonography indications

Unilatral or bilateral changes in kidney size are manifested by many renal diseases ,to these changes it is important to have standerd sonographic measurements. the aim of this study to determine the normal range values for renal volume in asymptomatic adult population and correlate it with age, sex and body mass index.

1.2 problem of the study

The renal diseases affected the kidney measurements and cause change lead to renal failure.

1.3 Objectives:-

1.3.1 General objective

The main of objective of this study to measure the normal kidney volume in adult patients using ultrasonogarphy.

1.3.2 Specific objectives

- To measure the renal length, width and anteroposterior diameters to calculate the volume.
- To find the correlation of the volume with age ,gender and BMI

1.4 Over view of the study

This study consisted five chapters. Chapters one is deal with introduction, problems of study, objective of the study, chapter two is literature review this include (anatomy, physiology, pathology of the kidney, normal son graphic features of kidney and pervious study , chapter Three is a material and methods. Chapter four is result and data analysis, chapter five is discussion, conclusion and recommendation.

Chapter Two

Theoretical Background and Previous Studies

CHAPTER TWO

Theoretical Background and Previous Studies

2.1 Anatomy:

The kidneys are retroperitoneal structures of the abdomen, having migrated upward from the pelvis during development. They are maintained in their normal position by intra-abdominal pressure and by their connections with the perirenal fat and renal fascia. (JACK T. STERN, et.al 1997).

2.1.1 Location of the kidney:

The kidneys have a bean-shaped structure; they are located in the retroperitoneum, one on each side of the spinal column. Ribs extend forward and downward over the kidneys, covering the upper third of each organ. The longitudinal axes of the kidneys converge toward the spinal column at an acute angle when viewed from behind and from the side. Their transverse axes form an approximately 45° angle with the sagittal plane.

The right kidney lies posteriorly in an angle between the spinal column, musculature, and right lobe of the liver. The right hepatic lobe extends laterally to the lower third of the kidney. The kidney is covered anteriorly by the right lobe, and its lower half in particular is covered by the right colic flexure and duodenum. (Berthold Block, 2011).

The left kidney lies posteriorly in an angle between the spinal column, musculature, and spleen. The spleen extends laterally to about the middle of the left kidney. The lower half of the kidney is covered by the descending colon and left flexure. The left flexure passes around the anterior surface of the kidney and is in contact with it. The stomach overlies the front of the upper pole. The left kidney usually lies 1 to 2 cm higher than the right kidney. 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 12th thoracic vertebra, and the inferior pole is at the level of the third lumbar vertebra. The kidneys move readily with respiration; on deep inspiration, both kidneys move downward approximately 1 inch. In the adult, each kidney measures approximately 9 to 12 cm long, 5 cm wide and 2.5 cm thick and weights 120 to 170 germ (Rumack. caroletal) .

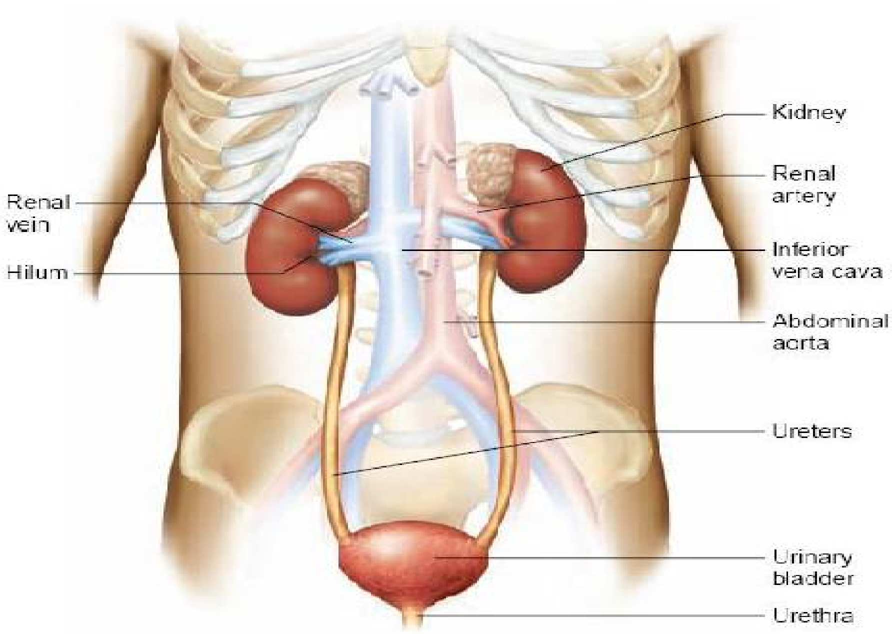


Figure (2.1) Organs of the urinary system.(Kathryn A et al.,2008)

2.1.2 Kidney structure:-

Internal structure of the kidney in a coronal or frontal section of the kidney, three areas can be the lateral and middle areas are tissue layers, and the medial area atthehilus is a cavity. The outer tissue layer is called the renal cortex. The outer cortex of the kidney is darker than the inner medulla because of the increased perfusion of blood it is made of renal corpuscles and convoluted tubules. These are parts of the nephron.

The inner tissue layer is the renal medulla, which is made of loops of Henle and collecting tubules (also parts of the nephron). The renal medulla consists of wedge-shaped pieces called renal pyramids. The tip of each pyramid is its apex or papilla. The third area is the renal pelvis; this is not a layer of tissues, but rather a cavity formed by the expansion of the ureter within the kidney at the hilus. Funnel shaped extensions of the renal pelvis, called calyces (singular: calyx), enclose the papillae of the renal pyramids. Urine flows from the renal pyramids into the calyces, then to the renal pelvis and out into the ureter.

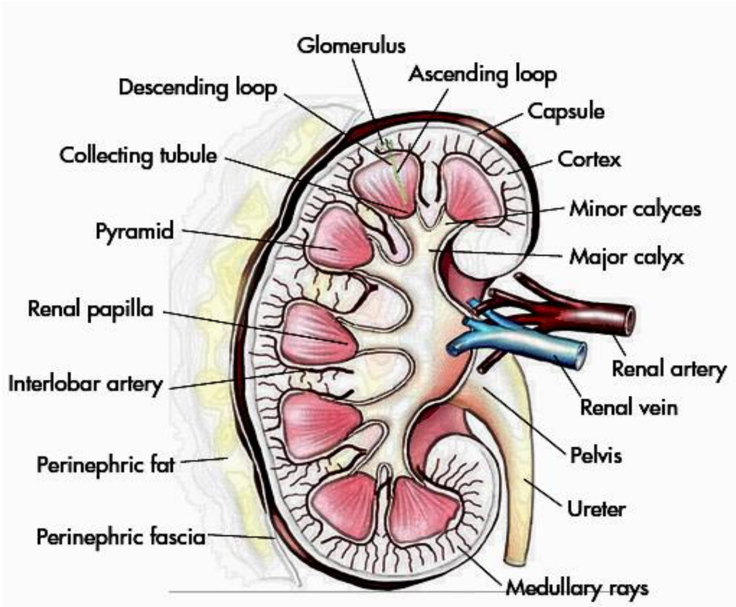


Figure (2.2) Coronal section of thekidney show internal structures. (Kathryn A et al.,2008)

The nephron of the kidney is made up of two major parts; the renal capusle and the tubules. These are then both sub-divided into various parts which allow the kidney to filter the blood and then alter the composition of this filtrate to ensure that waste products are excreted and useful compounds preserved. Renal capuscle can be subdivided into the glomerulus and the Bowman’s capsule. The tubules are split into the proximal tubule, the loop of Henley, the distal tubule and the collecting ducts. waste products are excreted and useful compounds preserved.

2.1.3 Blood supply:

Blood reaches the kidneys through the renal arteries, which are short and come directly from the abdominal aorta. It divided into several inter-lobar arteries and give rise to the actuatearteries, which cross the border between the cortex and the medulla of the kidney. From the arcuate arteries maney branches radiate into the renal cortex, the inter lober arteries, the afferent arterioles arise at right angle from the interlobular arteries and end in the glomeruli. (M.Y.sukar, et al 2000)

2.1.4 Relationships with Other structures:-

Anterior to the right kidney are the right adrenal gland, liver, Morison's pouch, second part of the duodenum, and right colic flexure. Anterior to the left kidney are the left adrenal gland, spleen, stomach, pancreas, left colic flexure, and coils of jejunum. Posterior to the right kidney are the diaphragm, costodiaphragmatic recess of the pleura, twelfth rib, psoas muscle, quadrates lumborum, and transverses abdominis muscles. The subcostal (T12), iliohypogastric, and ilioinguinal (L1) nerves run downward and laterally. Posterior to the left kidney are the diaphragm, costodiaphragmatic recess of the pleura, eleventh and twelve ribs, psoas muscle, quadrates lumborum, and transverses abdominis muscles. The same nerves are seen near the left kidney. (Sandral.ET.2012)

2.2 kidney physiology:

2.2.1 Glomerular filtration:

The glomerular capillaries have large pores in their walls, and the layers of Bowman's capsule in contact with the glomerulus have filtrations slits. Water together with dissolved solutes (except proteins), can thus pass from the blood plasma to the inside of the capsule and the nephron tubules. The volume of this filtrate produced by both kidneys per minute is called the glomerular filtration rate (GFR). The (GFR) averages 115mil per minute in women and 125 mil per minute in men. This is equivalent to 180 liter per day (about 45 gallons). Most of the filtrate water must obviously be returned immediately to the vascular system (Born,2005) .

2.2.2 Regulation of GFR:

Vasoconstriction or dilation of afferent arterioles affects the rate of blood flow to the glomerulus, and thus affects the GFR. Changes in the diameter of afferent arteriole result from both extrinsic regulatory mechanism produced by sympathetic nervous innervation and intrinsic

regulatory mechanism produced by the kidneys. The later is called renal auto regulations mechanism (ElaineN,2003) .

2.2.3 Renal auto regulations:

Is the ability of the kidney to maintain a relatively constant (GFR) in the face of fluctuating blood pressures. This is achieved through the effect of locally produced chemicals on the afferent arterioles. When systemic arterial pressure falls towards a mean of 70mm/11g, the afferent arterioles dilate, and when the pressure rises, the efferent arterioles constrict. Blood flow to the glomeruli and GFR can thus remain relatively constant within the auto regulatory range of blood pressure values (Stauart,2006) .

2.2.4 Juxtaglomerular apparatus:

The Juxtaglomerular apparatus is the region in each nephron when the afferent arteriole comes into contact with the last portion of the thick ascending limb of the loop. Under the microscope, the afferent arteriole and tube in this small region have a different appearance than in the other region. The cells in this region secrete the enzyme rennin into the blood. This enzyme catalyzes the conventions of angiotensinogen (a protein) into angiotensin I. Angiotensin I will be converted to angiotensin II by angiotensin converting enzyme (ACE). This convention occurs as the blood passes through the capillaries of the lung (Richart.S.Snell, 2004).

2. 2.5 Regulation of blood pressure by the kidneys:

The regulation of the blood by kidneys is done by a system called rennin-angiotensin aldesterone system. When the blood flow is reduced in the renal artery, juxtaglomerular apparatus start to secrete the enzyme rennin into the blood. Condition of salt deprivation, low blood volume, and low pressure in summary cause increased production of angiotensin II in the blood. Angiotensin II exerts numerous effects that produce a rise in blood pressure. This rise in pressure is partly due to vasoconstriction and partly to increase in blood volume. Vasoconstriction of arterioles and small muscular arteries is produced directly by the effect of angiotensin II on the small muscles of these vessels. The increased blood volume is an indirect effect of angiotensin II. Angiotensin II promotes a rise in blood volume by means of two ways or mechanism. The thirst centres in the hypothalamus are stimulated by angiotensin II, and thus more water is ingested, and secretion of aldesterone from the adrenal cortex, isstimulated by angiotensinII, and higher aldesterone secretions causes more salt and water to be retained by the kidneys, so blood volume will be increased.

The rennin angiotensin-aldesterone system can also work in the opposite direction: high salt intake, leading to high blood volume and pressure normally inhibits rennin secretion, with less angiotensin II formation and less aldesterone secretion, less salt is retained by the kidney and more is excreted in the urine. Unfortunately, many people with chronically high blood pressure may have normal or even elevated levels of rennin secretion (WilliamJ,2005).

2. 3 Renal Pathology and its songraphic apperance:-

2. 3.1 Glomerulonephritis:

Glomerulonephritis can be caused by a distant infection such as a throat infection or an autoimmune reaction. Some conditions, such as lupus, have glomerulonephritis as a characteristic feature. The infection can lead to significant glomerular damage and the kidneys can slowly shut down secondary to diminished filtration capabilities. Patients typically present with smoky urine, fever, proteinuria, hematuria, hypertension, and azotemia. Glomerulonephritis can be acute or chronic. In the acute stage, the kidney may enlarge and have varying degrees of echogenicity. The renal pyramids may appear more prominent with acute glomerulonephritis. Chronic glomerulonephritis, the result of a long-standing infection, can lead to end-stage renal disease.

Sonographically, chronic glomerulonephritis appears as a decrease in renal size and an increase in the cortical echogenicity.

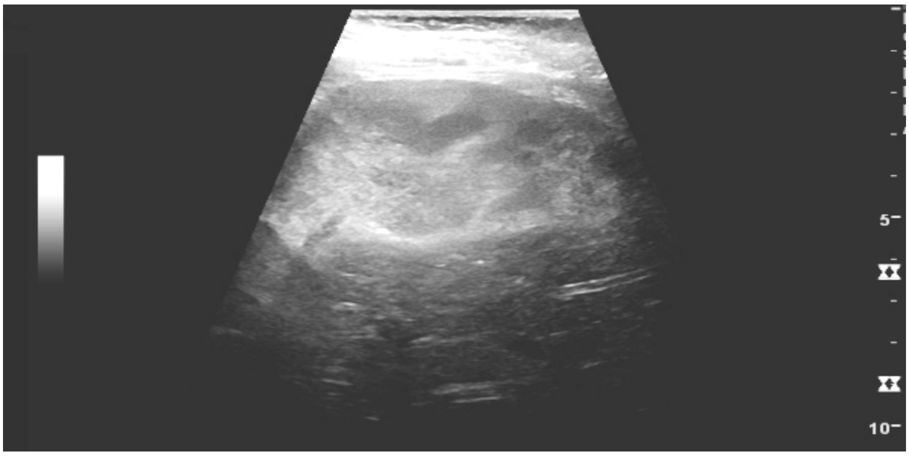


Figure (2.3). Acute pyelonephritis with increased cortical echogenicity and blurred delineation of the upper pole. (Osman, 2016).

2. 3.2 Tubular Necrosis:

Acute tubular necrosis (ATN) is the most common cause of acute reversible renal failure and is related to deposition of cellular debris within the renal collecting tubules. Both ischemic and toxic insults will cause tubular damage.

Initiating factors include hypotension, dehydration, drugs, heavy metals, and solvent exposure. (mosby etal, 2005)

The sonographic appearance of ATN depends on the underlying etiology. Hypotension-causing ATN will often produce no sonographic abnormality, whereas drugs, metals, and solvents will cause enlarged, echogenic kidneys. Prerenal disease and ATN account for 75% of all patien .

Figure (2.4). Postoperative renal failure with increased cortical echogenicity and kidney size. Biopsy showed acute tubular necrosis (Osman, 2016).

2.3.3 Diabetes Mellitus:

Diabetes mellitus is the most common cause of chronic renal failure. Diabetic nephropathy is believed to be related to glomerular hyperfiltration. Renal hypertrophy occurs. With time, diffuse intercapillary glomerulosclerosis develops, causing a progressive decrease in renal size. At sonography, the kidneys are initially enlarged but, with time and progressive renal insufficiency, the kidneys decrease in size and increase in cortical echogenicity, and corticomedullary junctions are preserved. With end-stage disease, the kidneys become smaller and more echogenic, and the medulla becomes as echogenic as the cortexts presenting with acute renal failure. (mosby etal, 2005)

2. 3.4 Renal Cystic Disease

2. 3.4.1 Simple Renal Cysts

These are true cysts that have a serous epithelial lining and are fluid filled, benign cortical masses.

Sonographic appearance: they meet all the ultrasound criteria of a simple cyst: they arespherical, anechoic, thin-walled and have accentuated posterior enhancement. These lesions range in size from a few millimeters to several centimeters. (mosby etal, 2005)

2. 3.4.2 Atypical Renal Cysts

An atypical renal cyst is any cyst that does not meet the strict criteria of a simple cyst. Many atypical cysts are simple cysts complicated by hemorrhage or infection. (Oneill, etal, 2005)

Sonographic appearances: complicated (i.e. atypical) cysts may have thick walls, contain septations and generate low levels of echogenicity from particulate matter associated with hemorrhage or infection. The echogenic cyst contents may be diffuse or show dependent layering. The cyst wall may be calcified and is considered a benign finding if all other US criteria for simple cyst are met.Thick walled circular lesions are associated with abscesses and cystic renal tumors, therefore, further investigation would be required. (Oneill, etal, 2005)

2. 3.4.3 Parapelvic Cysts

Parapelviccysts are cysts of the renal sinus. Most parapelvic cysts are asymptomatic.

Sonographic Appearances: parapelvic cysts may not appear anechoic due to beam width averaging. Acoustic enhancement may be difficult to demonstrate because of the highly reflective nature of the renal sinus in which they are located. (Oneill, etal, 2005)

2. 3.4.4 Acquired Uremic Cysts, Adenomas and Carcinomas

“Cysts and neoplasms have been identified with remarkable frequency in the end stage kidneys of chronic hemodialysis or peritoneal dialysis patients. Cysts generally do not become visible until the patient has completed 3 years of dialysis. Thereafter, they increase rapidly in number to a prevalence level approaching 100%.These cysts are prone to hemorrhage, rupture and the creation of perinephric hematomas.(Oneill, etal, 2005)

Sonographic Appearances: typical simple cysts appear within the cortex of an endstagekidney. The kidney may be difficult to visualize because end-stage kidneys are typically shrunken and highly echogenic blending with the echogenic perirenal fat.

2. 3.4.5 Multicystic Dysplastic Kidney

Multicystic dysplastic kidney disease (MCDK) is a congenital, nonhereditary, cystic renal disease. MCDK is typically unilateral, affecting a single kidney in its entirety, but may be bilateral or segmental.

Sonographic Appearances: characteristically, the kidney is large and filled withcysts of various sizes. The cysts do not communicate and appear benign.

2. 3.4.6 Autosomal Recessive Polycystic Renal Disease (ARPRD)

“Autosomal recessive polycystic kidney disease is an inherited disorder characterized by nephromegaly, microscopic or macroscopic cystic dilatation of the renal collecting tubules, and periportal hepatic fibrosis.

Sonographic Appearances: the kidneys are bilaterally and symmetrically enlarged. The parenchyma is highly echogenic due to multiple microscopic cystic interfaces. The dilated collecting ducts extend form the cortex through the medulla, so that the normal sharp distinction between echogenic renal cortex and anechoic pyramids is lost.

2. 3.4.7 Autosomal Dominant Polycystic Renal Disease (ADPRD)

This is an autosomal dominant disorder which often lies latent for many years and then manifests itself in the third, fourth, or fifth decades in what had appeared to benormal renal parenchyma. ADPRD consists of numerous cystic lesions in an enlarged kidney.

Sonographic Appearances: the early stages, the kidneys appear enlarged and contain more cysts than expected for the patient’s age. The cysts involve both the cortex and medulla.

2. 3.4.8 Medullary Cystic Disease

Medullary cystic disease is a hereditary disorder resulting in cysts located within the medullary portions of the kidney.

Sonographic Appearances: there are small echogenic kidneys with numerous small cysts in the central portion of the kidney or at the corticomedullary junction. The cysts range in size from 1 to 10 mm.

2. 3.5 Calyceal Diverticulum

This is an out pouching from the calyx. Stasis of urine may occur predisposing the patient to infection and stone formation. The diverticulum can project into the renal parenchyma.

2. 3.6 Hydronephrosis

Hydronephrosis refers to dilatation of the renal collecting system most frequently caused by incomplete or complete obstruction. Hydroureteris dilatation of the ureter also caused by complete or incomplete obstruction Sonographic. Technique. The role of ultrasound is to detect the presence or absence of hydronephrosis; estimate the amount of residual cortex present and to detect the presence of a pelvic mass or other etiology.

2. 3.7 Renal Calculus Disease

Urolithiasis is most prevalent in males aged 20-40 years.Calculi can form in any part of the urinary tract but most form in the kidneys. They may be clinically silent associated with flank pain. Hematuria (gross or microscopic) and renal colic are most often associated with ureteric calculi. Stones can occur within any part of the kidneys - the renal cortex, medulla, vessels, calyces or renal pelvis. Most calculi arise in the collecting system. Stone formation may be idiopathic or associated with stasis (stagnation) of urine, prolonged ingestion of stone forming substances, chronic urinary infections and climate conditions associated with dehydration. Stasis also predisposes the patient to infection. (Oneill, etal, 2005)

Sonographic appearance: ultrasound demonstrates calculi as highly echogenic structures regardless of chemical composition. Shadow detection posterior to the stone depends on stone size, transducer frequency, and transducer focal zone. Tiny calculi will not shadow if they are smaller than the focal zone.

2. 3.8 Neoplasms

2. 3.8.1 Angiomyolipoma (AML)

AML is a benign solid tumor containing variable amounts of blood vessels (angio), smooth muscle (myo) and fat (lipoma).

sonographic appearances depend upon the predominance of one of the three components. Typically, AMLs are extremely hyperechoic indicating the predominance of fat however, if muscle or vascular components predominate the lesion may be hypoechoic. Shadowing is demonstrated in 33% of AMLs.

2. 3.8.2 Oncocytoma

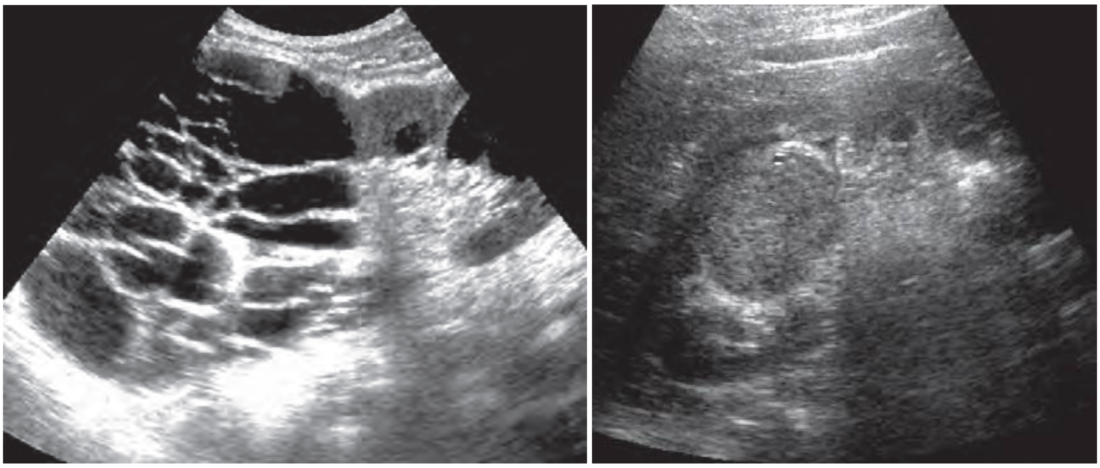
Oncocytoma is a benign solid renal tumor occurring most often in men in their 60's. It is usually asymptomatic and an incidental finding.

Sonographically, the tumor is solid, homogeneous and generates low levels of echogenicity. A stellate central hyperechoic scar is seen in about 25% of cases and then only in lesions greater than 3 cm.

2. 3.8.3 Renal Cell Carcinoma (RCC)

This is a primary tumor of the renal parenchyma thought to originate from the renal tubular epithelium. It is also called a hyper nephromaor a renal adenocarcinoma.

ultrasound appearances of a renal pelvic TCC are characteristically those of a solid, homogeneous, hypoechoic or isoechoic mass centrally located within the renal sinus.



(A) (B)

Figure (2.5). Renal Cell Carcinoma (RCC). (A) Large upper- pole systic mass show numerous thick internal septation. (B) Large central renal sinus mass with no associated caliectasis. (Rumakgcm, 2011)

2. 3.8.4 Renal Lymphoma

The kidney does not contain lymphoid tissue, therefore lymphomatous involvement of the kidney is metastatic in origin and occurs by hematogenous dissemination or direct extension of retroperitoneal disease.

Sonographic Appearances

i) Focal parenchymal involvement, which is most common (60%), consists of multiple, small (1-3 cm), bilateral, solid, homogeneous, hypoechoic tumors. It is rare for renal lymphomatous masses to be unilateral or to demonstrate calcification.

ii) Direct invasion (25-30%) into the renal sinus from retroperitoneal lymph node masses is typically nodular, hypoechoic and homogeneous. The mass may cause hydronephrosis. Typically, the large retroperitoneal adenopathy encircles the renal artery and vein, IVC and aorta. “The blood vessels remain patent despite encasement, a finding that is typical of lymphoma.

iii) A solitary homogeneous, hypovascular solid mass may be seen in 10-20% of renal lymphomas.1 They can become large - 15 cm in size and be indistinguishable sonographically from RCC.

iv) Diffuse infiltration globally enlarges the kidney with minimum or no alteration in the shape. Invasion of the renal sinus results in the loss of the echogenic central echo complex.

v) Perirenal involvement occurs when the disease invades the perirenal space and surrounds the kidney. The kidney may not be directly involved. Sonographic appearance: This appears as a hypoechoic mass or rind partially or completely surrounding the kidney. “This pattern of involvement is virtually pathognomonic of lymphoma, but is uncommon.”The appearances may be confused with hematoma in the perirenalspace.

2. 3.8.5 Leukemia

“Lymphoma and leukemia have a predilection for infiltration of the renal parenchyma and often cause focal or diffuse renal enlargement.“Acute lymphoblastic leukemia is the most common form to involve the kidney.

Sonographically, diffuse, bilateral renal enlargement is most common with loss of corticomedullary definition. The parenchyma may have increased or decreased echogenicity. There may be distortion of the central echo complex.

Discrete renal masses are uncommon but when they occur they resemble lymphoma. Renal, subcapsular or perinephric hemorrhage may be demonstrated, as these patients are prone to bleed.

2. 3.8.6 Nephroblastoma

A nephroblastoma is the most common renal tumor in children.It is seen most commonly in children between 2 to 3 years of age. a Wilm's tumers a rapidly growing malignant tumor of the kidneys, it is also known as, Wilm's embryonalcarcinoma

sonographicaly characteristically a large, intrarenal, solid mass with a well-defined margin or pseudocapsule of fibrous tissue and compressed renal parenchyma. The tumor may be homogeneous or heterogeneous,

2. 3.8.7Acute Renal Failure (ARF)

Renal failure is considered acute if it develops over days or weeks, and chronic if it spans months or years. Acute or chronic renal failure may result from insufficient renal perfusion (prerenal causes), intrinsic renal disease (renal causes), or obstructive uropathy (postrenalcauses). In the setting of ARF, the main purpose of the US study is to exclude hydronephrosis (Devin D,2005).

2. 3.8.8 Chronic Renal Failure (CRF):

Renal failure, also known as kidney failure or renal insufficiency, is amedical condition in which the kidneys fail to adequately filter waste products from the blood. The two main forms are acute kidney injury, which is often reversible with adequate treatment, and chronic kidney disease, which is often not reversible. In both cases, there is usually an underlying cause. (Devin D,2005).

Kidney failure is mainly determined by a decrease in glomerular filtration rate, which is the rate at which blood is filtered in the glomeruli of the kidney. The condition is detected by a decrease in or absence of urine production or determination of waste products (creatinine or urea) in the blood. Depending on the cause, hematuria (blood loss in the urine) and roteinuria (protein loss in the urine) may be noted. In kidney failure, there may be problems with increased fluid in the body (leading to swelling), increased acid levels, raised levels of potassium, decreased levels of calcium, increased levels of phosphate, and in later stages anemia. Bone health may also be affected. Long-term kidney problems are associated with an increased risk of cardiovascular disease. Kidney failure can be divided into two categories: acute kidney injury or chronic kidney disease. The type of renal failure is differentiated by the trend in the serum creatinine; other factors that may help differentiate acute kidney injury from chronic kidney disease include anemia and the kidney siz on sonography as chronic kidney disease generally leads to anemia and small kidney size. (Devin D,2005).

2. 4 Equipment and Physics:

Unlike x-rays, sound waves constitute a mechanical longitudinal wave, which can be described in terms of particle displacement or pressure changes. Some of the more important quantities that are described in ultrasound imaging consist of: frequency, propagation speed, pulsed ultrasound, interaction of ultrasound with tissue, angle of incidence, and attenuation. Many of the objects and artifacts seen in ultrasound images are due to the physical properties of ultrasonic beams, such as reflection, refraction, and attenuation. Indeed, physical artifacts are an important element in clinical diagnosis (Aldrich,2007).

2. 4.1 Ultrasound Transducers:-

A transducer is a device that converts one form of energy into another. For example. A loudspeaker converts electrical energy to sound energy, a microphone converts sound energy to electrical energy, and a thermocouple converts heat energy to electrical energy. These are three types of transducers. There is no specific term given to the transducer used in diagnostic ultrasound. Technically, the piezoelectric crystal is the transducing component. Ultrasound transducers are designed to convert electrical energy into mechanical energy (ultrasound) and also to convert the reflected ultrasound energy (echoes) into electrical signals. Transducers may be single-element or multi-element Elament is a synonym for crystal (these two words can be interchanged). Multi-element transducers are known as arrays and will be considered in detail in the section on real-time equipment. Historically, stand-alone A-mode and M-mode machines, as well as all static B-scanners, used a transducer that contained a single, disk-shaped piezoelectric crystal. As well, old mechanical real-time systems used a single piezoelectric crystal transducer. Today, modern transducers are electronic arrays that contain an arrangement of multiple small piezoelectric crystal elements. (Aldrich,2007).

Piezoelectric Effect:-

Piezoelectricity is the cornerstone of the diagnostic ultrasound process. All ultrasound transducers possess piezoelectric properties which permit them to generate and detect ultrasound waves. The piezoelectric effect is the formation of an electrical charge on the surfaces of the crystal when pressure (mechanical energy) is applied (Ballato, 1995). In pulse-echo imaging. This effect occurs when echoes return to the transducer and are converted into electrical signals. (Aldrich,2007).

2. 4.2 Ultrasound Interaction with Tissue:

A beam of ultrasound travels through material, various things happened to it. A reflection of the beam is called anechoic, a critical concept in all diagnostic imaging. The production and detection of echoes from the basis of the technique that it used in all diagnostic instruments. A reflection occurs at the boundary between two materials provided that a certain property of the materials provided that a certain property of the materials is different. this property is known as the acoustic impedance and is the product of density and propagation speed. If two materials have the same a caustic impedance, their boundary will not produce an echo. If the difference in acoustic impedance is small, a week echo will be produced, and most of the ultrasound will carry on through the second medium. If the difference acoustic impedance is large although a strong echo will be produced. If the difference in acoustic impedance is very large, all the ultrasound will be totally reflected {Aldrich.2007}.

2.4.3 Angle of Incidence:

If a beam of ultrasound strikes a boundary obliquely, however, then the interactions are more complex than for normal incidence. The echo will return from the boundary at an angle equal to the angle of incidence, as shown in. the transmitted beam will be deviated from a straight line by an amount that depends on the difference in the velocity of ultrasound at either side of the boundary. This process is known as refraction, and the amount of deviation is given by the relationship known as Snell’s law, which relates the angle of refraction to the speed of sound in that tissue (Aldrich, 2004).

2. 4.4 Attenuation:

The intensity of the ultrasound beam is further reduced by attenuation due to various processes such as reflection, refraction, scattering, and absorption. All these processes divert energy from the main beam. Reflection and refraction occur at surfaces that are large compared with the wavelength of the ultrasound. For objects that are small in comparison with the wavelength, energy is scattered in many directions, and the eventual fate of the ultrasound is to be absorbed as particle vibration and the production of heat. The amount of attenuation varies with the frequency eneral, have of ultrasound. A high-frequency beam will be attenuated more than a lower frequency. This means that if the examiner wants to penetrate and subsequently image deep into the body, (Aldrich, 2007).

2. 4.5 B-Mode imaging Controls

2. 4.5.1 Depth/F.O.V. Control

Varying the depth of the F.O.V. varies the write zoom and therefore the number of pixels per cm and spatial resolution potential of the system. It is important not to use excessively large F.O.V’s that redues spatial resolution achieveable but also not to “clip” the F.O.V. too tightly around the region of interest such that relationships with other structures are not show (Wikipedia, 2016) .

2. 4.5.2 Gain

Refers to the degree of amplification applied to all returning signals. If set too low there will be underwriting of the image and real echo will be lost from the display. If set too high there will be overwriting of the display with art factual noise introduced and also a reduction in contrast resolution as all echoes get progressively brighter (Aldrich, 2007).

2. 4.5.3 TGC

The T.G.C. control compensates for the effects of attenuation by progressively increasing the amount of amplification applied to signals with depth (time). The sonographer aims to produce an image of uniform brightness from top to bottom and this requires regular adjustment of this control during scanning. (Aldrich,2007).

2.4.5.4 Power or Output Control:

This controls the strength of the voltage spike applied to the crystal at pulse emission. Increasing power output increases the intensity of the beam and therefore the strength of echo retum to the transducer, i.e. increases signal to noise ratio (SNR). However it also increases the patients ultrasound dose. It is best practice to operate on minimum power and maximum gain, remembering though that no amount of gain can compensate for insufficient power. The obvious alternative to increasing power output if ‘dropout’ artifact is encountered at depth is to use a lower frequency transducer (Wikipedia, 2016).

2. 4.5.5 Dynamic Range:-

Refers to the range of echoes processed and displayed by the system, from strongest to weakest. The strongest echoes received are those from the ‘mainbang’ and transducer-skin interface and they will always be of similar strength. As DR is reduced therefore it is the echoes at the weaker end of the spectrum that will be lost. DR can be considered as a variable threshold of writing for weaker signals. For general imaging the DR should be kept at its maximum level to maximize contrast resolution potential. However in situations where low-level noise or artifacts degrads image quality the DR can be reduced to partially eliminate these appearances (Aldrich,2007).

2. 4.5.6 Focal Zones:-

Throughout the scan the sonographer should constantly check the position of the focal zone (s) and ensure they are at the depth of interest. Multiple focal zones can be used to maximize lateral resolution over depth if motion is not encountered, but it is important to minimize the focal zones used when assessing moving structures i.e. a fetal heart (Aldrich, 2007).

2. 4.5.7 Frequency:-

It is best to use the maximum frequency possible to image the region of interest, allowing for adequate penetration to this depth and thus avoiding ‘dropout’ artifact. There are several reasons for this, increasing frequency will; improve axial resolution, produce a better beam shape (longer near field) and increase the return from non-specular interfaces. Transducer frequencies common today are 5-15 MHz for superficial work and 2-7 MHz for deeper areas (Wikipedia,2016).

2.5 Normal Songraphic Appearances of Adult Kidneys:-

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 interiorly and the musculature posterior. Per renal fat is highly echogenic.

2.5.1 Cortex:

The renal cortex is homogeneous, fine textured and poorly echogenic. The cortex is equal to, or less echogenic than the normal liver .The renal columns (septal cortex or columns of Bertin) are the projections of cortex that extend between the pyramids. The columns are Sonographicaly identical to the peripheral cortex.

2.5.2 Medulla:

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

2.5.3 Sinus:

The renal sinus. The renal sinus is the most echogenic portion of the adult kidney.

The size of the kidneys is affected by age, sex (greater in men than in women), and body size. The left kidney is slightly larger than the right in most individuals. The normal renal length in females ranges from 9.5 to 12.1 cm and in males from 10.1 to 12.6 cm.2 Therefore, the normal adult kidney should measure 9-13 cm in length, 2.5 to 3.5 cm in thickness and 4 to 5 cm in width. These are good average measurements for exam purposes .Parenchymal thickness is 11-18 mm in the male and 11-16 mm in the female(Tublin et al., 2003).

The thickness of the renal parenchyma decreases at about 10% per decade after age 20 years. There is a loss of contrast between the cortex and pyramids as “the normal aging process increases cortical and pyramidal echogenicity, but the effect is more obvious in the pyramids, which gradually fade from view as their echogenicity increases. The overall size decreases gradually but is only apparent in the elderly(Hassan, 2016).

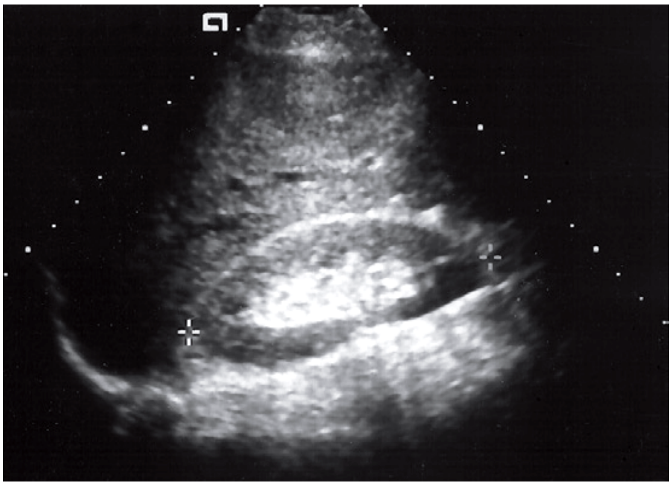


Figure (2.6) u/s Image Sagittal view of normal right kidney

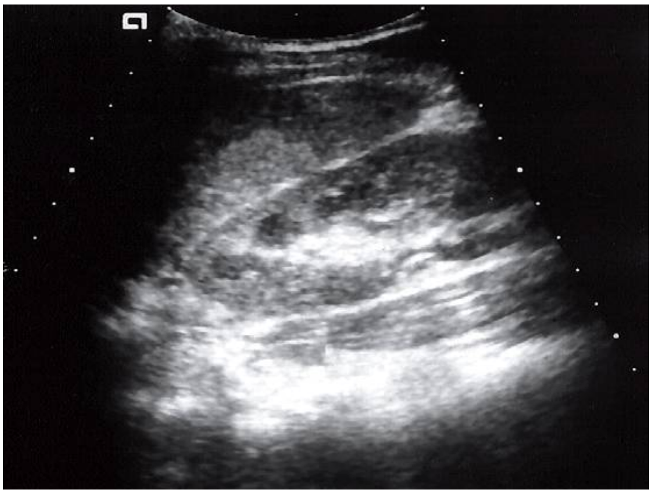


Figure (2.7) u/s Image Sagittal view of normal left kidney

2. 6 Renal volume:

Is estimated volume of kidney it will be calculated by formula; R v = L x w x d x 0.523 (RV :renal volume– l: length – W: width D: depth) .Or it calculated automatically by computer of the us machine .Cortical thickness: referred to distant between capsule and medullary pyramids .Cortical thickness is varies between individual kidneys, and tend to decrease by age .Parenchyma thickness (PT): defined as combined thickness of the cortex and medulla measured at the upper and lower poles and averaged it's from 11 - 18 mm in the male and 11- 16 in female. Medullary pyramid thickness: measurement of the dimension of the pyramids usually used for pediatrics (Devin Dean, 2005).

Ultrasonographic measurement of the length, width an depth of a kidney. Kidney volume is calculated using the ellipsoid formula as Length x Width x Depth x 0.523. (Leung et al., 2007)

2. 7 Previous studies:-

2.7.1Abdelrahman Mubarak [2015]:

Measurements of kidney volume in USE.

Mean renal volume in emarates population are found to be within the normal limits compared with the nearby countries, but it is less than in the reference value available in literature from American and the European population. Left kidney is significantly larger than the right and larger renal volume are seen bilaterally in males compare to females. A direct relationship between BMI and renal volume is seen in emarates population, a negative relation is seen between age and the kidneys volume.

2.7.2 Aisha Osman [20017]

Measurement of normal adults kidney volume using ultrasound This study concluded that there was no correlation between age and volume of the kidneys.

There was no correlation between BMI and volume of the kidneys.

The kidney volume in males is slightly more than in females with the left - - kidney volume larger than the right.

2.7.3 Adedeji A, etal [2010]

Evaluation of renal volume by ultrasonograghy in pt with essential hypertension in lle lfe, south western Nigeria

Conclusion

Renal volume is higher in the left than the right kidney in hypertensive patients of both sexes and female hypertensive pt have smaller kidney size compared to males. The study also shows that the volume of both kidneys decreases with age and positive correlation between renal volume BSA and BMI. However, there is no correlation between renal size and duration of hypertension. https www nobi.nlm.nih.gov.

Chapter Three

Materials and Methods

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

3.1.1 Patients:

This study was carried out on total number of 50 (25 males – 25 females) adult patients with normal renal status were evaluated sonographically at Bahri teaching hospital in Khartoum state

Inclusion criteria:

- Adult patients with normal u/s findings(normal renal echogenicity, cortical thickening and corticomedullary differentiation)

Exclusion criteria:

- Patients less than 18 yeas old were excluded.
- Patients with chronic renal disease.
- pregnant women.
- patients with congenital kidney anomalies.
- patients with renal cysts.
- The patients with history of hypertension or diabetes mellitus.

3.1.2 Machines:

A real time Machine with 3.5 MHZ, TA, convex transducer (sono scape, 352 made in China, MINDARY 4900, MEDISON-SONOACEX4 made in Korea.

3.1.3 Type of study:

Cross sectional study deal with ultrasound measurements of normal kidneys.

3.1.4 Study area:

This study was performed in Bahri area in Al Khartoum state.

3.1.5 Study duration:

The study carried out from (Desmber 2018 - Abril 2019).

3.1.6 Study variables:

Patients age, gender and body mass index.

3.2 Methods:

Using curvilinear prop (3.5-5MH),selection of frequency according to the patient weight, the data analysis program used in this study is Statistical Package for Social Science.

3.2.1 Technique used

The examination begins with the patient in the supine position. Scans are performed in the sagittal and transverse planes from the anterior approach using the liver and spleen as acoustic windows. Various maneuvers may enhance demonstration of the kidneys: left lateral decubitus or lateral oblique positions for the right kidney and right lateral decubitusor lateral oblique positions for the left kidney. Coronal longitudinal and transverse scansmay also be obtained and are recommended for evaluating the renal pelvis and proximal ureter on hydronephrotic patients. The highest frequency transducer permitting adequate penetration is used. This is usually in the 3 to 5 MHz range. A phased array sector probe with its small footprint permits subcostal and intercostal scanning (Burwin,2005).

3.2.2 Investigation protocols

The following technique was applied to allow visualization of both kidneys and pelvic ureter.

3.2.3 Patients preparation

none.

3.2.4 Patient position

Supine, left lateral oblique, left lateral decubitus.

3.2.5 Initial approach 0f kidneys

Longitudinal section – patient supine, transducer positioned directly below the costal margin in the mid clavicular line, beam positioning slightly cephalic. Respiratory maneuver deep inspiration and protrusion of entire abdominal wall.

3.2.6 Data collection:

Data collection sheet which was designed to include all variables to satisfy the study and ultrasound examinations.

3.2.7 Data Interpretation:

The data had been interpreted sonographers according to kidneys measurements

3.2.8 Data analysis:

Data had been analyzed by using statistical package for social sciences Statistical Package for Social Science.

3.2.9 Data presentation:

The data has been presented as figures, tables and graphs.

3.2.10 Ethical considerations:

The ethical approval was granted from the hospital and the ultrasound department; which include commitment of no disclose of any information concerning the patient identification.

Chapter Four

Results

CHAPTER FOUR

RESULTS

Table (4.1) frequency distribution of sex

Sex	Frequency	Percent	Valid Percent	Cumulative Percent
Male	25	50.0	50.0	50.0
Female	25	50.0	50.0	100.0
Total	50	100.0	100.0	

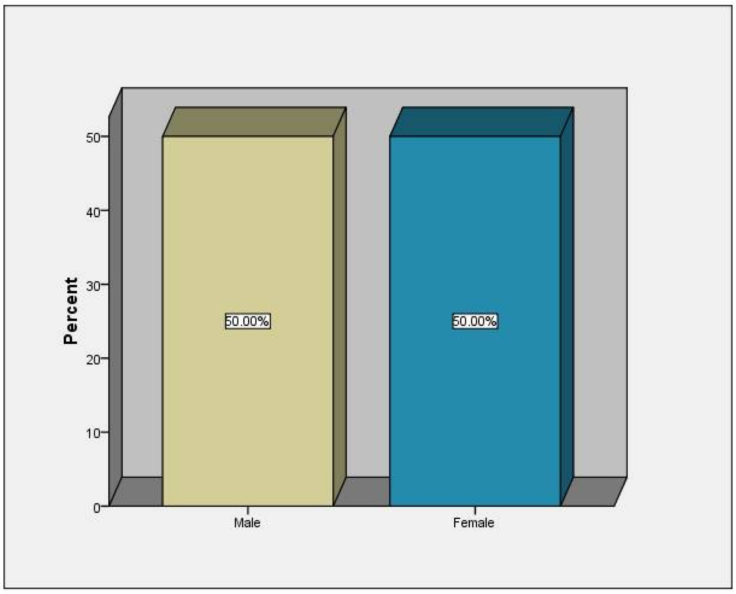


Figure (4.1) frequency distribution of sex

Table (4.2) frequency distribution of age\years

Age \years	Frequency	Percent	Valid Percent	Cumulative Percent
18-28	15	30.0	30.0	30.0
29-39	15	30.0	30.0	60.0
40-50	9	18.0	18.0	78.0
51-60	11	22.0	22.0	100.0
Total	50	100.0	100.0	

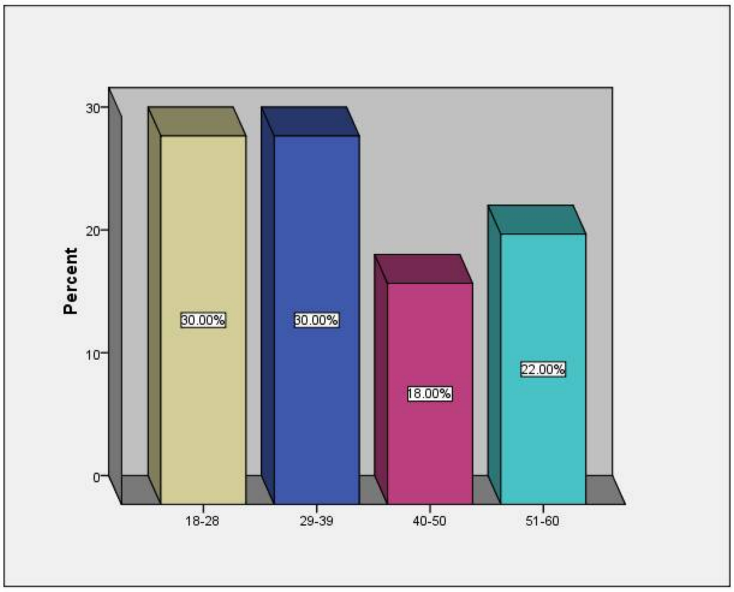


Figure (4.2) frequency distribution of age\years

Table (4.3) descriptive statistic for age, BMI and kidney measurements of kidneys (length, width, depth, volume ±Std. Deviation)

Descriptive	N	Minimum	Maximum	Mean	Std. Deviation
Age	50	18	60	37.74	12.844
BMI	50	22.0	34.0	26.040	2.4905
RKL	43	10.2	11.2	10.535	.2308
RKW	44	4.1	5.1	4.623	.3259
RKD	43	3.9	4.9	4.193	.2040
RKV	50	84.8	128.0	105.788	10.5282
LKL	42	10.4	11.8	10.810	.2477
LKW	42	4.3	5.6	4.860	.3408
LKV	50	88.6	146.0	117.574	11.6417
LKD	41	4.1	4.9	4.339	.1595
Valid N (listwise)	41				

Table (4.4) Compare mean measurements of kidneys in different gender

	Sex	N	Mean	Std. Deviation	Std. Error Mean
RKL	Male	20	10.515	.2300	.0514
	Female	23	10.552	.2352	.0491
RKV	Male	25	106.396	12.7291	2.5458
	Female	25	105.180	7.9691	1.5938
LKL	Male	19	10.853	.3080	.0707
	Female	23	10.774	.1839	.0384
LKV	Male	25	119.268	14.1991	2.8398
	Female	25	115.880	8.3132	1.6626

a. Mean

b. t. test

Table (4.5) one way -ANOVA test for compare mean measurements of kidneys in different age group

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
RKL	-.522-	41	.604	-.0372-	.0712	-.1809-	.1066
	-.523-	40.408	.604	-.0372-	.0711	-.1808-	.1064
RKV	.405	48	.687	1.2160	3.0036	-4.8231-	7.2551
	.405	40.308	.688	1.2160	3.0036	-4.8530-	7.2850
LKL	1.026	40	.311	.0787	.0768	-.0764-	.2338
	.979	28.170	.336	.0787	.0804	-.0859-	.2434
LKV	1.030	48	.308	3.3880	3.2907	-3.2285-	10.0045
	1.030	38.723	.310	3.3880	3.2907	-3.2697-	10.0457

Table (4.6) correlation between age and kidneys measurements

Age		RKL	RKV	LKL	LKV
18-28	Mean	10.642	108.347	10.850	119.933
	N	12	15	12	15
	Std. Deviation	.2503	9.8078	.1977	8.5395
	Minimum	10.3	90.0	10.5	95.0
	Maximum	11.2	122.0	11.1	134.0
29-39	Mean	10.500	114.327	10.873	126.807
	N	15	15	15	15
	Std. Deviation	.2646	7.0948	.3327	10.7487
	Minimum	10.2	104.0	10.5	117.0
	Maximum	11.2	128.0	11.8	146.0
40-50	Mean	10.450	100.700	10.662	112.744
	N	8	9	8	9
	Std. Deviation	.1604	7.4239	.1768	7.4674
	Minimum	10.2	90.0	10.4	103.0
	Maximum	10.7	115.0	10.9	123.0
51-60	Mean	10.525	94.818	10.771	105.718
	N	8	11	7	11
	Std. Deviation	.1581	4.3644	.0951	6.6195
	Minimum	10.3	84.8	10.6	88.6
	Maximum	10.8	102.0	10.9	114.0
Total	Mean	10.535	105.788	10.810	117.574
	N	43	50	42	50
	Std. Deviation	.2308	10.5282	.2477	11.6417
	Minimum	10.2	84.8	10.4	88.6
	Maximum	11.2	128.0	11.8	146.0
P value		0.266	0.000	0.234	0.000

Table (4.7) correlation between age, and BMI kidneys measurements

		RKL	RKW	RKD	RKV	LKL	LKW	LKD	LKV
Age	Pearson Correlation	-.152-	-.396**	-.220-	-.551**	-.179-	-.365*	-.437**	-.533**
	Sig. (2-tailed)	.331	.008	.155	.000	.257	.017	.004	.000
	N	43	44	43	50	42	42	41	50
BMI	Pearson Correlation	.253	.098	.247	.456**	.353*	.330*	-.096-	.402**
	Sig. (2-tailed)	.102	.527	.110	.001	.022	.033	.552	.004
	N	43	44	43	50	42	42	41	50
**. Correlation is significant at the 0.01 level (2-tailed).									
*. Correlation is significant at the 0.05 level (2-tailed).									

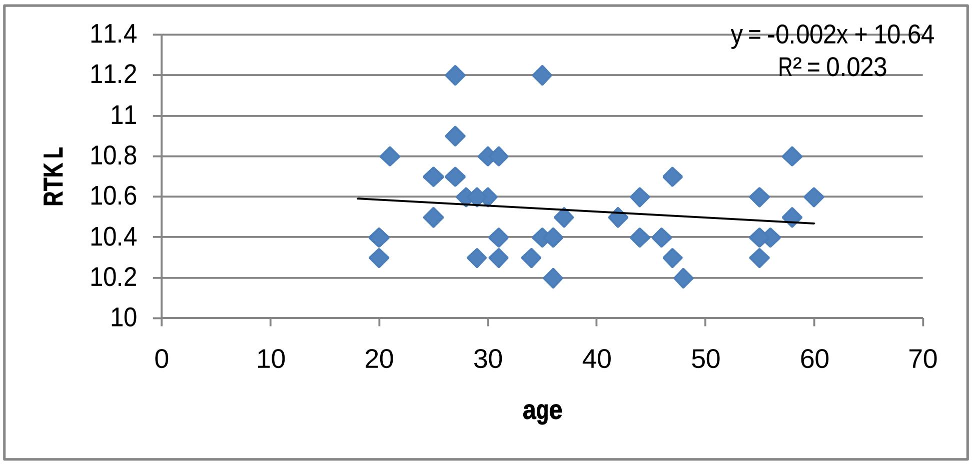


Figure (4.3) scatterplot shows relation between age and RTKL

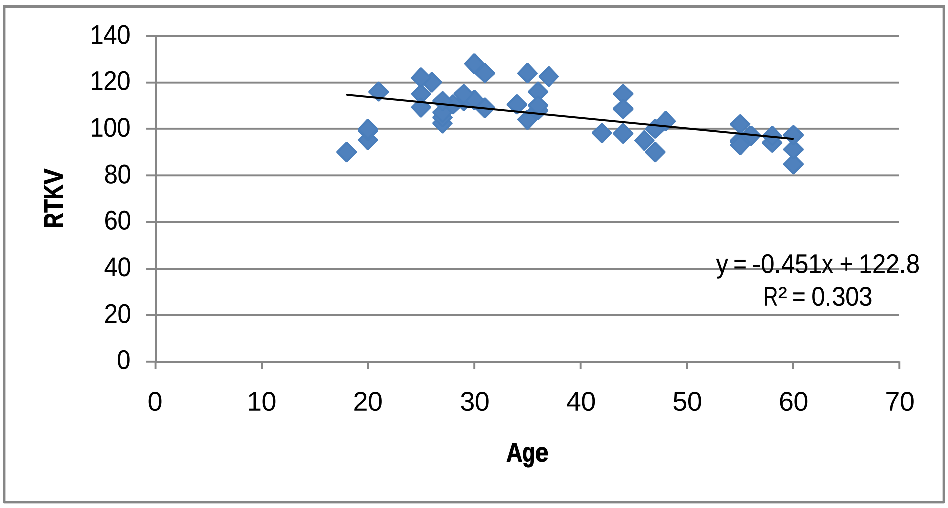


Figure (4.4) scatterplot shows relation between age and RTK V

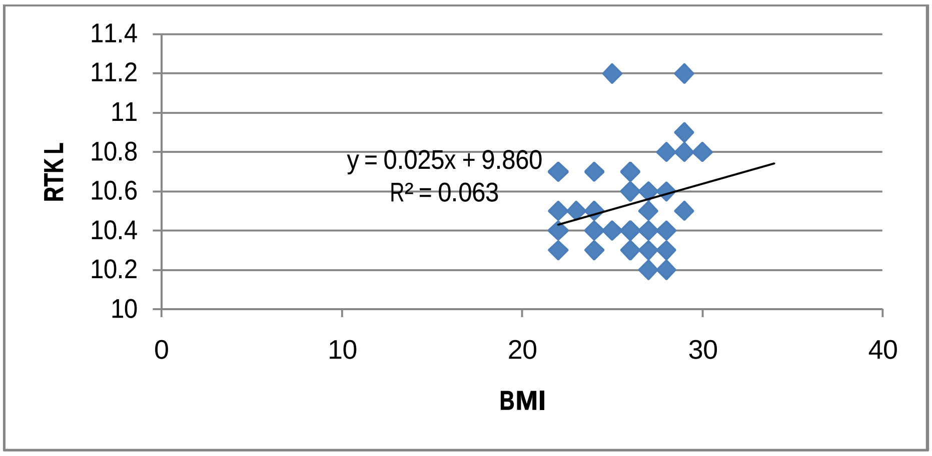


Figure (4.5) scatterplot shows relation between BMI and RTK L

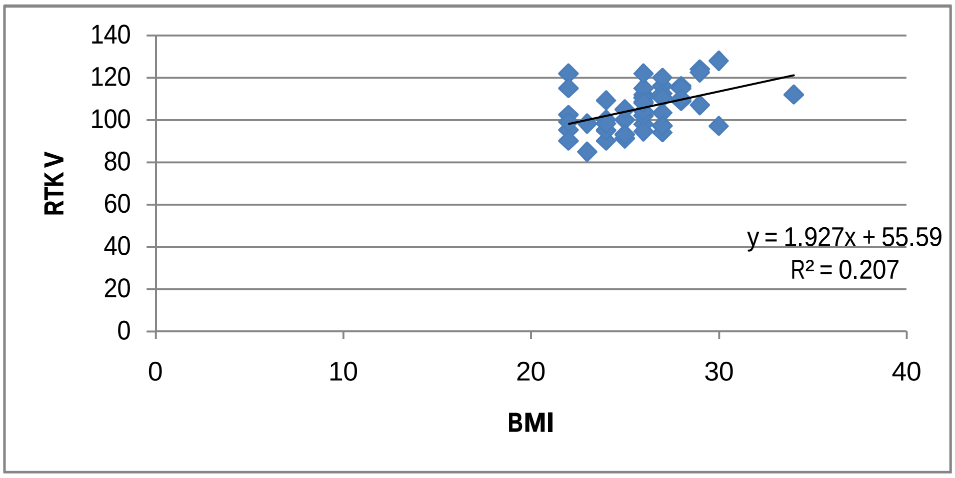


Figure (4.6) scatterplot shows relation between BMI and RTK V

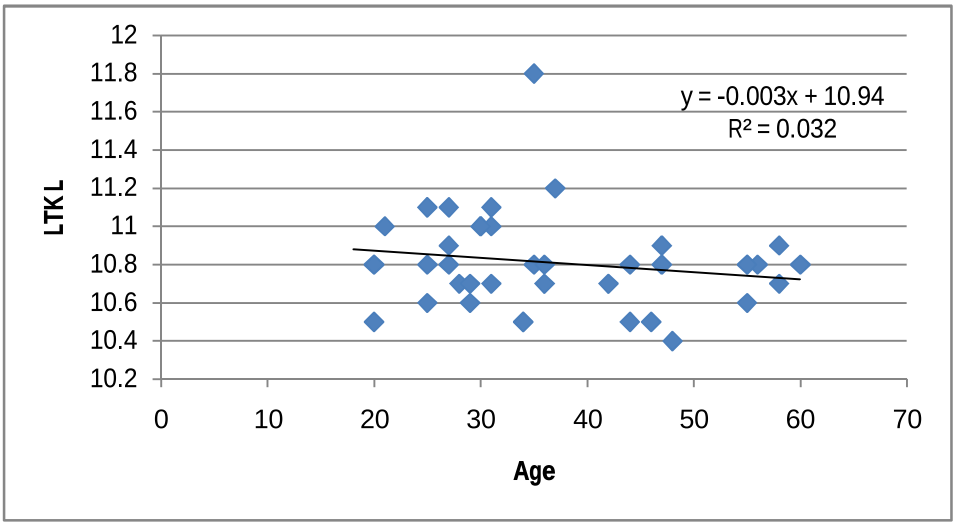


Figure (4.7) scatterplot shows relation between age and LTK L

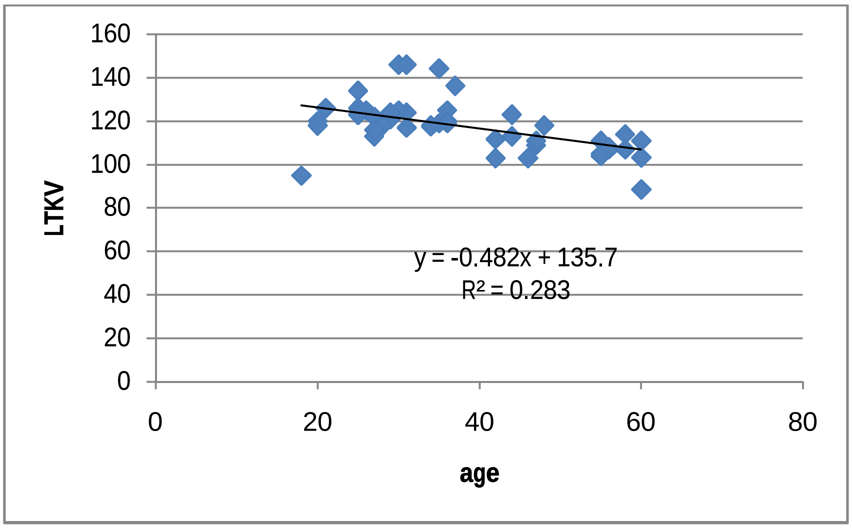


Figure (4.8) scatterplot shows relation between age and LTK V

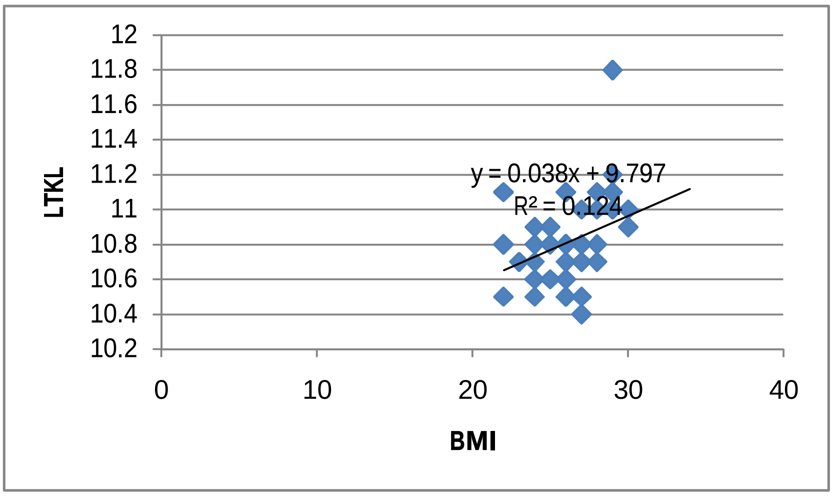


Figure (4.9) scatterplot shows relation between BMI and LTK L

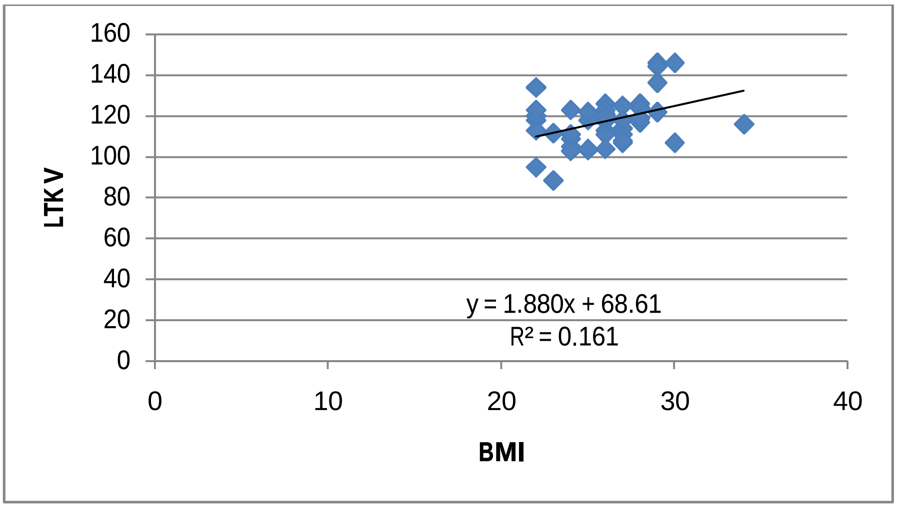


Figure (4.10) scatterplot shows relation between BMI and LTK V

Chapter Five

Discussion, conclusion and Recommendation

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATION

5-1 discussion

This is cross section study done in Bahri teaching hospital in the period From (Desembar 2018 – Abril 2019) to measure the kidneys volume in Sudanese adult using ultrasound.

The sampling includes 50 patients (25 male, 25 Female) each 50% as shown in table (4.1) Figure (4.1) 30% of them in age group 18 – 28 years, 30% of them in age group 29 – 39 years, 18% in age group (40 – 50 years, 22% in age group, 51 – 60 yeas) as shown to table (4-2) Figure (4-2) with mean age 37 yeas .

The study found that the mean Rtk (L,W,D) and volume) for adult Sudanese were (10,53 $\pm$ 0.23) cm 4.62 $\pm$ 32 cm, 4.19 $\pm$ 20 cm and 105.87 $\pm$ 10.52 cm^3 respectively. For left kidney (L,W,D and volume) were 10.81 $\pm$ 25, 4.86 $\pm$ 34 4.33 $\pm$ 159 and 117.5 cm^3 respectively as shown in (table 4.3).

R: 0.533, P 0.000

There significant Positive coloration between volume and BMI For

RTK	R: 0.456	P 0.00
Lt kV	R: 0.402	P 0.004

The study demonstrate that the Right and left kidney volume is larger in males then than females with no significant difference P > 0.05 the male Rt kidney volume 106 $\pm$ 12.72 cm^3 female Rt kv 105.18 $\pm$ 7.96 cm^3 the male Lt kv 119.26 $\pm$ 14.19 cm^3 while female Lt KV 115.88 $\pm$ 8.31 as shown in table (4.4)

The study found no significant difference in Both kidney length in different age group P > 0.09, but there was significant difference in both kidney volume in different age group .

The study found that there was significant negative correlation between age and both kidney volume

For Rt	r : 0.551	p: 0.000
For Ltr :	0.533	P: 0.000

There significant positive correlation between volume and MBI

For Rt	r : 0.456	P : 0.001
For Ltr :	0.402	P : 0.004

The study found that there was inverse linear relation between age and RKL as age increase one year the right kidney length decrease bay 0.002 cm as shown in figure (4.3).

There was inverse relation between age and right kidney volume as age increase one years right kidney volume decrease 0.45 cm as shown figures (4.4) the study found there was linear relation and between BMI and Rt kl and volume as BMI increase I Kg/ cm^2 RTL 4.5 Rt kl increase 0.025 cm figures (4.5). as BMI increase one Kg/ cm^2 Rt KV increase by $1.92cm^3$ as shown in figure (4.6).

The study found Inverse relation between age an LKL as age increase one year the Lt Kl increases 0.003 cm as shown in figure (4.7).

Inverse relationship between age and Lt KV as age increase one year the Lt KV decrease by 0.482 as shown in figure (4.8).

The study found there was in linear relation hip between BMI and lt kl as the BML increase I Kg/cm^2 lt kL increase 0.038 us shown in figure (4.9) .

The study found here linear relation between BMI and LKV as BMI increase $1Kg/cm^2$ the volume increase 1.88 cm^3 as shown in figure (4.10).

Which agree with (Abderahman Mubark 2015)

5-2 Conclusion

The right and left kidney volume is larger in male than female with no significant different. There is significant difference in Both kidney volume in deferent age group. Negative correlation between age and Both kidney volume. A significant positive correlation between volume and the BMI.

5-3 Recommendation:-

- Further study to show with increase number of data for more accurate results.
- Further study show other organs volume (liver- spleen- pancreas) and compared them with the patients age, gender and body mass index.
- Other study show the volume of transplant kidney and compared it with the normal kidney volume.
- The effect of some diseases in the renal volume by using u/s.

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Appendices

Appendix [I]

Data sheet

Number	Age	Body mass index	Right kidney length	Right kidney width	Right kidney depth	Right kidney Volume	Left kidney length	Left kidney width	Left kidney depth	Left kidney Volume
1										
2										
3										
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Appendix [II]

Ultrasound images for the study sample

Image (1) 57 years Male body mass 75 Kg came with hematouria sagittal Ultrasound image show normal kidney size and volume RT Kidney 141.8 cm^3 , LT Kidney 131,0 cm^3

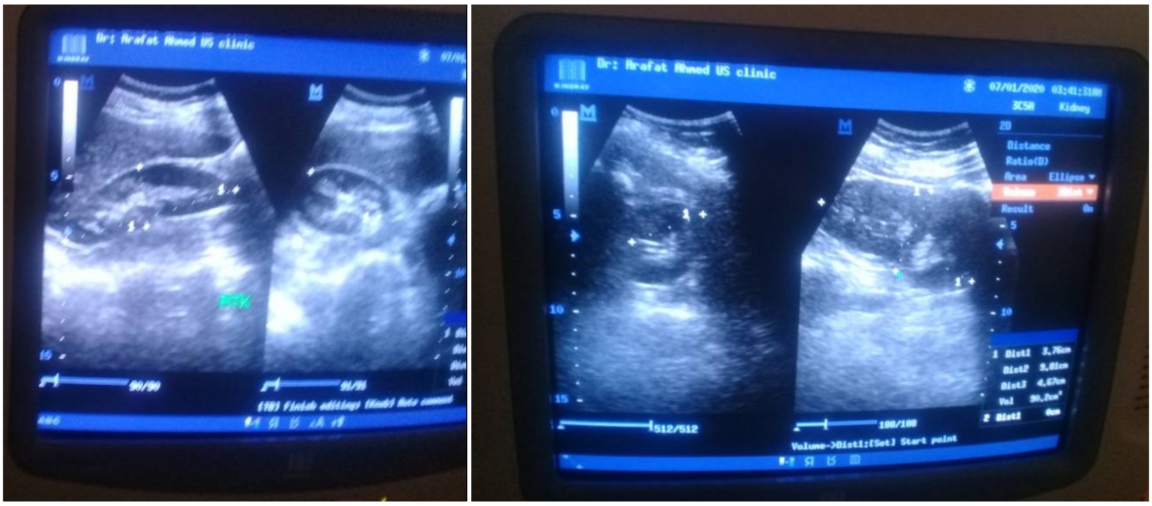

Image (2) 35 years Female body mass 67 Kg came with history of jundace normal show normal Ultrasound kidney size and volume RT Kidney 90 cm^3

Image (3) Long axis of kidney ultrasound Image 40 years old female came with abdominal pain image show normal right kidney size

Image (4) 48 years old male has abdominal pain image show normal both kidneys

Image (5) 60 years old male came with disuria image show normal kidneys size