**Sudan University of sciences and technology**

**College of graduate studies**

# Assessment of Normal Renal Parenchymal Thickness Using Ultrasonography

# تقييم سمك نسيج الكلى الطبيعيه باستخدام التصوير بالموجات فوق الصوتيه

A thesis submitted for Partial Fullfillment for the Requirement of M.Sc Degree in Medical Diagnostic Ultrasound

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# الآيه

**وَوَصَّيْنَا الْإِنسَانَ بِوَالِدَيْهِ إِحْسَانًا ۖ حَمَلَتْهُ أُمُّهُ كُرْهًا وَوَضَعَتْهُ كُرْهًا ۖ وَحَمْلُهُ وَفِصَالُهُ ثَلَاثُونَ شَهْرًا ۚ حَتَّىٰ إِذَا بَلَغَ أَشُدَّهُ وَبَلَغَ أَرْبَعِينَ سَنَةً قَالَ رَبِّ أَوْزِعْنِي أَنْ أَشْكُرَ نِعْمَتَكَ الَّتِي أَنْعَمْتَ عَلَيَّ وَعَلَىٰ وَالِدَيَّ وَأَنْ أَعْمَلَ صَالِحًا تَرْضَاهُ وَأَصْلِحْ لِي فِي ذُرِّيَّتِي ۖ إِنِّي تُبْتُ إِلَيْكَ وَإِنِّي مِنَ الْمُسْلِمِين)**

**(الايه 15 الاحقاف).**

## Dedication:

*To my parents*

*To my teachers*

*To my brothers and sisters*

*To my wife*

*And To my daughter*

## Acknowledgement

I am deeply grateful to God who gave me patience and power to complete my study; then to My Supervisor : Dr Babiker Abdalwahab, And Dr Ahmed Almustafa.

# Abstract

This study is across sectional descriptive study conducted in Sudan Khartoum state in Ribat Teaching hospital and Alzarra Clinic from November 2016 to February 2017.the problem of the study was need to determine reference values for thickness of normal kidneys in sudanes population. The study aimed to Assessment of Normal Renal parenchymal thickness Using Ultrasonography. the data was collected from 81 population classified and analysis by SPSS (statistical package for the social sciences).the study found that mean of renal parenchymal thicknesses were (1.426± 0.2724cm) for the right kidney and (1.584± 0.2552cm) for the left kidney. These result were correlated with age, gender, site, weight, height, renal length, renal width and renal AP diameter which showed that there is significant difference between right and left parenchymal thicknesses. No significant effect of age with right and left parenchymal thickness. No significant difference between renal parenchymal thicknesses according to gender. Significant positive correlation between weight and height with right and left parenchymal thickness. Significant positive correlation between kidney widths, AP diameter and kidney length with renal parenchymal thikness. This study recommended Establishment of normal renal values of renal parenchymal thickness in Sudanese population will help us in evaluation of patients with chronic or acute renal disease.

## مستخلص الدراسه

هذه الدراسه وصفيه مقطعيه تمت في السودان ولايه الخرطوم من شهرنوفمبر 2016 الى شهرفبراير2017 تكمن مشكله هذه الدراسه في ايجاد قيمه مرجعيه لسمك الكليه في السودانيين وتهدف هذه الدراسه الى تقييم سمك نسيج الكلى الطبيعيه باستخدام التصوير بالموجات فوق الصوتيه. تم جمع وتحليل هذه البيانات بواسطه برنامج الاحصاء .وجدت هذه الدراسه ان متوسط سمك الكليه اليمين هو 1.426 زياده او نقص0.272 ومتوسط سمك اليسار هو 1.584 زياده او نقص 0.2552 . يوجد اختلاف مقبول احصائيا بين سمك الكليه اليسار واليمين وايضا يوجد ارتباط ايجابي بين سمك الكليه مع وزن وطول الشخص.يوجد ارتباط سلبي ضعيف بين عمر الشخص وسمك كليته ولكن غير مقبول احصائيا.لا يوجد اختلاف مقبول احصائيا بين الذكور والاناث من حيث سمك الكليه.يوجد ارتباط ايجابي قوي بين سمك الكليه مع طول وعرض وارتفاع الكليه نفسها. هذه الدراسه توصي ان اثبات القيم الطبيعيه لسمك الكليه سوف يساعدنا كثيرا في معرفه امراض الكلى المتعلقه بتغيير حجم الكليه وخصوصا المزمنه منها.

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# Abbreviations

| | |
|---|---|
| BUN | Blood Urea Nitrogen |
| CT | Computerized Tomography |
| DGC | depth gain compensation |
| IVP | Intravenous pyelogram |
| IV | Intravenous |
| KUB | kidney, ureter and urinary bladder |
| MRI | magnetic resonance imaging |
| PRF | pulse repetition frequency |
| PACS | picture archiving and communications system |
| R | reflection coefficient |
| TGC | time gain compensation |
| US | ultrasound |
| 2-D | two-dimensional |
| Z | Acoustic impedance |
| 3-D | three-dimensional |

# Chapter one

# Introduction

## 1-1 Introduction:

background knowledge of normal renal dimensions help experts in the diagnosis of kidney diseases. Many renal diseases are associated with an increase or decrease in kidney size . Thus, it is important to establish the normal range of renal dimensions. Ultrasound is a useful, accessible, non-invasive, and inexpensive method to study renal morphology. Renal length and parenchymal thickness estimation by ultrasound are important parameters in clinical evaluation of adult patients with kidney disease . Measurements of longitudinal renal length involve the least inter-observer variation, and therefore, are more reproducible than volumetric estimations. Renal parenchymal thickness also was found to be one of the ultrasonic renal parameters that can offer prognostic information on end stage kidneys(mahmoud jabbary et al ,2016).

Renal size shows individual variations according to the patient's height, sex, and age. Ethnic differences are expected perhaps partly due to the above variables. The changes in renal size can be very suggestive evidence of disease, and their interpretations require specific parameters for the population to study. In general, measurements of renal length and parenchymal thickness of any age are compared with the measurements that are predicted by standard nomograms. However, to the best of our knowledge, the current nomograms (which are widely used) were derived from studies based on Caucasian population. this study aimed to evaluate the renal dimensions in sudanese population, and to verify their possible correlations with gender, body weight, age, and height(mahmoud jabbary et al ,2016).

**1-2 proplem of the study :**

Thickness of Renal paranchyma usualy affected by many factors (age,weight , hight , mass body indix ,kidney length, kidney hight and kidney width ..etc) so we need to determine reference values for thickness of normal kidneys in sudanes population.

**1-3 objectives:**

**1-3-1 general objective:**

To Assessment of Normal Renal parenchymal thickness Using Ultrasonography.

**1-3-2 specific objective:**

To measur renal parenchymal thickness.

To correlate between thickness of renal parenchyma to age and body characteristic.

To correlate between thickness of renal parenchyma to the renal length , height and width .

**1-4 overview of the study:**

This study falls in to five chapters, capter one is an introduction which include proplem of the study ,objective of the study and over veiw of the study, while chapter two includes literature review and previous study,chapter three deals with material used to collect the data and the method of data collection and analysis ,chapter four presented the result of the study and finally chapter five includs discusion of the result ,conclusion and recommendations.

# Chapter two

# Literature review

## 2-1 Anatomy of the urinary system:

The urinary system is one of the excretory systems of the body. It consists of the following structures two kidneys, two ureters, one bladder and one urethera(Ross and Wilson, 2004).

### 2-1-1 Kidneys:

The kidneys lie on the posterior abdominal wall, one on each side of the vertebral column, behind the peritoneum and below the diaphragm. They extend from the level of the 12$^{th}$thoracic vertebra to the 3$^{rd}$ lumbar vertebra, receiving some protection from thelower rib cage. The right kidney is usually slightly lowerthan the left, probably because of the considerable spaceoccupied by the liver.Kidneys are bean-shaped organs, about 11 cm long,6 cm wide, 3 cm thick and weigh 150 g. They are embeddedin, and held in position by, a mass of fat. A sheathof fibroelastic renal fascia encloses the kidney and the renal fat (Ross and Wilson, 2004).

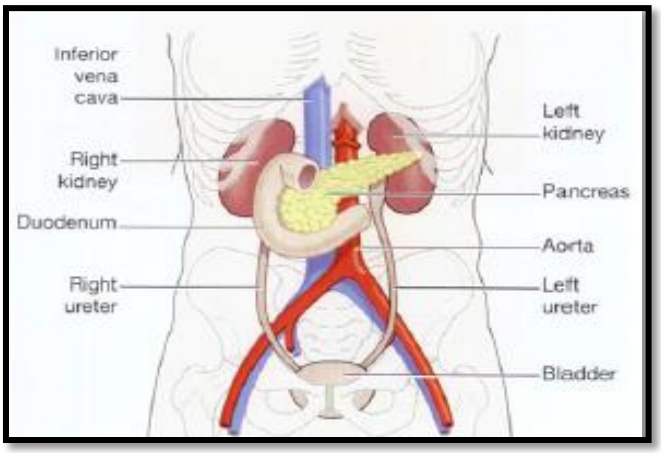



**Figure (2-1)** showsthe parts of the urinary system (excluding the urethra) and some associated structures (Ross and Wilson 2004).

### 2-1-1-1 Relation shape of the kidneys:

As the kidneys lie on either side of the vertebral column each is associated with a different group of structures.Right kidney related with right adrenal glandSuperiorly, the right lobe of the liver, the duodenum and the hepatic flexure of the colonAnteriorly,the diaphragm, and muscles of the posterior abdominal wallPosteriorly, whileleft kidney related withleft adrenal glandSuperiorly, pancreas, jejunum and splenic flexure of the colonAnteriorly,diaphragm and muscles of the posterior abdominal wallPosteriorly(Ross and Wilson, 2004).

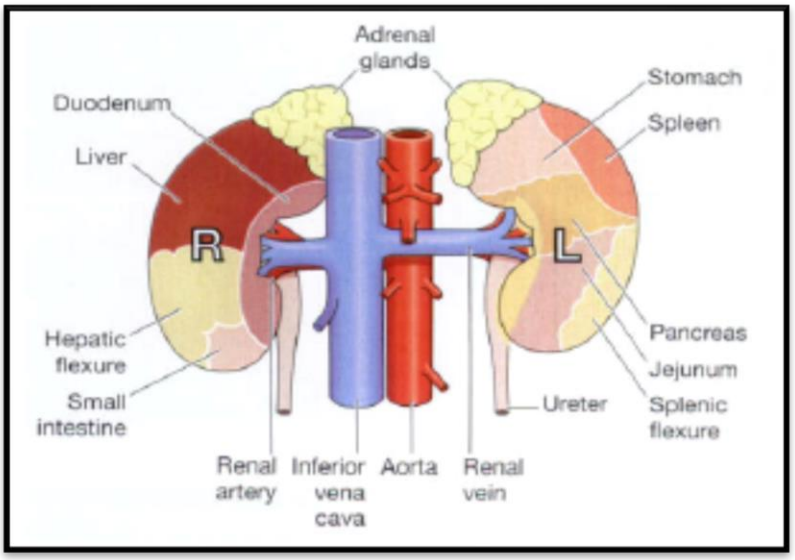



**Figure (2-2)** showanterior view of the kidneys showing the areas of contact with associated structures(Ross and Wilson, 2004).

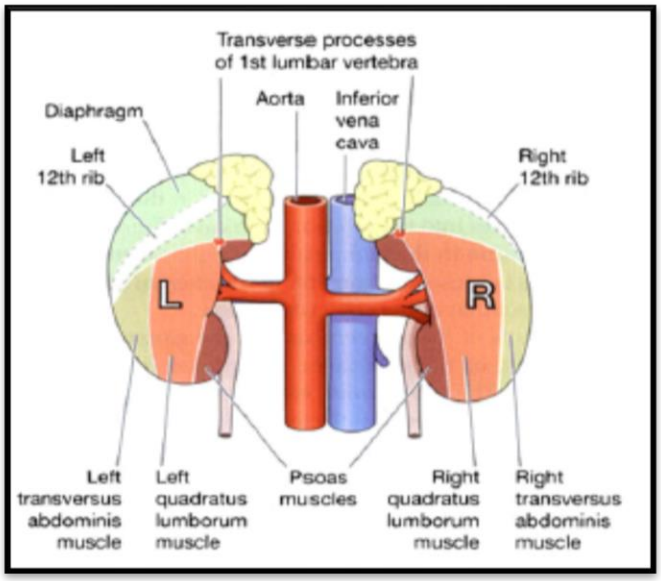



**Figure (2-3)** showPosterior view of the kidneys showing the areas of contact with associated structures (Ross and Wilson, 2004).

**2-1-1-2 Renal artery and vein:**

The paired visceral branches of the abdominal aorta include: the renal arterieslateral branches of the abdominal aorta that arise just inferior to the origin of the superior mesenteric artery between vertebrae LI and LII, and supply the kidneys. Drainage of renal veins to the inferior vena cava (Richardl Drake et al, 2007).

**2-1-1-3 Gross structure of the kidney:**

There are three areas of tissue which can be distinguished when a longitudinal section of the kidney is viewed with the naked eye: a fibrous capsule, surrounding the kidney, the cortex, a reddish-brown layer of tissue immediately below the capsule and outside the pyramids, the medulla, the innermost layer, consisting of pale conical-shaped striations, the renal pyramids.The hilum is the concave medial border of the kidney where the renal blood and lymph vessels, the ureter and nerves enter.The renal pelvis is the funnel-shaped structure whichacts as a receptacle for the

urine formed by the kidney It has a number of distal branches calledcalyces, each of which surrounds the apex of a renal pyramid (Ross and Wilson, 2004).

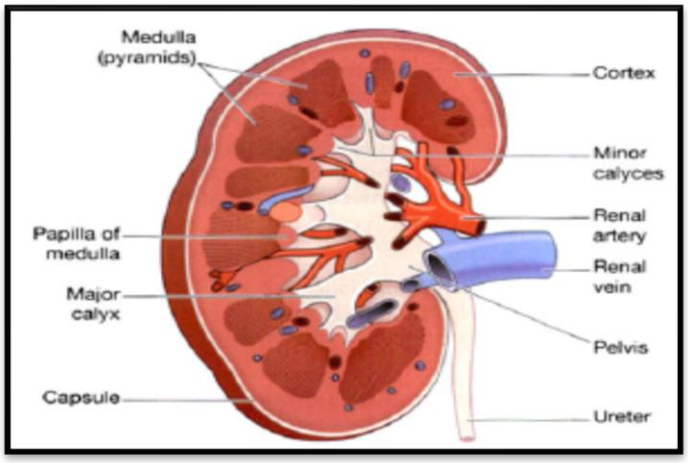



**Figure (2-4)** showA longitudinal section of the right kidney (Ross and Wilson, 2004).

**2-1-1-4 Microscopic structure of the kidney:**

The kidney is composed of about 1 million functional units, the nephrons, and a smaller number of collecting tubules. The collecting tubules transport urine through the pyramids to the renal pelvis giving them their striped appearance. The tubules are supported by a small amount of connective tissue, containing blood vessels, nerves and lymph vessels(Ross and Wilson, 2004).

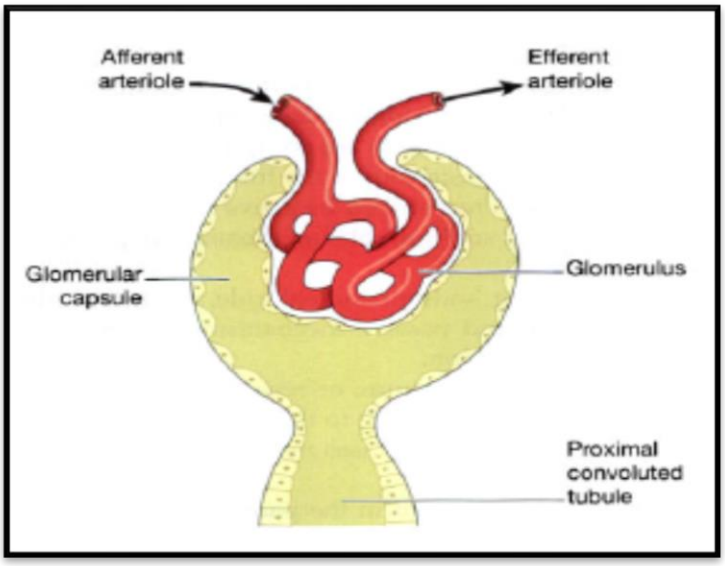



**Figure (2-5)** shownephronstructure (Ross and Wilson, 2004).

**2-1-2 Ureters:**

The ureters are the tubes that convey urine from the kidneys to the urinary bladder. They are about 25 to 30 cm long with a diameter of about 3 mm. The ureter is continuous with the funnel-shaped renal pelvis. It passes downwards through the abdominal cavity, behind the peritoneum in front of the psoas muscle into the pelvic cavity, and passes obliquely through the posterior wall of the bladder(Ross and Wilson, 2004).

**2-1-2-1 Structure:**

The ureters consist of three layers of tissue: outer covering of fibrous tissue, continuous withthe fibrous capsule of the kidney. a middle muscular layer consisting of interlacingsmooth muscle fibres that form a syncytium spiralling round the ureter, some in clockwise andsome in anticlockwise directions and an additionalouter longitudinal layer in the lower third.An inner layer, the mucosa, lined with transitionalepithelium (Ross and Wilson, 2004).

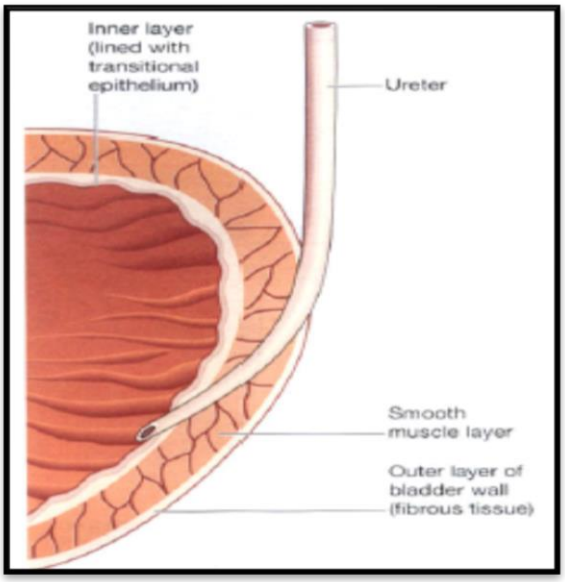



**Figure (2-6)** showThe position of the ureter where it passes through the bladder wall (Ross and Wilson, 2004).

**2-1-3 Urinary bladder:**

The urinary bladder is a reservoir for urine. It lies in the pelvic cavity and its size and position vary, depending on the amount of urine it contains. When distended, the bladder rises into the abdominal cavity (Ross and Wilson, 2004).

**2-1-3-1 Structure:**

The bladder is roughly pear-shaped, but becomes more oval as it fills with urine. It has anterior, superior and posterior surfaces. The posterior surface is the base. The bladder opens into the urethra at its lowest point; the neck. The bladder wall is composed of three layers:the outer layer of loose connective tissue, containing blood and lymphatic vessels and nerves, covered onthe upper surface by the peritoneum.the middle layer, consisting of a mass of interlacingsmooth muscle fibres and elastic tissue looselyarranged in three layers. This is called the detrusormuscle and it empties the bladder when it contractsthe mucosa, lined with transitional epithelium.When the bladder is empty the inner lining is arranged in folds, or rugae and these gradually disappear as the bladder fills. The bladder is distensible but when it contains 300 to

400 ml the awareness of the desire to urinate is initiated. The total capacity is rarely more than about 600 ml.The three orifices in the bladder wall form a triangle or trigone. The upper two orifices on the posterior wall are the openings of the ureters. The lower orifice is the point of origin of the urethra. Where the urethra commences is a thickening of the smooth muscle layer forming the internal urethral sphincter.This sphincter is not under voluntary control (Ross and Wilson, 2004).

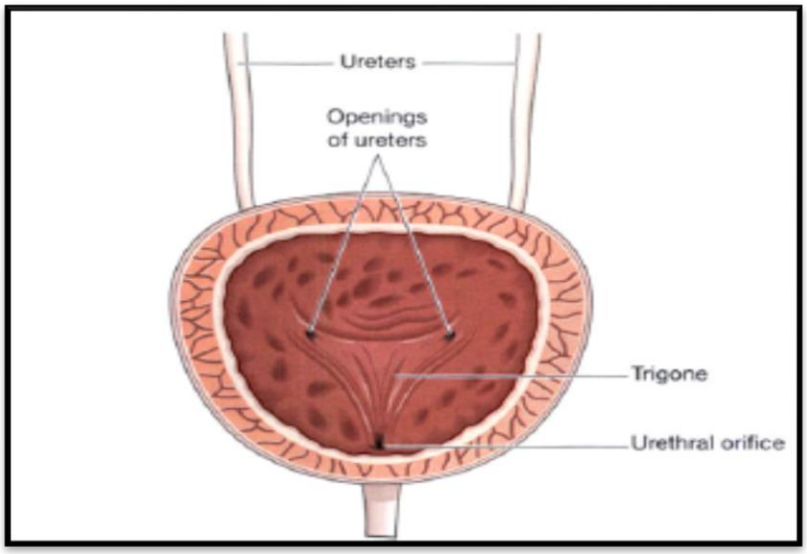



**Figure (2-7)** Section of the bladder showing the trigone (Ross and Wilson, 2004).

**2-1-4 The urethra:**

The urethra is a canal extending from the neck of the bladder to the exterior, at the external urethral orifice. Its length differs in the male and in the female. The male urethra is associated with the urinary and the reproductive systems. The female urethra is approximately 4 cm long. It runs downwards and forwards behind the symphysis pubis and opens at the external urethral orifice just in front of the vagina. The external urethral orifice is guarded by the external urethral sphincter which is under voluntary control.Except during the passage of urine, the walls of the urethra are in close apposition.The urethra in both sexes the basic structure is the same. Its wallsconsist of three layers of tissue. the muscle layer, continuous with that of the bladder. At its origin there is the internal urethral sphincter, consisting mainly of

elastic tissue and smooth muscle fibres, under autonomic nerve control. Slow and continuous contraction of this sphincter keeps the urethra closed. In the middle third there is skeletal muscle surrounding the urethra, under voluntary nerve control that forms the external urethral sphincter. thesubmucosa, a spongy layer containing blood vessels and nerves.the mucosa, which is continuous with that of the bladder in the upper part. In the lower part the lining consists of stratified squamous epithelium, continuous externally with the skin of the vulva(Ross and Wilson, 2004).

**2-2 Physiology of kidneys:**

The kidneys eliminate water and are therefore the principal means of fluid volume regulation. Many metabolic wastes are eliminated by the kidneys; in particular, urea, uric acid, creatinine and ammonia which are wastes derived from the breakdown of protein. The kidneys also regulate the pH of plasma, the electrolyte pattern of extracellular fluid and play a role in the elevation of blood pressure (Devin Dean, 2005).

## 2-3 Pathology:

### 2-3-1 Normal Variants:

In the first trimester, the developing kidneys ascend in the fetal abdomen. If the progress is hampered, this can result:

**2-3-1-1 Dromedary Humps:** are prominent focal bulges on the lateral border of the left kidney. They are normal variants of the renal contour, caused by the splenic impression onto the superolateral left kidney Dromedary humps are important because they may mimic a renal mass, and as such is considered a renal pseudotumour(Devin Dean, 2005).


**Figure (2-8)** show Sagital US image Dromedary humps (Devin Dean, 2005).

**2-3-1-2 Extra Renal Pelvis:** refers to the presence of the renal pelvis outside the confines of the renal hilum. It is a normal variant that in ~10% of population. The renal pelvis is formed by all the major calyces. An extarenal pelvis usually appears dilated giving a false indication of an obstructive pathology. Subsequent investigation with CT, usually clarifies the false interpretation on ultrasound (Devin Dean, 2005).

**Figure (2-9)** showSagital US image Extra Renal Pelvis (Devin Dean, 2005).

**2-3-1-3 Junctional parenchymal defects:** in renal imaging are a normal variant. It results from incomplete embryonic fusion of renunculi. sonographic appearance : It can be seen as an triangular echogenic cortical defect, frequently seen in upper lobe parenchyma. The defect is the extension of sinus fat into the cortex, usually at the border of the upper pole and interpolarregion of the kidney (Devin Dean, 2005).

**Figure (2-10)** show Sagital image Junctional Parenchymal Defects (Devin Dean, 2005).

**2-3-1-4 Duplex kidney: appears** as two central echo complexes with intervening renal parenchyma. Hydronephrosis at one pole is suggestive of a duplex kidney.

Although hydronephrosis can occur at either pole, it is more common in the upper one. Occasionally, two distinct collecting systems and ureters can be observed on ultrasonographic images (Devin Dean, 2005).

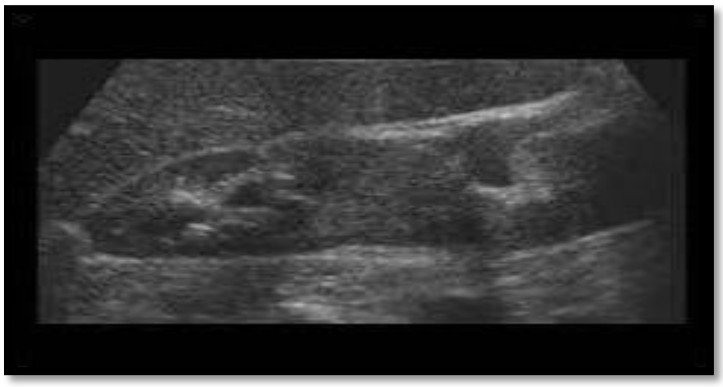


**Figure 2-11**Sagital image Duplex kidneys(Devin Dean, 2005).

**2-3-1-4 Congenital Fusion (Horseshoe Kidney):**Horseshoe kidney is the most common renal fusion anomaly, with a prevalence of approximately 1:400 births and a male predominance. The lower poles of the kidneys fuse and this fused area is calledthe isthmus. The hilum of each kidney looks forwards and the ureters always pass in front of the connecting in ultrasound, the isthmus can be seen anterior to the aorta and IVC; the low position and abnormal renal alignment will be seen (Devin Dean, 2005).

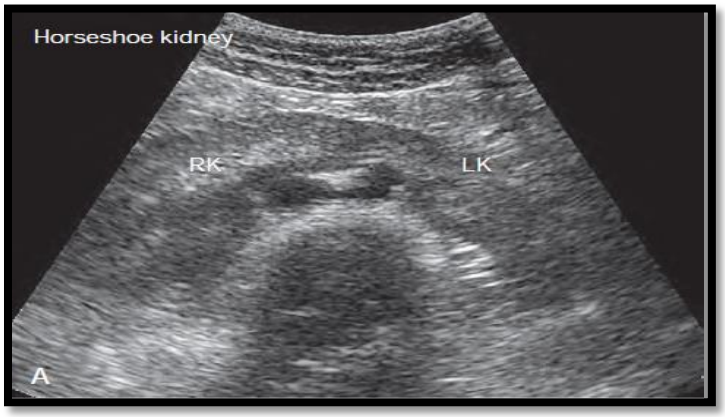



**figure (2-12)** showSagital image Horseshoe Kidney (Carol M Rumack, 2011).

## 2-4 Investigation of the kidneys:

### 2-4-1 Laboratory Tests Related to Kidney Function:

Serum CreatinineCreatinine is a nitrogenous compound formed as an end product of musclemetabolism. It is formed in muscle in relatively small amounts, passed into the bloodand excreted in the urine.Blood creatinine level measures renal function. Normally it is produced in regularconsistently small amounts.Therefore an elevation means a disturbance in renalfunction. Renal impairment is virtually the only cause of creatinine elevation.Blood Urea Nitrogen (BUN): Urea is an end product of protein metabolism and is readilyexcreted by the kidneys.Therefore the blood urea concentration normally is fairly low.Blood urea nitrogen level measures renal function. The BUN level rises when thekidney's ability to excrete urea is impaired. It also rises with reduced renal blood flowas with dehydration and urinary tract obstructions.An elevated level of BUN may lead to mental confusion, disorientation and coma(Devin Dean, 2005).

### 2-4-2 Radiological investigation:

#### 2-4-2-1 Plain x-ray for kidney, ureter and urinary bladder (KUB):

KUB x-ray is a plain AP supine radiograph of the abdomen to assess the organs and structure of the urinary and or gastrointestinal system, the indication of KUB x-ray to determine the shape and position of the kidneys and bladder also to detect obvious abnormalities of the urinary system such as kidney stones (Kursus, 2015).

#### 2-4-2-2 Intravenous Urography (Intravenous Pyelography or Excretory Urography):

Intravenous pyelogram (IVP) is x-ray exam that uses an injection of contrast material to evaluate your kidneys, ureter and bladder and help diagnose blood in the urine or pain in your side or lower back (Radiologyinfo.org , 2016).

**2-4-2-3 Computerized Tomography:**

Computerized tomography scans use a combination of x-rays and computer technology to create three dimensional (3D) images, CT scans can show stones in the urinary tract,obstructions,infections, cysts, tumors, and traumatic injuries (US. Department of Health, 2012).

**2-4-2-4 Magnetic resonance imaging (MRI):**

is atest that takes pictures of the body's internal organs and soft tissues without using x-rays.MRI machines use radio waves and magnets to produce detailed pictures .MRI my include the injection of contrast medium.MRI used to diagnosis large number of disease such as tumor, cystic lesion ,obstruction and infections(US. Department of Health, 2012).

**2-4-2-5 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 (Devin Dean, 2005).

**2-4-2-6 Ultrasound:**

**2-4-2-6-1 Renal Ultrasound Protocol:**

Preparation of the patient**:** No preparation is required. If the urinary bladder is to be examined, the patient should drink water. Position of the patient:

Start with the patient lying on his/her back (supine). Cover the right upper abdomen liberally with coupling agent. Choice of transducer: For adults, usea3.5MHz transducer. For children and thin adults, use a 5.0 MHz transducer. Setting the correct gain: Start by placing the transducer over the right upper abdomen. Angle the beam as necessary andadjust the gain to obtain the best image of the renal parenchyma.

Scanning technique: The right kidney can be seen best with the patient supine, using the liver as an acoustic window. Scanning is always done in deep suspended 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 a 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 (P. E. S. Palmer ,1995).

**2-4-2-6-2 Normal songraphic features of kidney:**

The cortex of the normal kidney is slightly hypoechoic when compared to the adjacent liver parenchyma, although this is age-dependent. In young people it may be of similar echogenicity and in the elderly it is not unusual for it to be comparatively hyperechoic and thin. The medullary pyramids are seen as regularly spaced, echo-poor triangular structures between the cortex and the renal sinus. The tiny reflective structures often seen at the margins of the pyramids are echoes from the arcuate arteries which branch around the pyramids. The renal sinus containing the PCS is hyperechoic due to sinus fat which surrounds the vessels. The main artery and vein can be readily demonstrated at the renal hilum and should not be confused with a mild degree of PCS dilatation. (jane Bates ,2004).

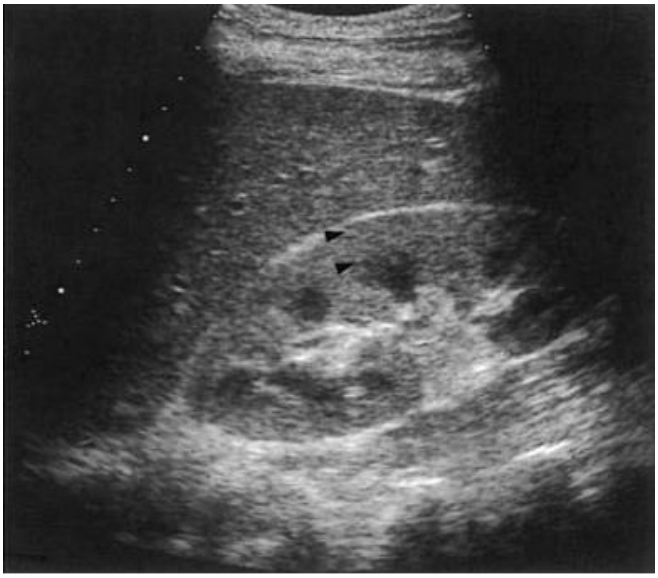


**Figure (2-16)** Right normal kidney (janeBates, 2004).

**Normal renal measurements in adult:**Measurements made by ultra sound are generally less than those made by radiography; they are more accurate. The size of the kidneys is affected by age, sex,(greater in males more than females) and body habitus , furthermore , the left kidney is slightly larger than the right in most individuals. Renal measurements is part scanning protocol because of that any measurement out of range is indication of pathology. Sonographer and sonologist used to do several renal measurements such as:Renal length: referred to longest pole to pole distance measure in three positions supine, supine lateral, and prone normal measurement between 9 to 12 cm in adult. Renal width: referred to maximum dimension in transverse crossection at the level of renal hilum normal measurement 4 to 6 cm may is little varying with the angle of scanning.Renal depth or breadth or thickness:is referred to orthogonal anteroposterior from maximum dimension in transverse crossection normal measurement up to 3.5 in adult but may vary little by angle of scan.Renal volume: is estimated volume of kidney it will be calculated by formula; Rv= l x w x d x ,49 ( 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 individualkidneys, and tend to decrease by age.Parenchyma thickness (PT): defined as combined thickness of the cortex and medulla measured at the upper and lowerpoles 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).

Renal measurements in pediatric :The kidneys of newborns are about 4.5 cm long, almost 2 inches, and weigh just less than an ounce. Kidneys of adults are about 12 cm long, nearly 5 inches, and weight about 5 ozs. The growth of kidneys correlates more with a child's growth in height rather than age, and the normal length of the kidneys can be estimated using asimple mathematical formula based on your child's height. The kidneys grow rapidly in the first year of life, from 4.5 cm to 6.5 cm, and then gradually into adulthood, only about 0.3 cm, an eighth of an inch, per year on average(Devin Dean, 2005).

**2-5 previous study:**

-Study done byZeb Saeed et al, 2012 (Pakistan) which include Sonographic Measurement of Renal Dimensions in Adults and its Correlates in the city of Karachi, Pakistan.Result : Mean kidney lengths were 9.85cm ( 9.74-9.95 cm) on right side and 10.0cm (9.85-10.1 cm) on left. The mean width was 4.61cm (4.53 – 4.68cm), cortical thickness 1.46 cm (1.43-1.49cm) with estimated average kidney volume 35.7 cm3 (34.1-36.5 cm3). Males had larger kidney sizes than females ($p < 0.001$); age however wasonly associated with a decrease tyifyhuuu;and above.($p=0.001$) Renallength best correlated with body weight (correlation coefficient 0.384) .

-Study done byMahmoud Jabbari et al,**2016** (Iran) which include Normal Renal Dimensions in Iranian Adults Measured by Ultrasound**,** Renal dimensions, including length and parenchymal thickness were measured by sonography in 103 individuals

with no renal disease.Results: Mean (SD) kidney length was 104.96(6.6) mm for the right, and 106.22(6.16) mm for the left kidney (P=0.02). Mean (SD) parenchymal thickness for the right kidney was 16.9(1.6) mm and on the left side, it was 18.2(1.7) mm (P<0.001). Gender related analysis showed significant differences between male and female renal length and parenchymal thickness (P<0.05). Age group analysis regardless of sex showed significant decrease in renal length and parenchymal thickness beyond the fifth decade of life.There was a positive correlation between bilateral renal length and body weight as well as BMI. Also, there was a weak positive correlation with body height.

-Study done byEze Charles et al, 2014 (Nigeria) which include Normative ultrasound values of renal parenchymal thickness among adults in Enugu, South-East Nigeria.Methods:This was a prospective clinic based study involving 310 normal adults (135 males and 175 females) scanned at University of Nigeria Teaching Hospital, Enugu between August 2003 and November 2004. The RPT measurements were made from the outer renal cortical margin to the outer margin of the sinus echoes at the three major poles. The age, height, weight and body mass index were recorded for each subject.

Results: The average RPT are 1.85 +0.20 cm for the right kidney and 1.95 +0.19 cm for the left kidney. RPT exhibited strong positive correlation with height, weight and body mass index and significant negative correlation with age. No significant difference in mean RPT of both kidneys between genders ($p > 0.05$). The mean RPT of the left kidney was found to be statistically higher than that of the right kidney ($p < 0.05$).

-Study done byMujahidRaza et al, 2011(Pakistan) which include ultrasonographic assessment of renal correlation with body mass index in adults without known renal disease. Methods:Study was conducted in the Department of Diagnostic Radiology, Shifa International Hospital and PIMS Islamabad. Renal size was

assessed by ultrasound in 4,035 adult subjects with normal serum creatinine and without any known renal disease, between November 2002 and December 2010. Renal length, width, thickness and volume were obtained and mean renal length and volume were correlated with body mass index and other factors like age, side, gender, weight and height of the subjects. Results:Mean renal length on right side was 101.6±8.9 mm, renal width 42.7±7.1 mm, and parenchymal thickness 14.4±2.9 mm. On left side, mean renal length was 102.7±9.2 mm, width 47.6±7.0 mm, and parenchymal thickness 15.1±3.1 mm. Mean renal volume on right was 99.8±37.2 $cm^3$ and on left was 124.4±41.3 $cm^3$. Left renal size was significantly larger than right in both genders. Relationship of mean renal length was significant when correlated with age, side, gender, height and $^{weight}$, and body mass index. Renal volumes also showed a similar relationship with side, gender, height and weight, and body mass index; but with age such a relationship was seen only for left kidney.

-Study done byAbdoelrahman Hassan A. B,2016 (Sudan) Ultrasonographic Renal Length and Parenchymal Thickness in Normal Sudanese Population.This study was intended to measure the ultrasound normative values of renal length and parenchymal thickness in adult Sudanese population in order to establish their reference value for Sudanese population while no recorded reference value in literature for them. Ultrasonographic kidney measurements were performed on 77 adult patients without known kidney lesions. Measurements included length and parenchymal thickness. The effect of age, gender, site (left and right side) and height wasstatistically analyzed. All normal patient was included in this study while any renal disease were excluded. This study was include (35) males and (42) females. The mean renal lengths were (10.15± 0.78) and (10.33± 0.80) cm for the right and left kidney respectively. The mean parenchymal thicknesses were (1.4714± 0.33cm) for the right kidney and (1.7169± 0.36cm) for the left kidney. These result were correlated with age, gender, site, and height which showed that there is no significant

difference between right and left renal length, but there was significant difference between right and left parenchymal thicknesses. The significant effect of age was found only in left renal length. The significant effect of gender was noted only in the right parenchymal thicknesses. No significant difference among height groups for renal length, but there was significant difference in right parenchymal thickness. The study concluded that normal value of left renal length was affected with age and normal parenchymal thickness was affected with site (left or right). The right parenchymal thickness was affected with gender and height. Establishment of normal renal values of renal length and parenchymal thickness in Sudanese population will help us in evaluation of patients with chronic renal disease.

# Chapter three

# Material and methods

**3-1 Design of the study:**

This study is across sectional descriptive study was collected from population were either healthy or patient coming to hospital complaining for diseases not related to urinary system.

**3-2 Place and duration of the study:**

This study was carried out in the period from November 2016 to February 2017 in Khartoum state at Ribat Teaching hospital and Alzarra Clinic.

**3-3 Sample size and type**:

This study consisted of 81 populations randomly from 5-80 years. 41 male and 40 female all healthy population included in this study and any population with disease excluded.

**3-4 Study variables :**

Independent (Age, Sex,Height , Weight, Body Mass index ) and Dependant Variables(Renal Length ,Renal Width , renal AP diameter and parenchymal Thickness).

**3-5 material :**

Data of this study was collected by scanning the patient using ultrasound machine (Risingmed, model :RUS 6000D) equipped with 3.5 MHZ curvilinear transducer using coupling gel with Sony printer with thermal paper.

**3-6 Population of the study:**

The population of this study was patient with normal free from any kidney disease.

**3-7 Methods of data collection:**

Using a special data collection sheet (questionnaire), sample of 81populationswith normal free from any kidney disease.

**3-8 sonographic technique :**

Preparation of the patient: No preparation is required. If the urinary bladder is to be examined, the patient should drink water.Position of the patient: Start with the patient lying on his/her back (supine). Cover the right upper abdomen liberally with coupling agent. Choice of transducer: For adults, usea3.5MHz transducer. For children and thin adults, use a 5.0 MHz transducer.Setting the correct gain: Start by placing the transducer over the right upper abdomen. Angle the beam as necessary andadjust the gain to obtain the best image of the renal parenchyma (P. E. S. Palmer, 1995).

Scanning technique: The right kidney can be seen best with the patient supine, using the liver as an acoustic window. Scanning is always done in deep suspended 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 a 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 (P. E. S. Palmer 1995).

**3-9 data analysis:**

The data of this study was analyzed by using Microsoft excel and SPSS program.

**3-10 Ethical approval:**

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

# Chapter four

# Results

## 4-1 Results:

Demographic data for the study population are shown Participants' ages ranged from 5 to 80 years. The data for the different anthropometric measurements in the total study population were as follows: height, 105 to 180 cm; body weight, 15 to 105kg, and BMI, 14to 39kg/m2.

**Table (4-1) general data of the studied population and normal values for kidney parameter:**

| **Descriptive Statistics** | | | | | |
|---|---|---|---|---|---|
| | N | Minimum | Maximum | Mean | Std. Deviation |
| Age | 81 | 5 | 80 | 35.51 | 16.759 |
| Weight | 81 | 15 | 105 | 66.84 | 14.410 |
| Height | 81 | 1.05 | 1.80 | 1.6489 | .11653 |
| BMI | 81 | 14 | 39 | 24.32 | 4.538 |
| RT Kidney Length | 81 | 4.6 | 11.6 | 9.595 | 1.1296 |
| RT Kidney AP Diameter | 81 | 2.5 | 6.9 | 4.196 | .8235 |
| RT Kidney Width | 81 | 3.4 | 7.0 | 5.177 | .8169 |
| RT Kidney Parenchyma Thickness | 81 | .8 | 2.2 | 1.426 | .2724 |
| LT Kidney Length | 81 | 7.0 | 11.7 | 10.020 | .9215 |
| LT Kidney AP Diameter | 81 | 3.0 | 7.0 | 4.830 | .7620 |
| LT Kidney Width | 81 | 3.4 | 8.2 | 5.589 | .8395 |
| LT Kidney Parenchyma Thickness | 81 | .8 | 2.1 | 1.584 | .2552 |

**Table (4-2) Relationship of renal parenchymal thickness with gender:**

| gender | Parenchymal thickness | N | mean | Std.deviation | P value |
|---|---|---|---|---|---|
| male | right | 41 | 1.473 | 0.3066 | |
| | left | 41 | 1.612 | 0.2731 | 0.114 |
| female | right | 40 | 1.378 | .2259 | |
| | left | 40 | 1.555 | .2353 | 0.260 |
| total | right | 81 | 1.426 | .2724 | |
| | left | 81 | 1.584 | .2552 | 0.000 |

From table (4-2) no significant different between male and female kidney.

**Table(4-3)Distribution of renal parenchymal thickness means according to participant's side (right and left) through the whole cases.**

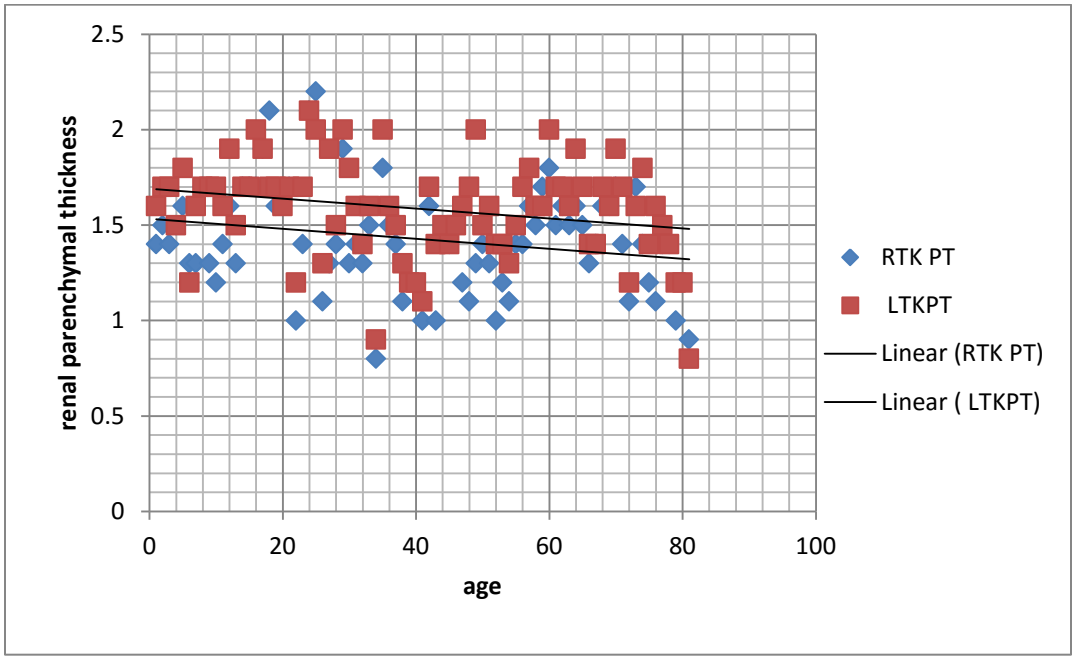
| renal parenchymal thickness | mean | N | Std. deviation | Std. error | Sig(2 tail) |
|---|---|---|---|---|---|
| Right | 1.426 | 81 | .2724 | .0303 | |
| Left | 1.584 | 81 | .2552 | .0284 | 0.000 |

From table (4-3) Significant different between right and left parenchymal thickness about 0.16cm.

**Table (4-4 )distribution of renal parenchymal thickness according to age group (years):**

| Renal parenchyma thickness(cm) | 5-15 N=4 | 16-25 N=26 | 26-35 N=17 | 36-45 N=13 | 46-55 N=10 | 56-65 N=6 | 66-75 N=4 | 76-85 N=1 | P value |
|---|---|---|---|---|---|---|---|---|---|
| Right(mean) | 1.15 | 1.4961 | 1.435 | 1.468 | 1.35 | 1.45 | 1.27 | 1.3 | 0.462 |
| Left(mean) | 1.25 | 1.6153 | 1.7 | 1.646 | 1.47 | 1.583 | 1.35 | 1.2 | 0.140 |

From table(4-4) distribution of renal parenchymal thickness acording to age group noted the parenchymal thickness decrease after age group (46-55) years in both kidneys.No significant negative correlation between age and renal parenchymal thickness-0.083 with right , -0.16 with left.

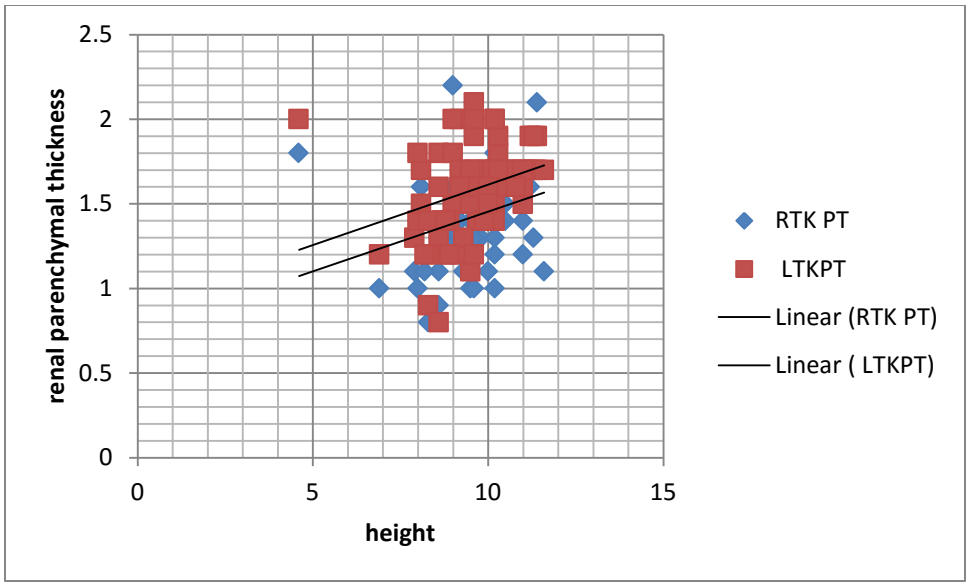



**Figure(4-1)** distribution of renal parenchymal thickness acorrding to age show weak negative correlation with right -0.083 and left –0.165.

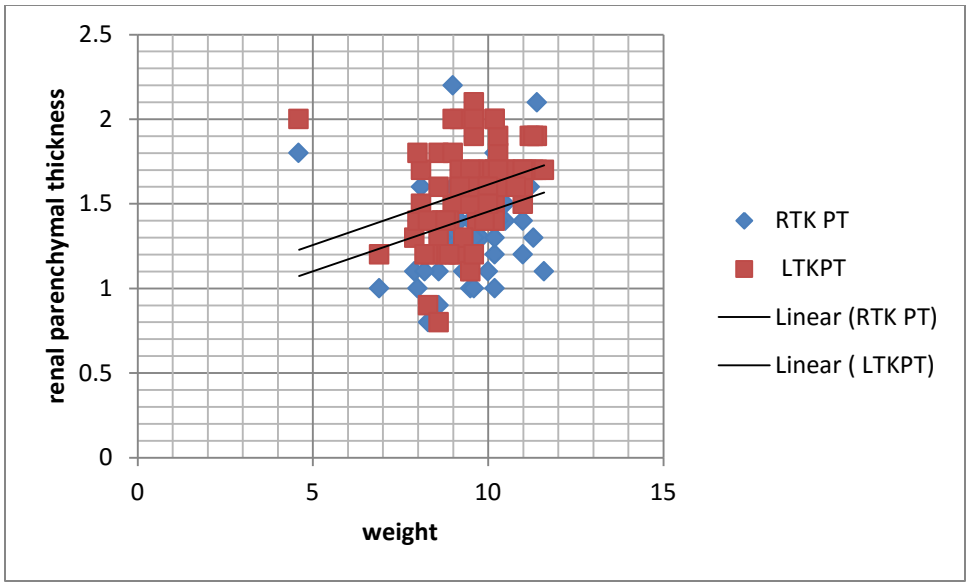
**Table (4-5 )correlation between renal parenchymal thickness with body height and weight:**

| Renal parenchymal thickness | | height | weight |
|---|---|---|---|
| Right | correlation | 0.356 | 0.311 |
| | Sig. (2-tailed) | 0.01 | 0.05 |
| | N | 81 | 81 |
| Left | correlation | 0.295 | 0.236 |
| | Sig. (2-tailed) | 0.007 | 0.034 |
| | N | 81 | 81 |

From table (4-5) significant positive correlation between renalparenchymal thickness with body height and weight.




**Figure(4-2)**correlation between renal parenchymal thickness with body height positive correlation 0.35in right 0.29 in left.



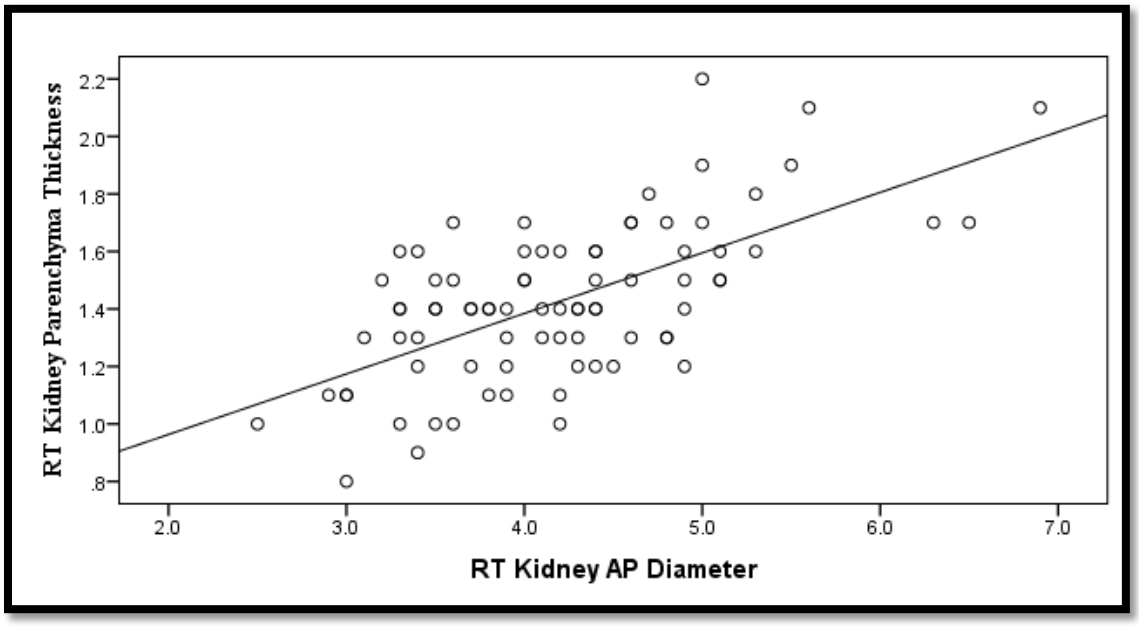

**Figure(4-3)**correlation between renal parenchymal thickness with body weight positive correlation 0.311 in right and 0.236 in left.

**Table (4-6) correlation between kidney length, AP diameter and width with renal parenchymal thickness:**

| Renal parenchymal thickness | | kidney length | kidneyAP diameter | kidney width |
|---|---|---|---|---|
| right | Correlation | 0.293** | 0.636** | 0.615** |
| | Sig. (2-tailed) | 0.008 | 0.000 | 0.000 |
| | N | 81 | 81 | 81 |
| left | Correlation | 0.581** | 0.581** | 0.501** |
| | Sig. (2-tailed) | 0.000 | 0.000 | 0.000 |
| | N | 81 | 81 | 81 |

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

From table (4-6) show significantpositive correlationbetween renal parenchymal thickness with kidney length, AP diameter and kidney width.




**Figure(4-4)** show positive correlation between renal parenchymal thickness with right kidney AP diameter.

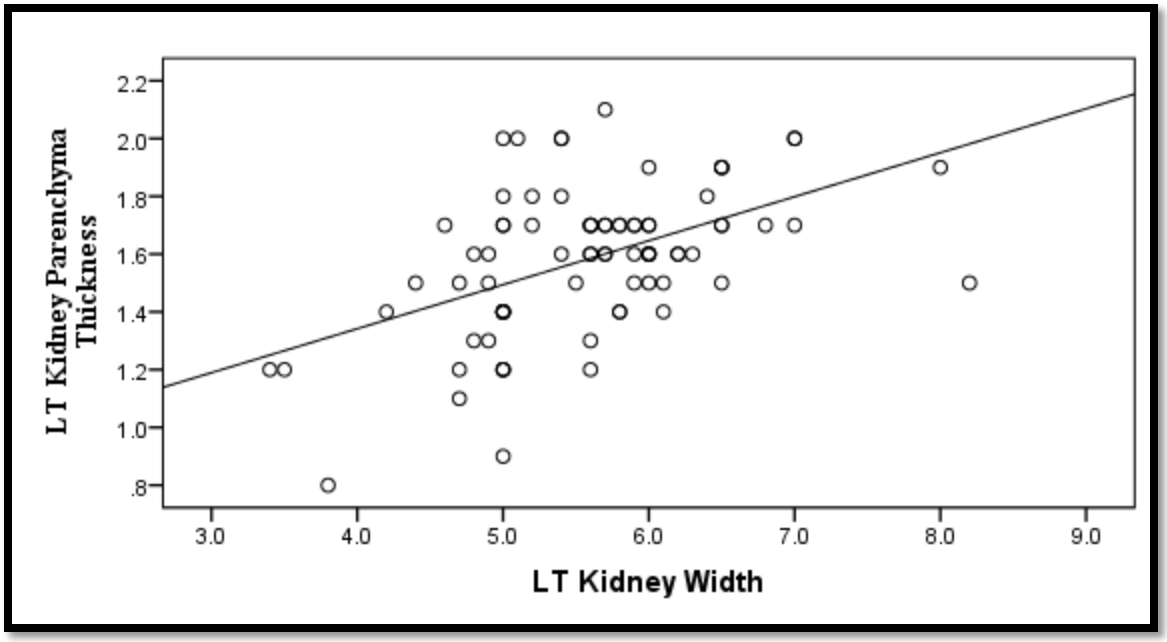



**Figure (4-4)** show positive correlation between renal parenchymal thickness with left kidney width.

# Chapter five

# Discussion, conclusion and recommendation

## 5-1 Discussion

Renal measurements by sonography are important in studying renal function and its disorders, which offersthe advantage of a non-invasive method.

Regarding table (4-2) Relationship of renal parenchymal thickness with gender: The Present study reveals that the mean of right renal parenchymal thickness was (1.47cm) and (1.378 cm) for male and female respectively and left renal parenchymal thickness (1.61cm)and (1.55cm) for male and female respectively The study revealed that no significant difference in renal parenchymal thickness (right and left) between male and female at (P= 0.114), (P=0.260) respectively , this study agree with (Mahmoud Jabbari et al ,2016iran) and( Eze Charles et al , 2014nigeria) whose found that no significant difference in renal parenchymal thickness (right and left) between male and female.

Regarding table (4-3) Distribution of renal parenchymal thickness means according to participant's side (right and left) through the whole cases: The mean of renal parenchymal thickness was (1.426cm) and (1.584 cm) for the right and left kidney respectively. The study also revealed that, the left parenchyma was thicker than the right one, with significant difference between the right and left parenchymal thickness at (P= 0.00) using paired samples statistics, the study agreed with study done by some authors such as (Mahmoud Jabbari et al, 2016 iran), (Eze Charles et al , 2014nigeria) and (Abdoelraman Hassan, 2016sudan) whose found that significant difference between the right and left parenchymal thickness .

Regarding table (4-4) distribution of renal parenchymal thickness according to age group (years): The smallest mean of right renal parenchymal thickness was (1.15cm), noted in the age group (5-15) and the largest mean was

(1.496cm), noted in age group (16-25). The study revealed that there was no significant difference in right renal parenchymal thickness through age groups at (P=0.462) , the study agree with study done by (Abdoelrahman Hassan A. B, 2016 Sudan) who found that no significant difference in right renal parenchymal thickness through age groups .

The thinnest left parenchymal thickness (1.2cm) was noted in the age group (76-85) and the thickest one (1.7cm) was noted the age group (26-35). The study revealed that, no significant difference at (P=0.140) (table 4-4), that mean parenchymal thickness did not vary significantly with age , the study agree with study done by (Abdoelrahman Hassan A. B, 2016 Sudan) who found that no significant difference in left renal parenchymal thickness through age groups .

While this study found that both renal parenchymal thickness decrease after age group (46-55) years in both kidneys,some study show decrease in parencymal thickness after age 50 years by (Mahmoud Jabbari et al,2016Irain).This study foundvery weak negative correlation between age and renal parenchymal thickness-0.083 with right , -0.16 with left, in some study show significant negative correlation between age and renal parenchymal thickness by (Eze Charles et al,2014Nigeria),this indicator for decrease sample size in this study specially in age after 50 years give me weak negative correlation between age and renal parenchymal thickness.

Regarding table (4-5) correlation between renal parenchymal thickness with body height and weight: Renal Parenchymal thickness according to participant's height Show significant positive correlation p= 0.01 in right and p= 0.007 in left (table 4-5) the study agree with study done by (Eze Charles et al, 2014Nigeria) who found significant positive correlation between height and renal parencymal thickness.

Renal Parenchymal thickness according to participant's weight Show significant positive correlation p= 0.005 in right and p= 0.03 in left ), the study agree with study done by (Eze Charles et al, 2014Nigeria) and (Mahmoud Jabbari et al, 2016Iran). Whose found significant positive correlation between weight and renal parenchymal thickness.

Regarding table (4-6) correlation between kidney length, AP diameter and width with renal parenchymal thickness: The correlation between right kidney length, AP diameter and width with right renal parenchymal thicknessshow strong positive correlation p value 0.008, 0.000, and 0.000 respectively.

The correlation between left kidney length ,AP diameter and width with left renal parenchymal thickness show strong positive correlation p value 0.000, 0.000, 0.000 respectively from this strong positive correlation between the same kidney measurement, we can measuring only renal parenchymal thickness enough to known normal or abnormal kidney measurement.

## 5-2 Conclusion:

The average of renal parenchymal thickness is 1.42 +0.27 cm for the right kidney and 1.58+0.25 cm for the left kidney. Renal parenchymal thickness exhibitedstrong positive correlation with height, weight and weak negative correlation with age. No significant difference in mean of renal parenchymal thickness between genders ($p > 0.05$). The mean renal parenchymal thickness of the left kidney was found to be statistically higher than that of the right kidney ($p < 0.05$).Significant positive correlation between renal parenchymal thickness and kidney AP diameter, kidney width and kidney length ($p<0.05$)

**5-3 recommendation:**

- study recommended using in evaluation of patients with chronic or acute renal disease in addition to corticomedulary differentiation.
- Establishment of normal renal values of renal parenchymal thickness in Sudanese population will help us detecting renal changes early.
- This study recommended to other studies in renal measurement with large number of population and different areas in Sudan.

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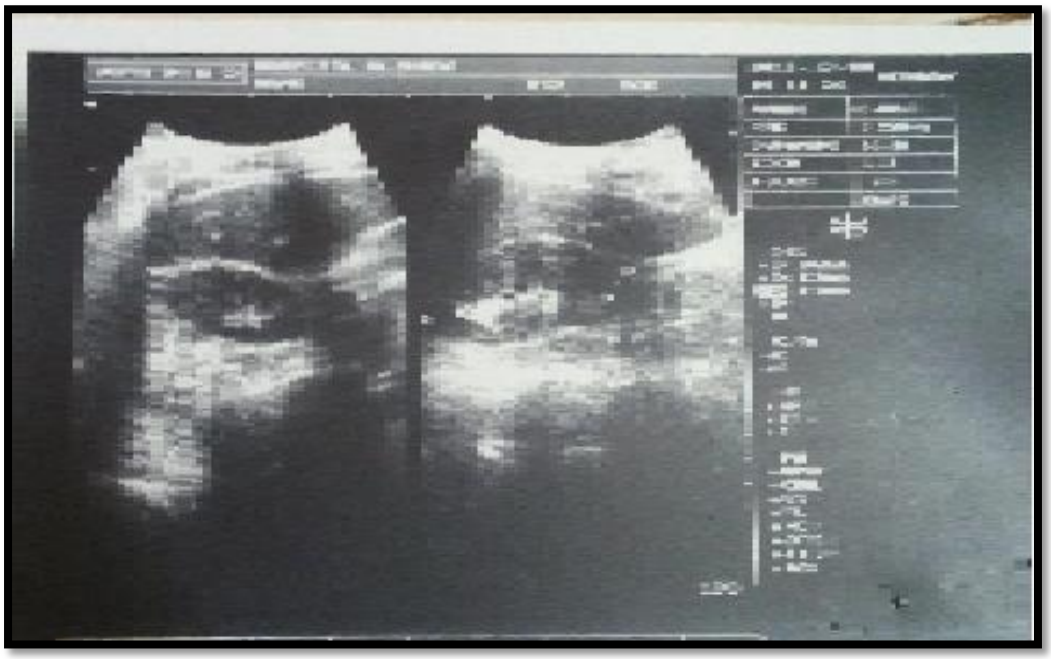
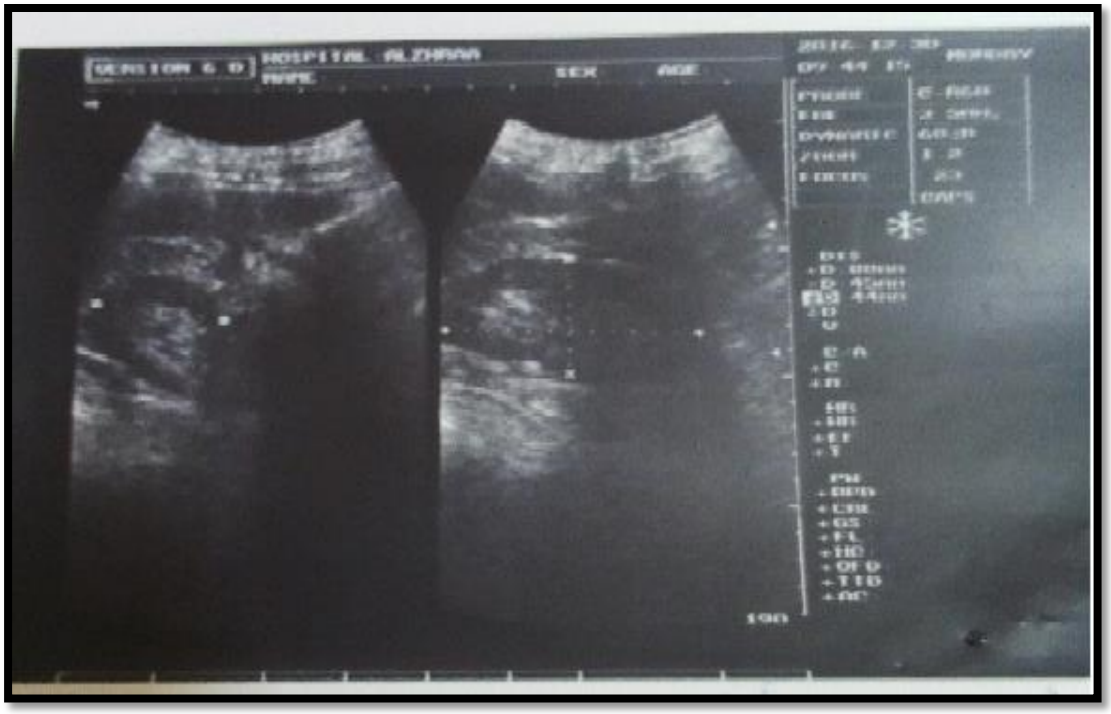
# Appendices

**Images of Normal Kidneys**

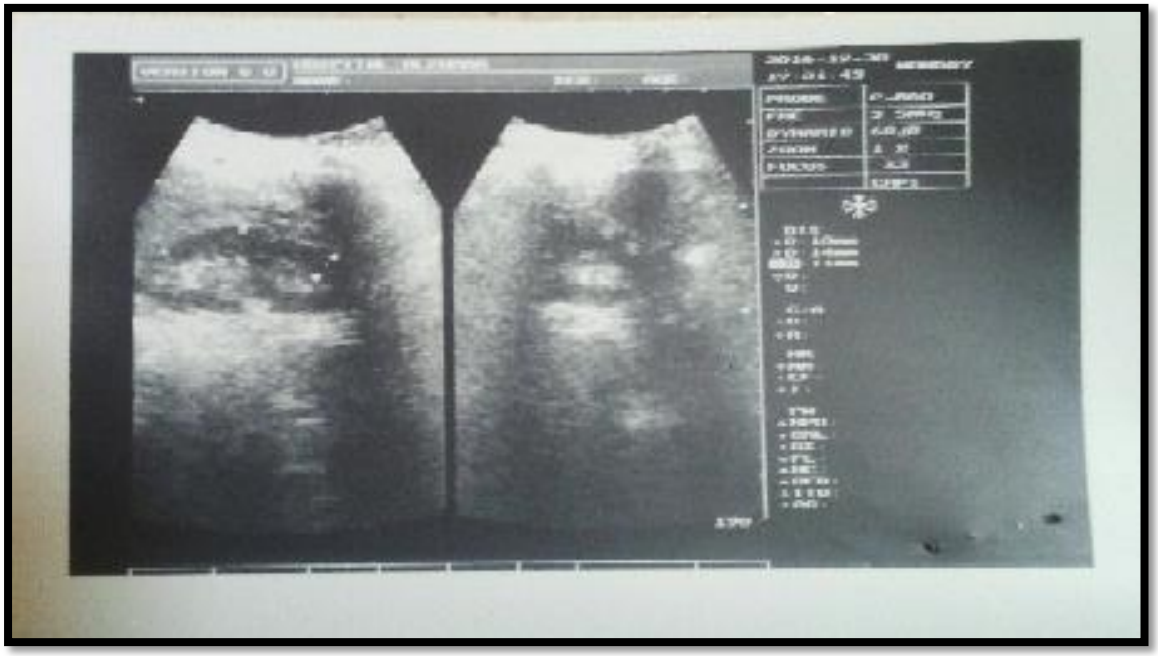
**Ultrasound image (1) Right kidney for female age 20 years**



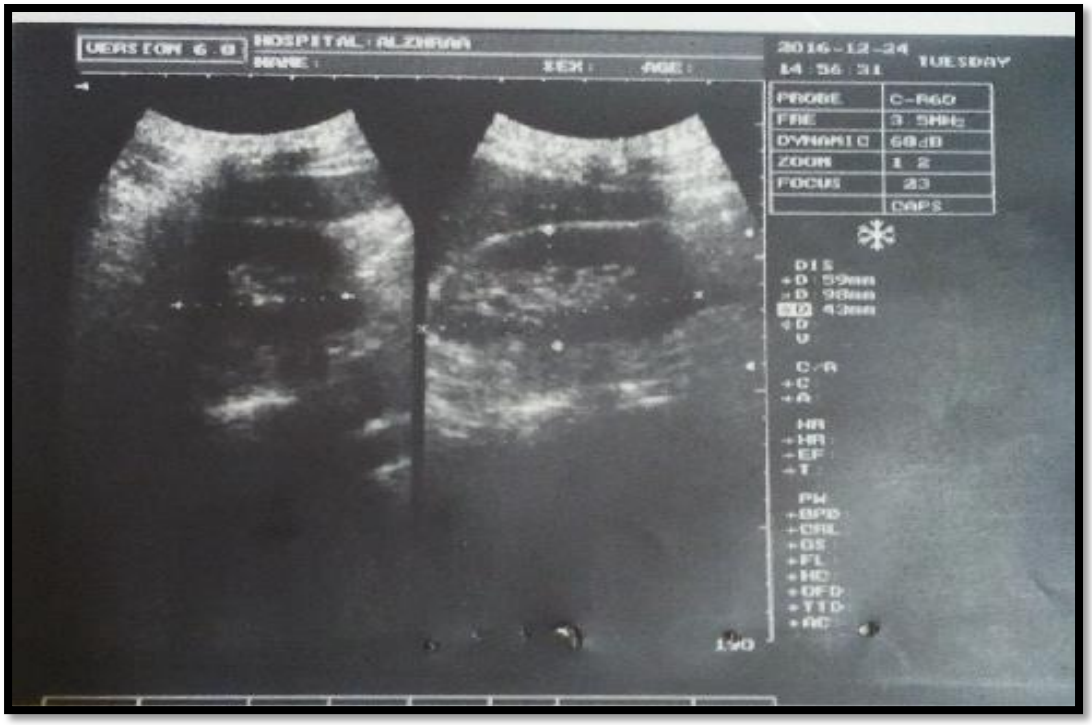
**Ultrasound image (2) Right kidney for female 30 years**



**Ultrasound image (3) Left kidney for female 60 years**



**Ultrasound image (4) Left kidney for male 60 years**

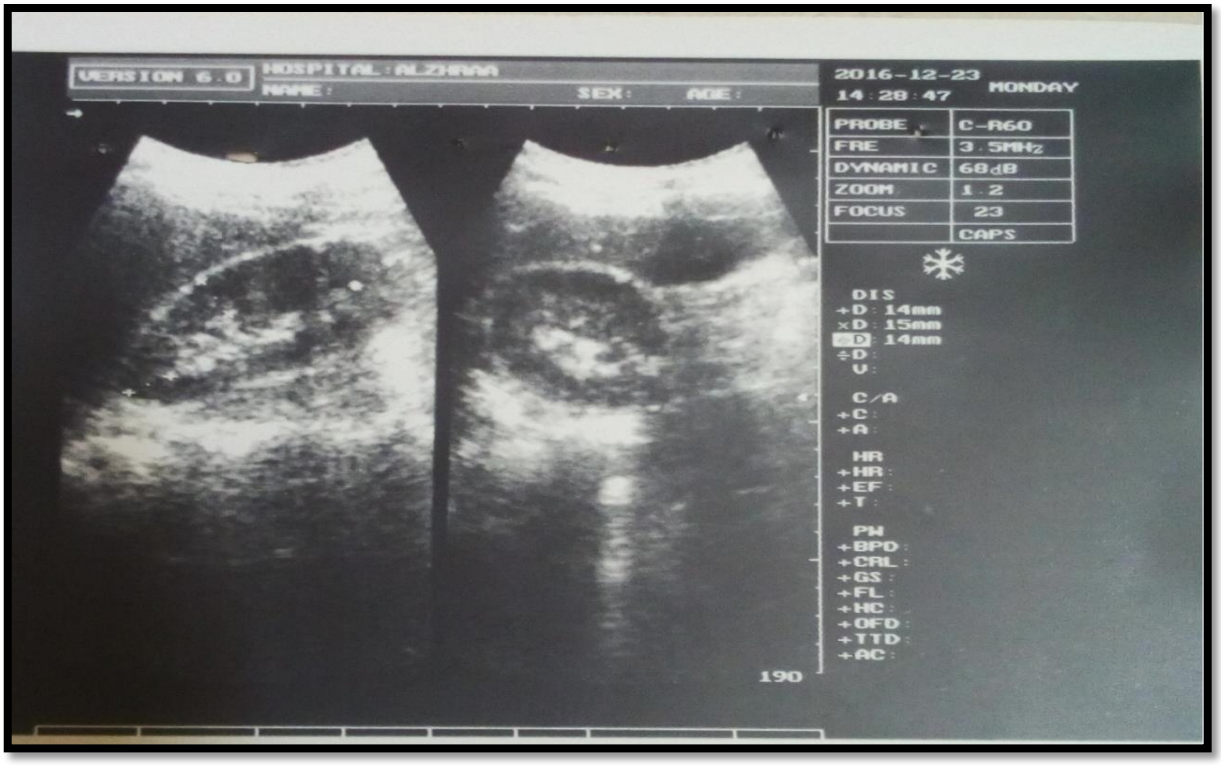



**Ultrasound image (5) right kidney for female 40 years**

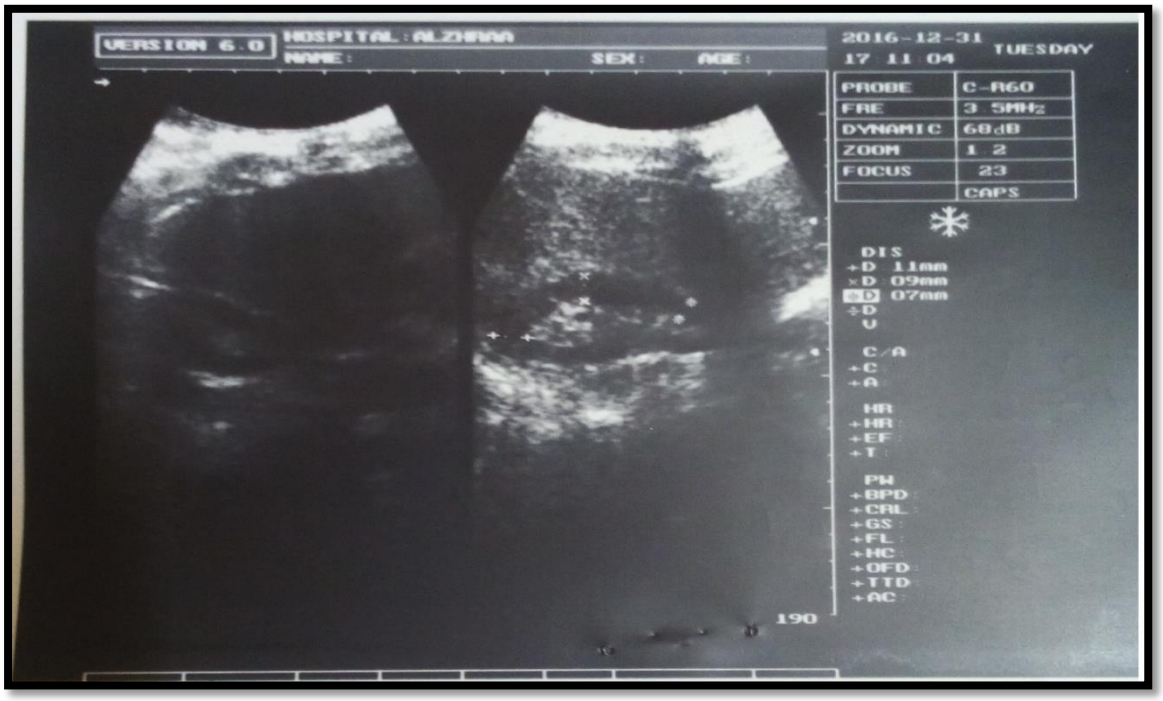

**Ultrasound image (6) Right kidney for female 35 years**


**Ultrasound image (7) right kidney for female 45 years**

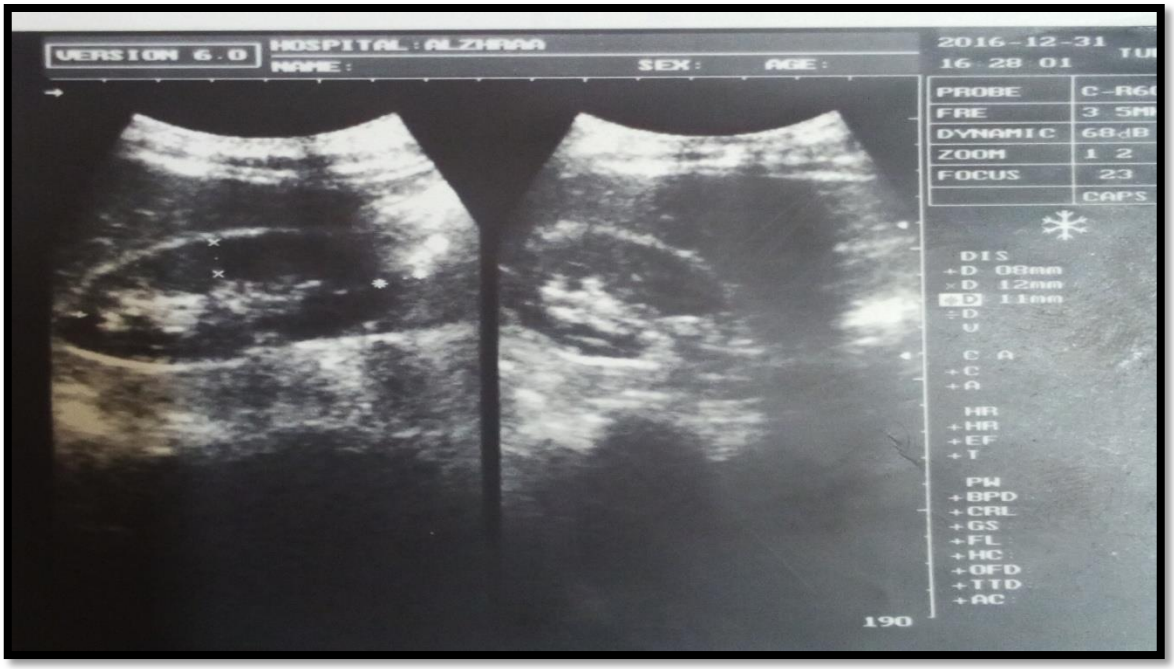

**Ultrasound image (10) Right kidney for male 25 years**



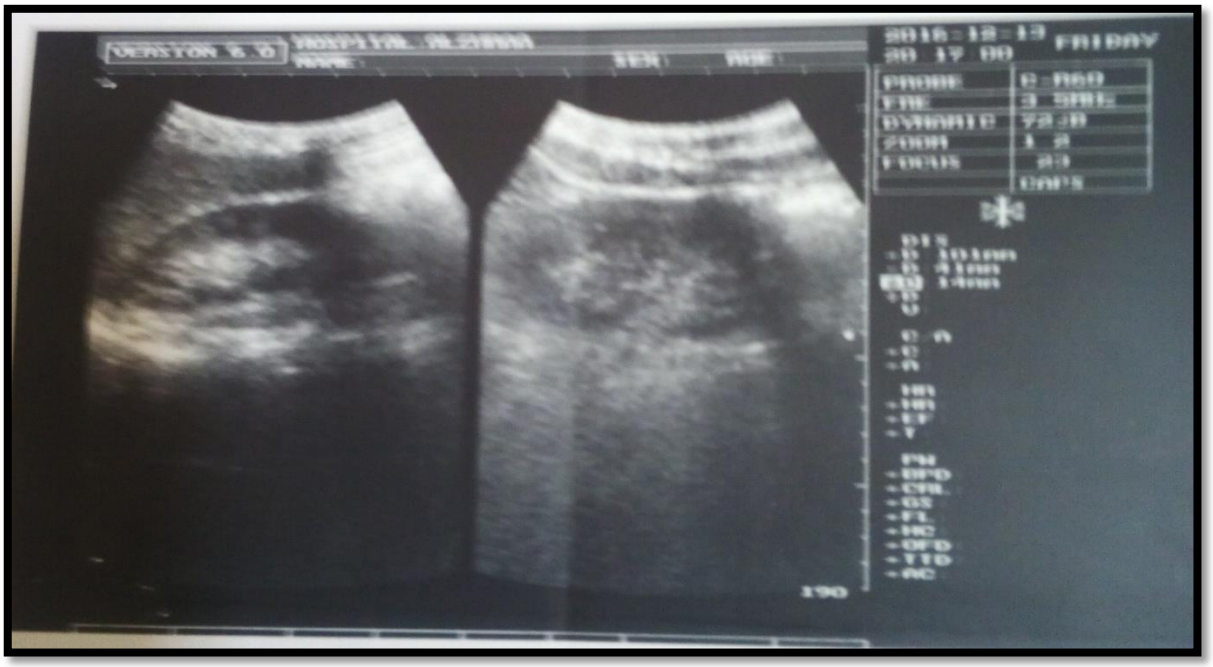

**Ultrasound image (8) Right kidney for male 33 years**




**Ultrasound image (11) Right kidney for female 50 years**

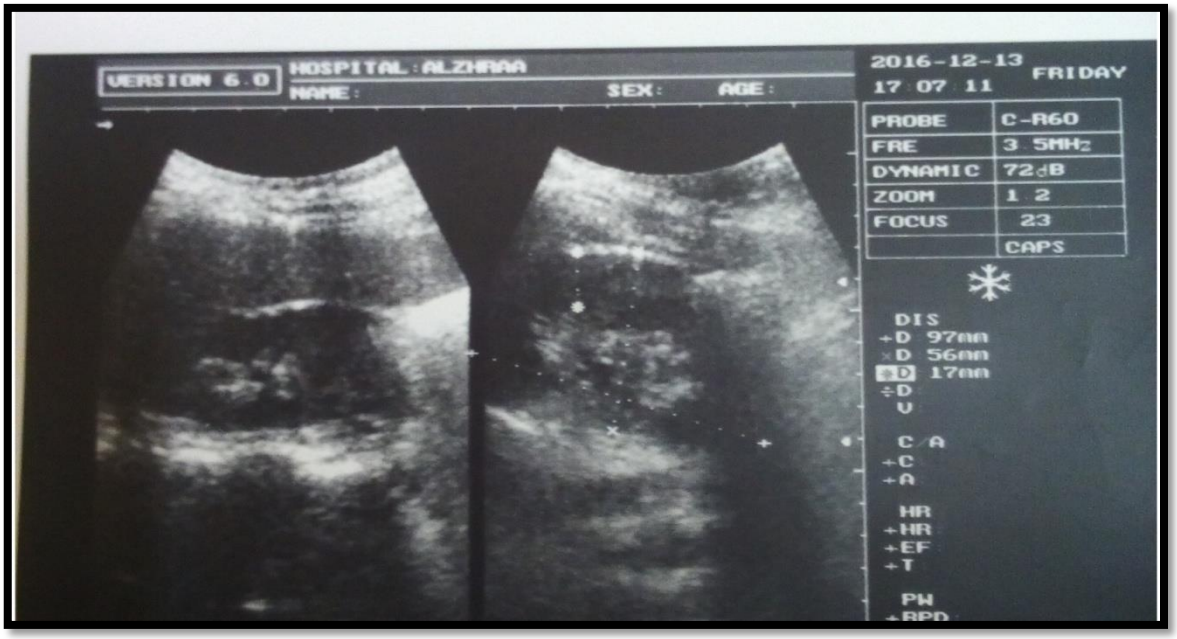



**Ultrasound image (9) Right kidney for male 52 years**

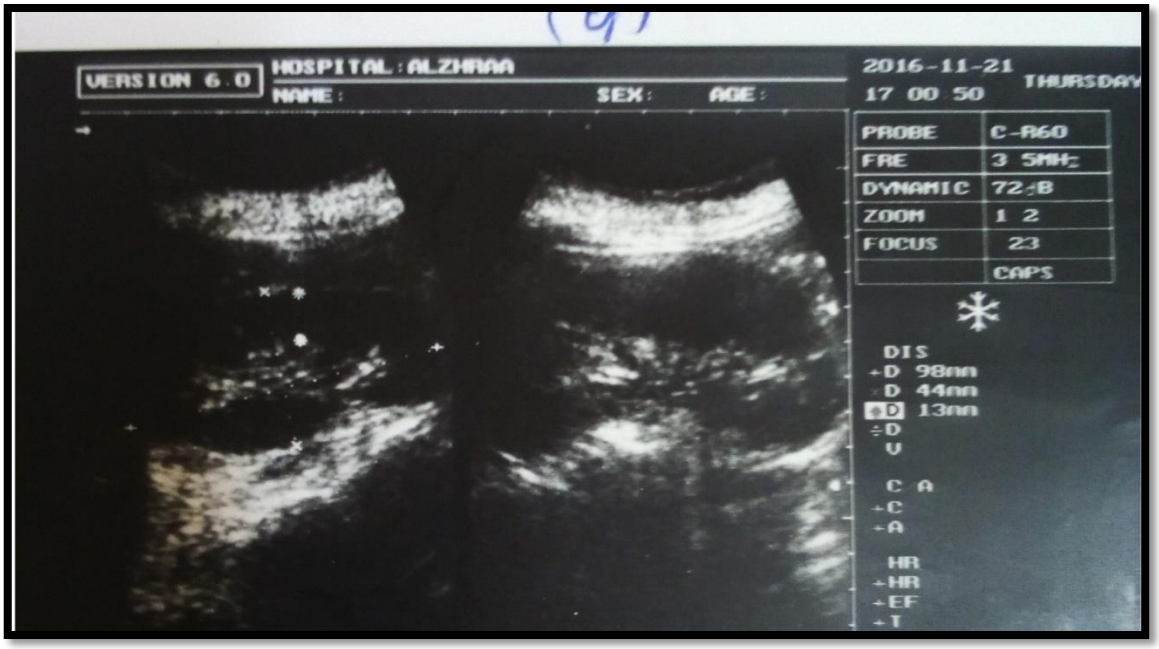



**Ultrasound image (12) Right and left kidney for male 31 years**

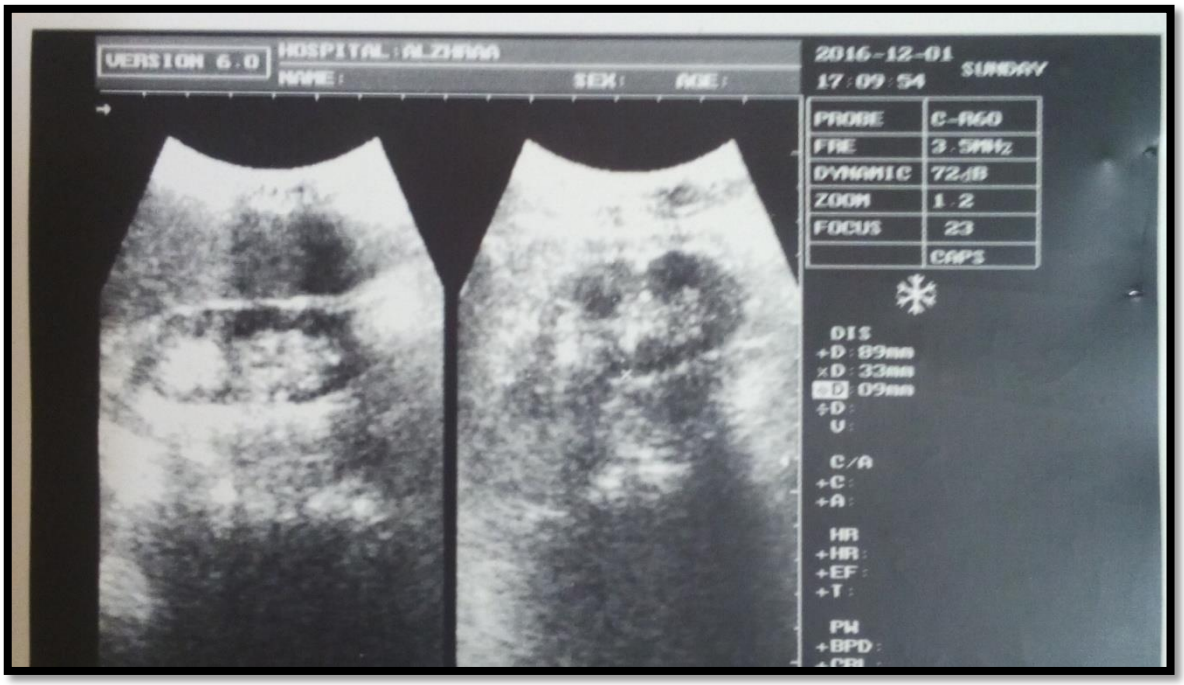

**Ultrasound image (13) Right kidney and left for male 10 years**




**Ultrasound image (16) Right and left kidney for male 17 years**

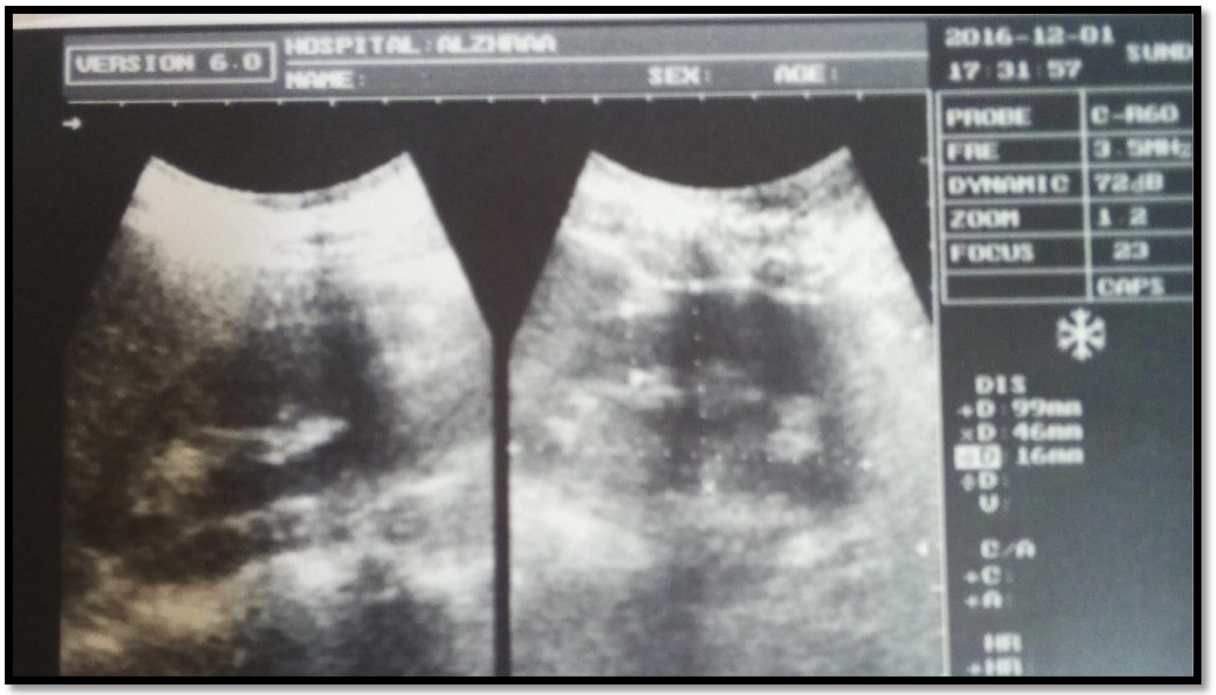



**Ultrasound image (14) Right and left kidneys for female 22 years**




**Ultrasound image (17) Right and left kidneys for male 60 years**


**Ultrasound image (15) Right and left kidneys for female 27 years**




**Ultrasound image (18) Right and left kidneys for female 29 years**

# Sudan University of sciences and technology

## College of graduate studies

### Data Sheet collection

| no | gender | age | weight | tall | BMI | Kidney parameter | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | RT kidney | | | | | | | LT kidney | | | | | | | |
| | | | | | | **length** | **AP** | **Width** | Cortex thickness | | | | **length** | **AP** | **width** | Cortex thickness | | | |
| | | | | | | | | | U p | midle | LP | mean | | | | UP | midle | LP | mean |
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