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Sonographic Renal Measurements for Sudanese Children

قياسات الكلى عند الأطفال السودانيين باستخدام الموجات فوق الصوتيه

Athesis Submitted For Partial Fulfilment of the Requirments of M.Sc Degree in Medical Diagnostic Ultrasound

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May 2016

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سورة طه الايه 114

Dedication

I dedicate this work

To

All Children in my Beloved Country,

My Family,

My Colleagues

And

Radiology Department of Mohamed Alamin Hamed Hospital for Pediatric

Safia

Acknowledgment

I would like to thank all pearsons they help me to produce this work

My Supervisor : Dr Babiker Abdalwahab,

My CO.Supervisor(PediatricNephrologist,Sonologist) : Dr Awad Alla Hassan

And

Dr Ahmed Almustafa

Sa

Abstract

Childhood is an important period of growth for many organ systems, among various growth parameters, kidney size is an important parameter used for the clinical evaluation of renal growth and renal abnormalities, the aim of this study was to evaluate the association between renal dimensions and somatic parameters and analyze the affecting factors for renal size during growth to provide a reliable and practical reference for normal standard kidney length and volume values in Sudanese children.

we examined 60 Sudanese children ages from 1month to 14 year age including a total of 33 boys and 27 girls without renal problems. The maximum renal length (L) (cm), Breadth(orthogonal anterior-posterior diameter orD) (cm) and width (W) (cm) of each kidney were measured by ultrasound Esaote Pie Medical with convex 3.5 frequency transducer . Kidney volume was calculated as 0.523 x L x D x W (cm3) an age and anthropometric indices including height (cm), weight (kg) and body mass index (m2/kg) were collected through a medical record review. the mean renal length ,and volume with standard deviation (SD) were estimated for every group of age. The renal length and volume were determined and corresponded with different somatic variables. Descriptive statistics with Regression analysis was done.

There were significant correlations between all renal dimensions with age, weight, height, In the regression analysis, the most significant contributing factor to renal growth was height , there was statistically significant differences were observed between right and left kidneys length and volume but there is no significant difference between other kidney measurements(width and breadth).also the study found that was no significant difference in the kidney length and volume among boys and girls in all age groups. Scatter plots were created, and they showed a close linear relationship between height and renal length and renal volume.

The research presents reliable practical reference for normal standard kidney length and volume values by sonography in healthy pediatric population in Sudan .

ملخص البحث

الطفولة هي فترة مهمة للنمو في العديد من أجهزة الجسم المختلفة ,من بين معايير النمو المختلفة حجم الكلى و هو معيار مهم يستخدم في التقييم السريري لنمو الكلى و تشوهات الكلى ،كان الهدف من هذه الدراسة تقييم الارتباط بين أبعاد الكلى والعمر والمعايير الجسدية كالطول والوزن والوزن / الطول مربع وتحليل العوامل التي تؤثر على حجم الكلي خلال فترة النمو لتوفير قيم مرجعيه عمليه موثوق بها لطول وحجم الكلى القياسي الطبيعي عند الأطفال السودانيين

تم فحص 60 طفلا سودانيا تتراوح اعمارهم من شهر الى 14 عاما بما في ذلك ماجموعه 33 ذكور و 27 إناث ليس لديهم مشاكل في الكلي تم قياس الحد الأقصى للطول الكلوي (L) (سم)، و اتساع (متعامد القطر الأمامي الخلفي أوعمق) (سم) و عرض (W) (سم) كل من الكليتين بواسطة الموجات فوق الصوتية (إيسوت باي مديكال) مع محدب محول 3.5 التردد. تم حساب حجم الكلى 0،523 × طول الكليه × عرض الكليه×سمك الكليه,تم تسجيل بيانات العمر والوزن(كجم) والطول(سم) و مؤشر كتلة الجسم (متر2 / كجم) لكل حاله تم جمعها من خلال مراجعة السجلات الطبية . قدر متوسط طول وحجم الكليه ، بانحراف معياري (SD) لكل مجموعة من العمر. تم تحديد طول الكليه وحجمها علي حسب المتغيرات الجسمية المختلفة . و تم عمل إحصاءات وصفية مع تحليل الانحدار.

وجد ان هناك ارتباط كبير بين جميع أبعاد الكلى مع تقدم العمر والوزن والطول ، وفي تحليل الانحدار كان الطول هو العامل الأكثر اهميه في نمو الكلى ، وكما لوحظت فروق ذات دلالة إحصائية بين الكليه اليمين واليسار اثبتت ان اليسار اكبر من اليمين,ولكن ليس هناك فرق كبير بين قياسات الكلى الأخرى كعرض الكليه اليمنى و عرض الكليه اليسرى ، سمك الكليه اليمنى و سمك الكليه اليسرى كما وجدنا انه لا يوجد اختلاف كبير في طول الكلى و حجمها بين البنين والبنات في جميع الفئات العمرية . تم إنشاء رسم احصاءي مبعثر ، أظهر وجود علاقة خطية وثيقة بين الطول و طول الكلوي وحجم الكلى ، صيغت معادلات حيد المتغير باستخدام الانحدار الخطي البسيط لتقدير الطول الكلوي من خلال الطول المعين

قدم البحث مجموعة قيم مرجعية عملية موثوقة لطول الكلى و حجم الكلى القياسي الطبيعي بالموجات فوق الصوتية للأطفال الأصحاء في السودان.

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List of Abbreviations

AML	Angiomyolipoma
ARPRD	Autosomal Ressive Polycystic Renal Disease
ARF	Acute Renal Failure
BMI	Body Mass Index
BUN	Blood Urea Nitrogen
CRF	Chronic Renal Failure
CT	Computed Tomography
IVU	Intravenous Urogram
MPT	Medulary Paramid Thickness
NKF	National Kidney Foundation
NM	Nuclear Medicine
GFR	Glumerular Fillteration Rate
RCC	Renal Cell Carcinoma
RPT	Renal Pyramid Thichnes
TCC	Transitonal Cell Carcinoma

Chapter One

1-1 Introduction

No medical treatment can or should be considered or given until a proper diagnosis has been established**,** for a considerable number of years after Roentgen first described the use of ionizing radiation at that time called ‘X-rays’ for diagnostic imaging in 1895, this remained the only method for visualizing the interior of the body. however, during the second half of the twentieth century new imaging methods, including some based on principles totally different from those of X-rays, were discovered, ultrasonography was one such method that showed particular potential and greater benefit than X-ray-based imaging. during the last decade of the twentieth century, use of ultrasonography became increasingly common in medical practice and hospitals around the world, and several scientific publications reported the benefit and even the superiority of ultrasonography over commonly used X-ray techniques, resulting in significant changes in diagnostic imaging procedures. (Elisabetta Buscarini, 2013)

Ultrasound is safe and painless, and produces pictures of the inside of the body using sound waves. the ultrasound images are captured in real-time,. it is used to help physicians evaluate symptoms such as:Pain,swelling,infection.it’s is a useful way of examining many of the body's internal organs, including the abdominal aorta and its branches, liver, gallbladder, spleen, pancreas, kidneys, bladder, uterus, ovaries and unborn child (fetus) in pregnant patients, eyes, thyroid, and parathyroid glands, scrotum,(testicles) ,brain in infants, hips in infants Ultrasound is also used to: guide procedures such as needle biopsies, in which needles are used to sample cells from an abnormal area for laboratory testing. Image the breasts and guide biopsy of breast cancer and diagnose a variety of heart conditions, including valve problems and congestive heart failure, and to assess damage after a heart attack. Ultrasound of the heart is commonly called an “echocardiogram” or “echo , Doppler ultrasound images can help the physician to see and evaluate: blockages to blood flow (such as clots),narrowing of vessels, tumors and congenital vascular malformations. (America, 2014), conventional ultrasound displays the images in thin, flat sections of the body. advancements in ultrasound technology include three-dimensional (3D) ultrasound that formats the sound wave data into 3D images**.** (America, 2014)

Kidney ultrasound is a noninvasive diagnostic exam that produces images, Renal ultrasonography has become the standard imaging modality in the investigation of kidneys because it offers excellent anatomic detail, requires no special preparation of patients is readily available and does not expose the patient to radiation or contrast agents. Renal size and location can be determined. Solid tumors can be detected and can be distinguished from renal cysts. Ultrasonography can detect nephrolithiasis and hydronephrosis. Dilated ureters can frequently be followed up to the location of the occluding concernment. detection of renal arteries is reliably possible with Color Doppler sonography. (Wrenger, 2010)

Renal size is an important parameter in the assessment of a child with renal disease since the kidney continues to grow in size after birth and reaches the near adult size of 10 cm by 12 years of age decrease or increase in kidney size is an important sign of renal disease. Thus while evaluating a child presenting for the first time with a sudden deterioration of renal functions; it is the kidney size which helps differentiate acute kidney injury where the size maybe normal or large, from an acute exacerbation of chronic kidney disease (CKD) where the kidney size is invariably small. Shrunken kidney size can also be decisive factor for avoiding a renal biopsy or immunosuppressive therapy in certain disorders. The clinical value of measuring the size of the two kidneys has now received general acknowledgement . Renal size can be estimated by measuring renal length, renal volume and cortical volume or thickness. Renal volume is the most accurate measurement of kidney size because it is correlated with the subject’s height, weight and total body area; however measurement of renal volume is not a precise method due to high inter-observer variation. Renal length as measured by ultrasonography is a simple, practical and reproducible measurement and widely accepted to monitor renal size and growth.. A growing kidney in a child is a healthy kidney, whereas a kidney static in size over time may be an early indicator of CKD. (Kanitkr, JULY,19, 2012)

Only a few studies have been published on sonographic renal measurements in a pediatric age group in the western world. We are lacking normative data according to age, gender, and body size for Sudanese children**.** In this study we have determined the renal sizes for healthy Sudanese children (1 month to 14 years), we measured the kidney length , W :(width of kidney), depth (thickness) and volume calculated by a formula V= LxWxD for healthy children by using ultrasound, we found Individual variations associated with age and somatic parameters (,height and weight, BMI).The mean renal dimensions and volume were calculated for each age group. The renal length and calculated renal volume were correlated with somatic parameters like age, weight, height and body mass index Regression equations were derived for kidney length and height, we found: no statistical difference in renal size between sexes and between right and left kidney. A strong correlation was seen between renal size with various somatic parameters, the best correlation was between renal length and body height (coefficient of correlation) .

In conclusion**:** This study provides values of renal length and volume (mean) in normal Sudanese children. Renal length can be easily calculated by derived linear regression equation.

1-2 problem of study :

Renal size is an important parameter used in the diagnosis and follow up of renal diseases, however while making decisions clinicians must be aware of the dependence of these dimensions to somatic parameters(age ,weight , height ,Body mass index).

There is no established nomogram for renal sizes in the Sudanese children .

1 - 3 Objectives :

Since there is no kidney size reference values available for sudanese children so the aim of study to provide reliable and practical reference for Normal Standard Kidney Measurements Values for Sudanese Children according to age, height, weight and body mass index.

1-3-1 General objectives :

To measure the renal size for sudanese children using ultrasound .

1-3-2 specific objectives :

To evaluate the relationship between somatic parameters and renal length and volume measured with ultrasound in Sudanese children who have morphologically normal Kidneys.

To determine normal sonographic measurement of renal size and correlation with somatic variables in pediatric population on subset of Khartoum .

1-4 significance of study:

This study provide estimated renal size for pediatric associate with their age and somatic parameters therefore mistake in renal measurements will decreas , so early management can take place.

1 – 5 Overview of Study:

This study consist of five chapters : with chapter one is an introduction introduce briefly this thesis and contained (introduction , problem of study , objectives ,significant of study and over view of study). Chapter two is literature review which include theoretical pack ground and previous study. Chapter three was describe the methodology (material and method) that used in this study. Chapter four included result presentation. Chapter five is discussion , conclusion ,and recommendations for future scope in addition to reference and appendices.

Chapter Two

Literature Review

Firstly we review the Embryology, Anatomy , Physiology , Pathology , General Investigation Done for Kidney ,Renal Sonography and previous studies.

2-1 Embryology:

Kidney development, or nephrogenesis, describes the embryologic origins of The kidney.

2-1-1 phases:

The development of kidney proceed through a series of successive phases, each marked by development of amore advance kidney: the pronephros ,mesonephric, and metaphors.

Pronghorns : the pronephros develop in cervical region of the embryo during approximately day 22 of human gestation , the paired pronephros appear to words the cranial end of intermediate mesoderm .In this region epithelial cells arrange themselves in a series of tubules called nephrotoms and join laterally with the pronephric duct this duct fully contained within the embryo and excrete filtered material outside the embryo there for pronephros is non functioning in mammals (Carlson, 2015).

Mesonephros: the development of pronephric duct proceeds in a cranial – to caudal direction .As it elongates caudally the pronephric duct induces nearby intermediate mesoderm in the thoracolumbar area to become epithelial tubules called mesonephric tubules glum. Each mesonephric tubules receive blood supply from a branch of aorta ending in capillary tuft analougus to glomerulus of the definitive nephron , the mesonephric tubule form a capsule around the capillary tuft allowing filtration of blood (Carlson, 2015).

Metanephros :during the fifth week of gestation the mesonephric duct develops an out pouching the ureteric bud ,near it,s attachment to cloaca . This bud also called metanephrogenic diverticulum , grow posterior and to words the head of the embryo ,the elongated stalk of the ureteric bud ,called the metenephric duct ,later form the ureter , as the cranial end of the bud extends in to intermediate mesoderm , it undergoes series of branching to form the collecting duct system of the kidney . It also forms the major and miner calyces and the renal pelvis . The portion of un differentiated intermediate mesoderm in contact with the tips of the branching ureteric bud is known as metanephrogenic blastoma.Signal released from ureteric bud induce the differentiation of metanephrogenic plastoma in to renal tubules . As the renal tubule grow , they come in to contact and join with connecting tubules of the collecting duct system, forming a continuous passage for flow from renal tubule to collecting duct.stimultaneously, precursors vascular endothelial cells begin to take their position at the tips of the renal tubules. These cell differentiate in to the cell of the definitive glomerulus .In human all the branches of ureteric bud and the nephrogenic units have been formed by 32 to 36 weeks of gestation . However ,these structures are not yet mature , and will continue to mature after birth . once matured human have anestimated one million nephrons (approximately 500,000 per kidney) . (Carlson, 2015)

Migration :after including the metanephric mesenchyme the lower portion s of the nephric duct will migrate caudally (down ward) and connect with the bladder, there by forming the ureters . The ureter will carry urine from the kidneys to the bladder for excretion from the fetus in to amniotic sac . As the fetus develops , the torso elongates and the kidneys rotate and migrates up ward with in the abdomen which couse the length ureters to increase figure (2-1) . (Carlson, 2015)

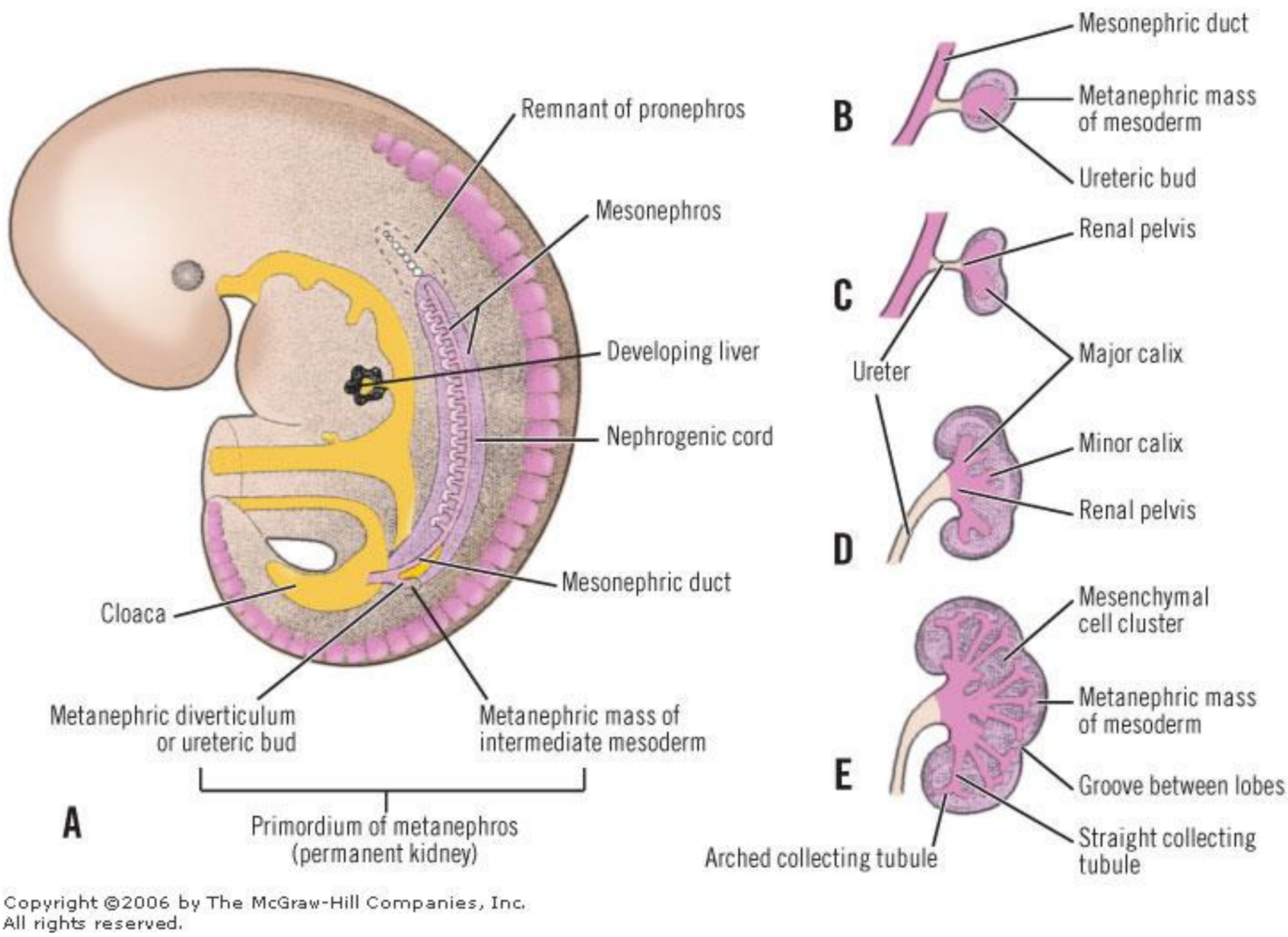


figure (2-1) Embryology of Kidney (Carlson, 2015)

2-2 Anatomy:

The main part of urinary system is the kidneys which are connected to the urinary bladder by ureters and urethra that connects to the external genitalia as shown in figure (2-2) .

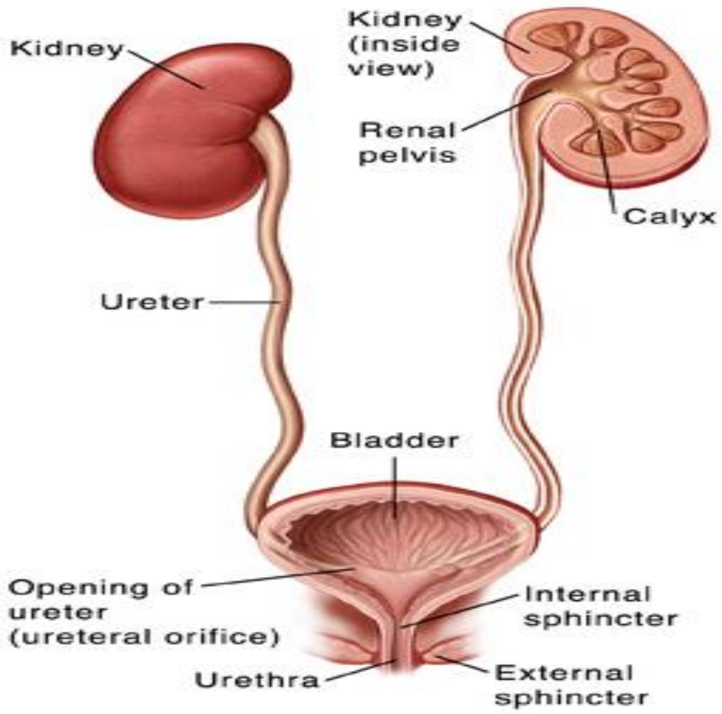


figure (2-2) Urinary System (Richard Lee Drake, 2010)

2-2-1 kidneys anatomy :

The kidneys are in situated the lumber region they are positioned symmetrically about the vertebral column , their upper and lower poles lying between the 12th thoracic vertebra and the 3rd lumber vertebra respectively (Richard Lee Drake, 2010).

2-2-1-1 Structure of the kidney

The kidney compound from two parts: as cortex(Glomerulus apparatus) and medulla (divided in outer and inner layers)Consist 1million filtering units Termed **nephrons** which in turn representing the the functional units of kidney , (the anatomical structure of kidney is shown in figure (2-2-1) (Richard Lee Drake, 2010)

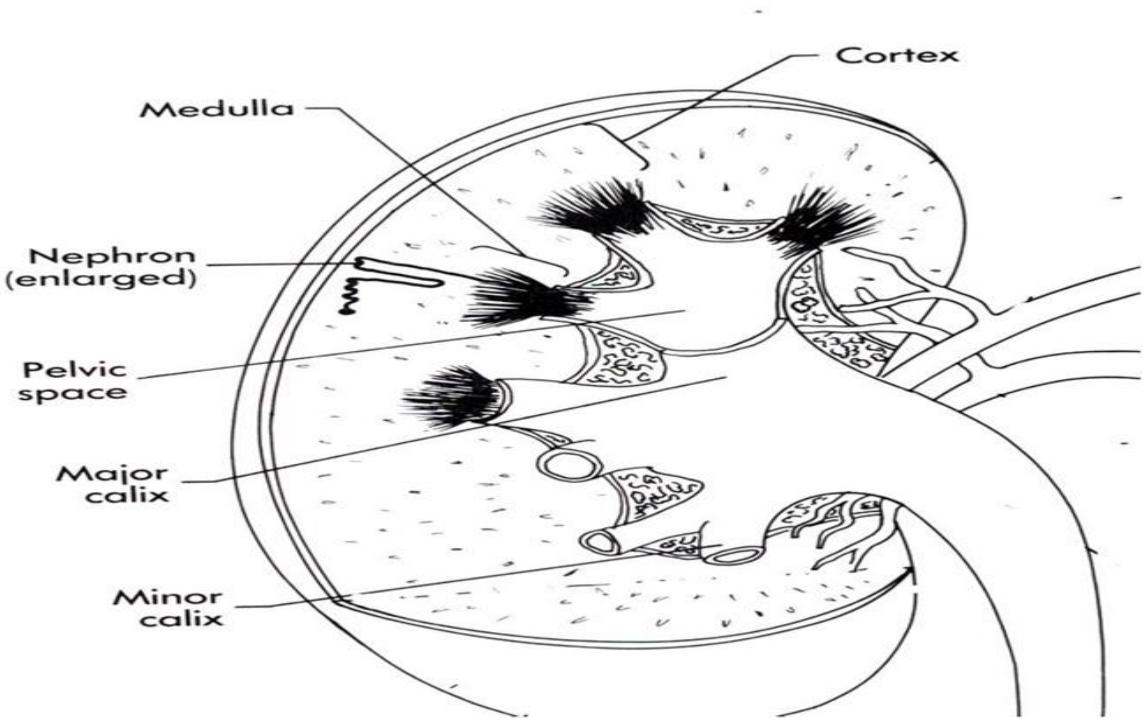


Figure (2-2-1) Structure of Kidney (Richard Lee Drake, 2010)

2-2-1-2 Renal Blood Vessels :

The kidney have extensive circulatory network to continuous cleansing and modification of a large volume of blood , the renal arteries arise from aorta at the level of the second lumber vertebra and enter the hilum of kidney . the renal vein emerge from the hilum of the kidney and drains in to the inferior vena cava . (Kent M. Van De Graaff, 2001)

2-2-1-3 Lymph Draining and Nerve Supply:

The lymph vessels drain in to the lateral aortic lymph nodes around the origin of the renal artery the renal sympathetic plexus- the afferent fibers travel through the renal plexus enter the spinal cord in tenth , eleventh and twelfth thoracic nerves**.** (Richard Lee Drake, 2010)

2-3 Physiology :

The kidney plays a major role in the control of the consistencies of internal environment, the blood flowing in the kidney is filtered (**glomerularfiltration**) so that all the blood constituent except blood cells and plasma proteins go in to micro tubular system. kidneys play a dominant role in regulating the composition and volume of the extracellular fluid (ECF) They normally maintain a stable internal environment by excreting in the urine appropriate amounts of many substances. These substances include not only waste products and foreign compounds, but also many useful substances that are present in excess because of eating, drinking, or metabolism. this chapter considers the basic renal processes that determine the excretion of various substances the kidneys perform a variety of important functions:

1-They regulate the osmotic pressure (osmolality) of the body fluids by excreting osmotically dilute or concentrated urine.

2-They regulate the concentrations of numerous ions in blood plasma, including Na + , K + , Ca2 + , Mg 2 + , Cl bicarbonate (HCO 3), phosphate, and sulfate.

3-They play an essential role in acid–base balance by excreting H+ when there is excess acid or HCO3 -when there is excess base.

4-They regulate the volume of the ECF by controlling Na+and water excretion.

5-They help regulate arterial blood pressure by adjust-ing Na+ excretion and producing various substances (e.g., renin) that can affect blood pressure.

They eliminate the waste products of metabolism including urea (the main nitrogen-containing end product of protein metabolism in humans), uric acid (an end product of purine metabolism), and creatinine (an end product of muscle metabolism).

6-They remove many drugs (e.g., penicillin) and foreign or toxic compounds. (George A. Tanner, 2009)

2-3-1 Endocrine Function of the Kidney:

The kidney produce several substances, some of which may not strictly be labeled as hormones, these are rennin , erythropoietin and vitamin D3 . These substances either act locally or are responsible for the production of other hormonal agents. (George A. Tanner, 2009)

2 - 4 Pathology :

2-4-1 Normal Variants:

In the 1st trimester, the developing kidneys ascend in the fetal abdomen. If the progress is hampered, this can result:

2-4-1-1 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 (figure 2-4-1-1). (Gaillani, 2003)

Figure 2-4-1-1 Sagital US image Dromedary humps (Gaillani, 2003)

2-4-1-2 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 (figure 2-4-1-2). (Gaillani, 2003)

Figure 2-4-1-2 Sagital US image Extra Renal Pelvis (Gaillani, 2003)

2-4-1-3 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 interpolar region of the kidney (figure 2-4-1-3). (Gaillani, 2003)

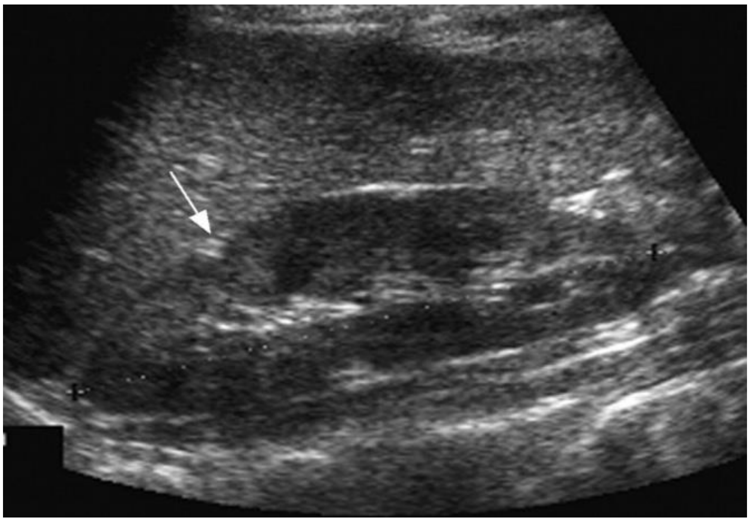


Figure 2-4-1-3 Sagital image Junctional Parenchymal Defects (Gaillani, 2003)

2-4-1-4 Duplex kidney :appears as 2 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, 2 distinct collecting systems and ureters can be observed on ultrasonographic images figure(2-4-1-4). (Gaillani, 2003)

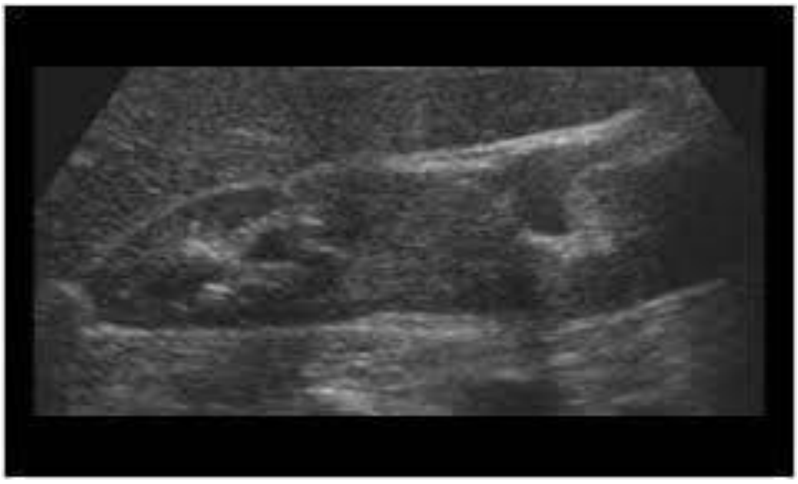


Figure 2-4-1-4 Sagital image Duplex kidney (Gaillani, 2003)

2-4-2 Congenital anomalies of the kidney:

Congenital anomalies of the kidney and urinary tract(CAKUTs) occur in 3–6 per 1000 live births and are responsible for 34–59% of chronic kidney disease (CKD)and for 31% of all cases of end-stage kidney disease (ESKD) in children in the United States. (Gaillani, 2003)

2-4-2-1 Ectopic Kidney: An ectopic kidney is a kidney located outside the renal bed. The kidney can be located anywhere between the pelvis and upper abdomen. However, most ectopic kidneys are located in the pelvis and are called pelvic kidneys. Often ectopic kidneys lie on an unusual plane which may impair the normal drainage of the organ. (Gaillani, 2003)

2-4-2-2 Fused Ectopia – "In crossed renal ectopia, both kidneys are found on the same side. In 85% to 90% of cases, the ectopic kidney will be fused to the other kidney. Usually the lower pole of the normally positioned kidney is fused to the upper pole of the ectopic kidney. The pelvis of the ectopic kidney is directed interiorly . (Gaillani, 2003)

2-4-2-3 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 called the 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 figure(2-4- 2-1.) (Gaillani, 2003)

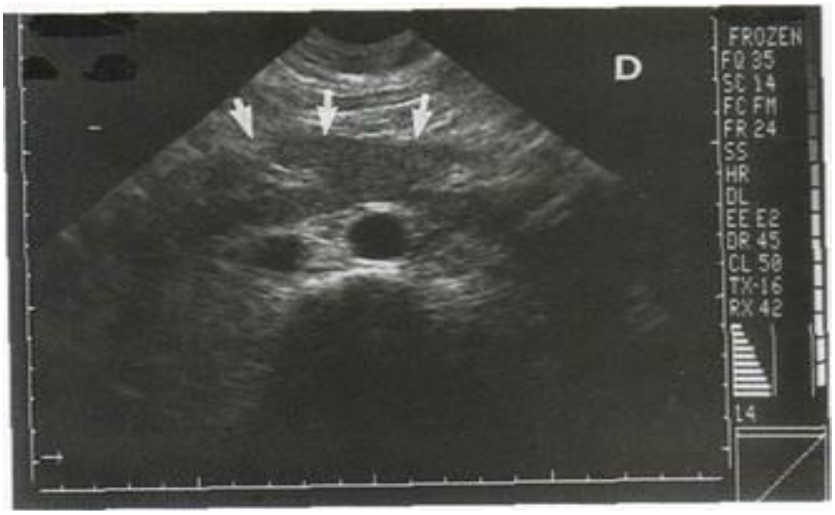


figure 2-4-2-1 Sagital image Horseshoe Kidney (Gaillani, 2003)

2-4-3 Renal Cystic Disease:

2-4-3-1 Simple Renal Cysts: These are true cysts that have a serious epithelial lining and are fluid filled, benign cortical masses. They meet all the ultrasound criteria of a simple cyst: they are spherical, anechoic, thin-walled and have accentuated posterior enhancement, Sonographic Appearances : these lesions range in size from a few millimeters to several centimeters. They are most frequently unilocular(Figure 2-4-3-1). (Gaillani, 2003)

Figure 2-4-3-1 Sagital image Simple Renal Cyst (Gaillani, 2003)

2-4-3-2 Atypical Renal Cyst : 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 Sonographic appearances Complicated (i.e. atypical) cyst.

2-4-3-3 Parapelvic Cysts : Parapelvic cysts are cysts of the renal sinu. Genelly they are anechoic and exhibit posterior acoustic enhancement “Parapelvic cysts are rarely purely spherical,figure(2-4-3-2).

Figure 2-4-3-2 1 Sagital image Para Pelvic Cyst (Gaillani, 2003)

2-4-3-4Autosomal Recessive Polycystic Renal Disease(ARPRD): Autosomal recessive polycystic kidney disease is an inherited disorder characterized by nephromegaly, microscopic or acroscopic cystic dilatation of the renalcollecting tubules, and periportal hepatic fibrosis. The renal abnormalities are seen early in life ,while the liver pathology becomes predominant with increasing age.

ARPRD is associated with pulmonary hypoplasia., Sonographic appearances **:** In 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. In later stages, the kidneys are huge (sometimes reaching 20 cm) And contain numerous cysts with little residual cortex. The cysts do not communicate with each other or with the calyces and renal pelvis. The cysts may be complicated with infection or hemorrhage and contain debris or focal wall calcification. Renal stones are common. (Gaillani, 2003)

2-4-4 Hydronephrosis:

Hydronephrosis refers to dilatation of the renal collecting system most frequently caused by incomplete or complete obstruction.

Hydroureter is dilatation of the ureter also caused by complete or incomplete obstruction.

Sonographic Appearances of Hydronephrosis :

Mild - there is minimal dilatation of the collecting system. The calyces are blunted but some pyramidal indentation remains. On ultrasound this appears as a single, ellipsoidal fluid collection spreading the central echo complex. Slight dilatation of the renalpelvis and calyces will be seen (Figure 2-4-4-1).

Moderate - the calyces are clubbed and there is no pyramidal indentation in to the calyces. On ultrasound there is a lobulated fluid collection with a few septae between the distended calyces. The parenchymal thickness is preserved.

Severe - the calyces are still discretely defined and separate from each other. The collecting system is markedly dilated with thinning of the parenchyma.

Extreme - the calyces are so distended that they blend into one another except for residual margins that appear as thin septae. On ultrasound there are multiple rounded fluid containing structures which are the distended calyces. These

distended calyces displace the central echo complex and totally replace the normal parenchyma.

Hydroureter appears as a fluid distended and often tortuous ureter whereas **megaureter** is a congenitally dilated ureter).

Hydronephrosis and the Neonate - The collecting system should not be larger than one third the anteroposterior measurement of the kidney . (Gaillani, 2003)

Figure 2-4-4-1Sagital image Mild Hydroneprosis (Gaillani, 2003)

2-4-5 Renal Calculus Disease:

Urolithiasis is most prevalent in males aged 20-40 years.1 Calculi can form in any part of the urinary tract but most form in the kidneys.

2-4-5-1 Collecting System Stones: The reflectivity of stones located in th renal sinus may be equal to that of the renal sinus itself, therefore, it may be beneficial to scan with the patient hydrated if collecting system calculus is being onsidered (figure 2-4-5-1). (Gaillani, 2003)

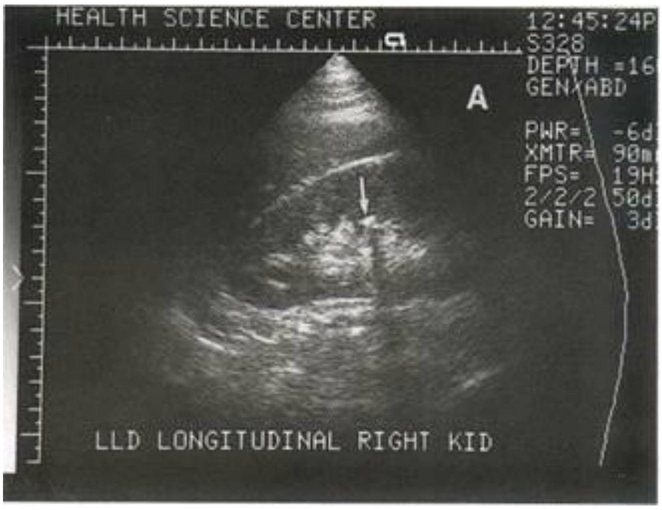


Figure 2-4-5-1 Sagitl image a single shadowing stone (Gaillani, 2003)

2-4-5-2 A staghorn calculus: is a stone that completely fills the entire ollecting system (i.e. the pelvis and calyces). It is usually associated with chronic infection and obstruction.sonographic appearance A staghorn calculus appears as a curved echogenic structure in the renal sinus area. The acoustic shadow created by the calculus often hides any associated hydronehrosis (Figure 2-4-5-2). (Gaillani, 2003)

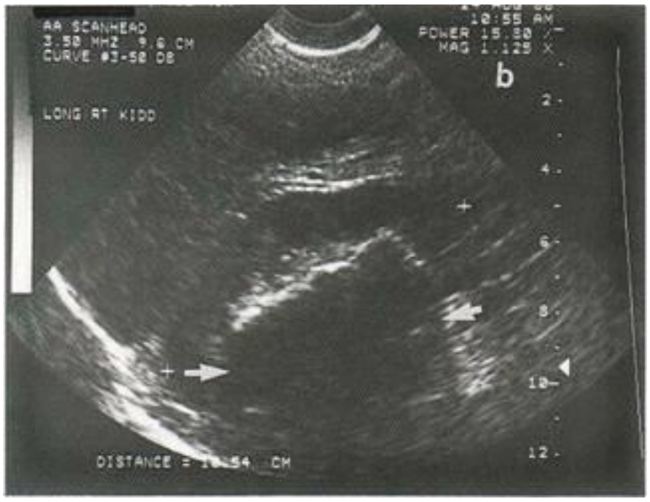


Figure 2-4-5- 2 Sagital image staghom calculus (Gaillani, 2003)

2-4-6 Neoplasm:

2-4-6-1 Benign Lesions:

2-4-6-1-1 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. AML’s show significant growth when followed by US over time Tumors range from 1 or 2 cm to more than 20 cm,2 however tumors less then4 cm tend to be asymptomatic.“AML is difficult to differentiate from RCC (renal cell arcinoma) when the renal tumor .(figure 2-4-6-1-1).

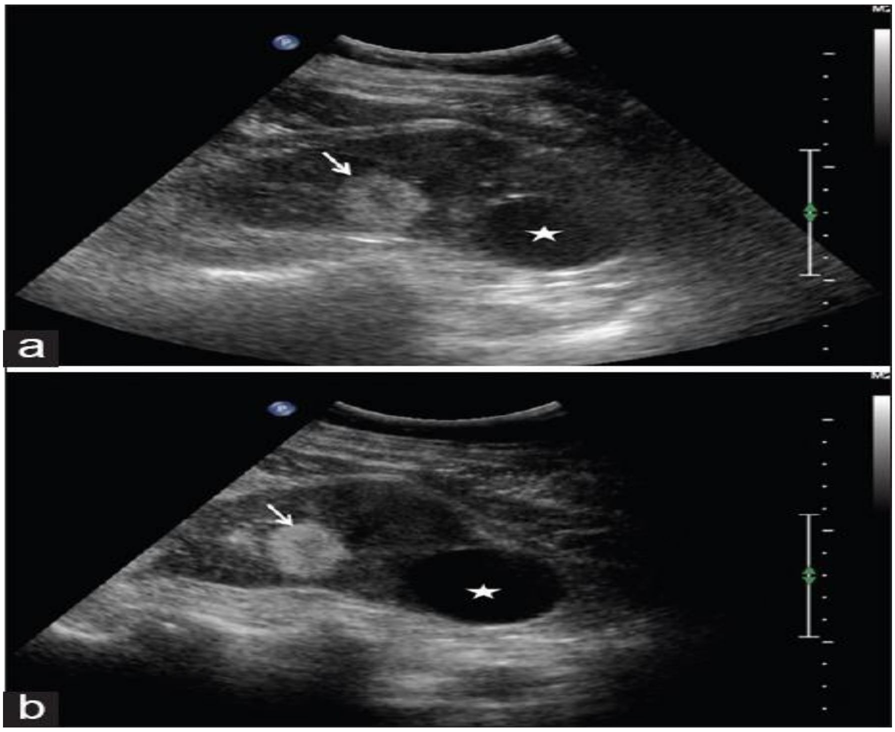


Figure 2-4-6-1-1 Sagital image Angiomyolipoma , simple cyst (*)

(Wrenger, 2010)

2-4-6-1-2 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 satellite central hyperechoic scar is seen in about 25% of cases and then only in lesions greater than 3 cm. However, “no imaging finding reliably distinguishes this tumor from renal cell carcinoma. Diagnosis is made by surgical excision(figure 2-4-7-1-2).

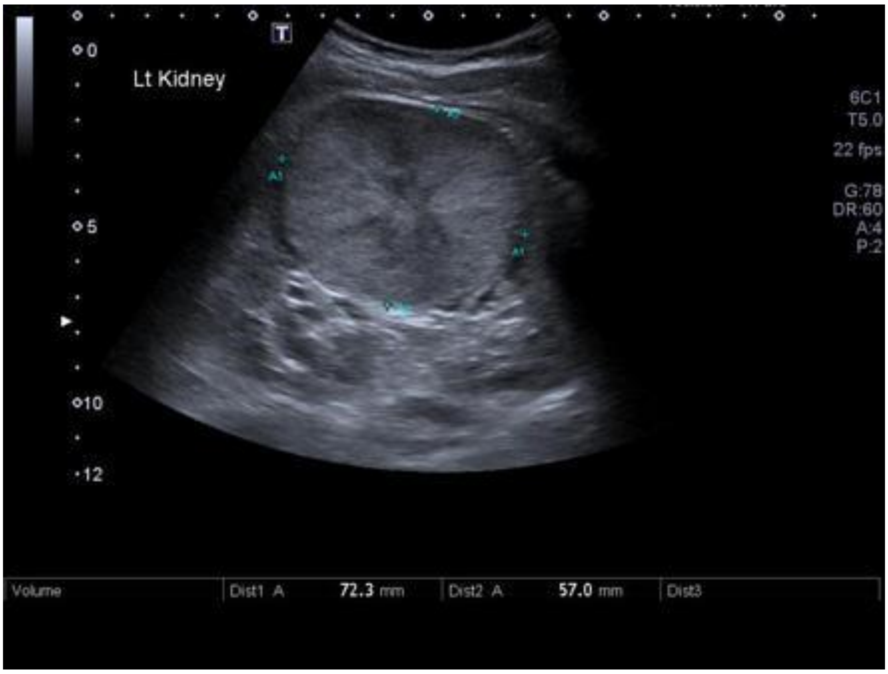


Figure 2-4-6-1-2 Sagital image renal lesion, with the central satellite non-enhancing scar, is typical for renal oncocytoma (Sikmin, 2014)

2-4-6-2 Malignant Lesions:

2-4-6-2-1 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 **hypernephroma** or a **renal adenocarcinoma**.Renal cell carcinomas (RCC) are the most common primary malignant renal parenchymal tumors (86%).3 These tumors occur most frequently in males between the fifth to the seventh decade. They are usually unilateral and clinically silent until they become large (figure 2-4-6-2-1).

Sonographic findings**:** Characteristically a spherical, solitary, unilateral tumor of variable size and echogenicity. The majority of tumors are either isoechoic or hypoechoic to the normal renal parenchyma, however 10% are more echogenic than normal renal parenchyma.(A complex echo pattern usually indicates areas of hemorrhage,necrosis or tumor vascularity.

- Calcification is common (up to 18%) and variable in appearance: punctuate, coarse,central, peripheral or curvilinear.
- The mass frequently distorts the collecting system .Hydronephrosis is not a common feature.
- RCC is a non encapsulated tumor, therefore the borders are poorly defined.

- Cystic forms of RCC most often have thick walls and internal debris. RCC arising within simple cysts are rare and appear as
- Multicystic form of RCC has thick walls (>2mm) and thick septations.
- Metastasis – Metastatic lymph adenopathy is usually near the renal vessels and around and between the IVC and aorta.1,2 Hepatic metastasis may be by direct extension or hematogenous spread. (Hepatic metastases have variable appearances.
- In 20% of cases, RCC extends into the renal vein and in 10% of cases it extends as far as the IVC Tumor thrombi are typically homogeneous, generate low level. (Gaillani, 2003)

Figure 2-4-6-2-1 Sagital image Renal cell carcinoma (Gaillani, 2003)

2-4-6-2-2 Transitional Cell Carcinoma (TCC): This is a malignancy involving the epithelial lining of the renal collecting system, ureters or bladder,ultrasound appearances of a renal pelvic TCC are characteristically those of a solid, homogeneous, hypoechoic or isoechoic mass centrally located within the renal sinus. It causes a separation of the central echo complex. TCC tumors commonly obstruct the urinary tract, therefore there may be evidence of focal calyceal or renal pelvis dilatation. (Gaillani, 2003)

2-4-6-2-3 Leukemia:“Lymphoma and leukemia have a predilection for infiltratioof the renal parenchyma and often cause focal or diffuse renal enlargement. “Acute lymphoblastic leukemia is the most common form to involve the kidney.Sonographically,appear as adiffuse, 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 un common but when they occur they resemble lymphoma figure 2-4-6-2-3 (Gaillani, 2003)

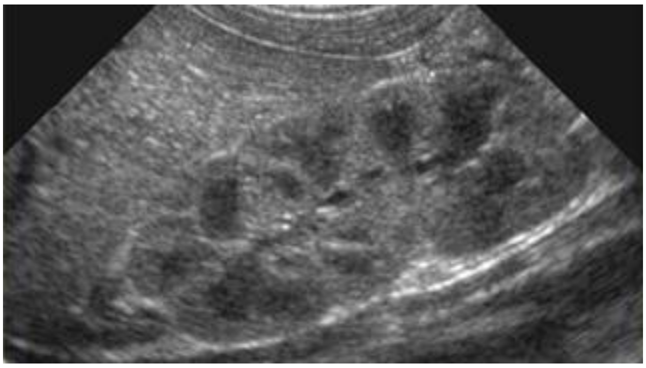


Figure 2-4-6-2-3 RT kidney enlarge and hetrogenous (Leukemia). (Gaillani, 2003)

2-4-6-2-4 Nephroblastoma:A nephroblastoma is a rapidly growing malignant tumor of the kidneys, consisting of embryonal elements. It is also known as Wilm's tumors, Wilm's embryoma or embryonal carcinoma. A nephroblastoma is the most common renal tumor in children. It is seen most commonly in children between 2 to 3 years of age Sonographically a Wilm's tumor is characteristically a large, intrarenal, solid mass with a well-defined margin or pseudocapsule of fibrous tissue and compressrenal parenchyma. The tumor may be homogeneous or heterogeneous, if necrosis or hemorrhage has occurred. “The tumor rarely is calcified, rarely crosses midline, and rarely envelopes major blood vessels, such as the aorta or IVC(figure 2-4-7-6). An adrenal neuroblastoma, common to a similar age group, does cross midline, has calcifications in half the cases and does envelope blood vessels., Wilm’s tumor may extend to regional lymph nodes or into the renal vein and IVC. Vascular extension does not occur with neuroblastoma. (Gaillani, 2003)

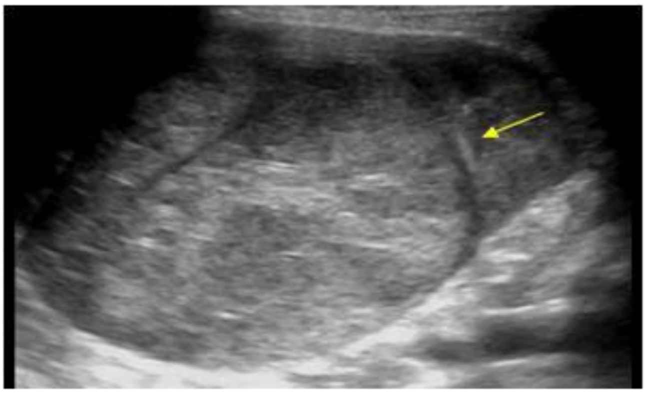


Figure 2-4-6-2-4 Sagital imge Rt renal, homogenous mass (Nephroblastoma) (Gaillani, 2003)

2-4-6-2-5 Metastases to Kidney:

Metastases to the kidney are usually asymptomatic and demonstrated in patients with a known malignancy which has already metastasized elsewhere. Spread to the kidneys is via the hematogeneous route. The most common primary tumors associated with renal metastases are from the lung, breast and RCC of the contralateral kidney. Less common are colon, stomach, cervix, ovary, pancreas and prostate primaries,sonographic appearance of renal metastases is nonspecific (Gaillani, 2003)

2-4-7 Medical Renal Disease:

This term describes renal disorders that are initially treatable with medicine rather than surgery, Normal or enlarged kidneys in patients with suspected medical renal disease usually require biopsy for definitive diagnosis of the underlying abnormality. In general, adult patients with renal lengths of less than 9 cm. are considered to have abnormally small, end stage kidneys, and biopsy is usually not required because the underlying renal disease is unresponsive to treatment. Patients require dialysis or renal transplant. The hallmark of diffuse parenchymal renal disease is a diffuse increase in echogenicity throughout the parenchyma of both kidneys with prominent echo poor pyramids. Later the pyramids become less distinct and difficult to differentiate from the cortex until corticomedullary differentiation is lost. (Gaillani, 2003)

2-4-7-1 Acute Renal Failure : 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 (post renal causes). In the setting of ARF, the main purpose of the US study is to exclude hydronephrosis(figure 2-4-7-1) (Gaillani, 2003)

(Figure 2-4-7-1) Sagital image Acute Renal Failure . The kidney is enlarged, the corticalechogenicity is increased and the pyramids are enlarged (Gaillani, 2003)

2-4-7-2 Chronic Renal Failure (CRF): Diabetes mellitus is the most common cause of CRF Other common causes are glomerulonephritis, chronic pyelonephritis, renal vascular disease, gout and polycystic renal disease.Sonographically, there is an initial renal enlargement, however, with time there is a reduction in size and an increase in cortical echogenicity. The corticomedullary junction is preserved. Later as the disease progresses, the medulla is usually not identified. In end stage kidney, the kidney is small and hyperechoic with a loss of distinction between the cortex, medulla and central sinus echoes.figure(2-4-7- 2) .

Figure 2- 4-7 -2 Sagital image Chronic renal failure secondary to diabetic nephropathy.The long axis measures 7.08 cm, renal cortex is more echogenic (Gaillani, 2003)

2-4-8 Renal Infections:

Most renal infections occur via the ascending route. They are usually caused by contaminants from the intestinal tract Instrumentation, stasis, calculi, and vesicoureteral reflux are predisposing factors. Hematogenous infection also occurs as the result of intravenous drug abuse, tuberculosis and in immunocompromised patient. (Hung-Wen Kao, 2008)

2-4-8-1 Acute Pyelonephritis (Acute Bacterial Nephritis): Acute pyelonephritis is infection of the renal pelvis, calyces and parenchyma. This is most often (85%) caused by an ascending Escherichia coli (E. coli) infection, ultrasound is used to rule out obstructions or abscesses in patients who have not responded to antibiotics or who have progressive symptoms. Most kidneys demonstrate no abnormality however, edema may result in diffuse renal enlargement In addition, there may be decreased parenchymal echogenicity and loss of corticomedullary differentiation. The walls of the renal pelvis or major calyces may be thickened (figure 2-4-8-1) (Hung-Wen Kao, 2008)

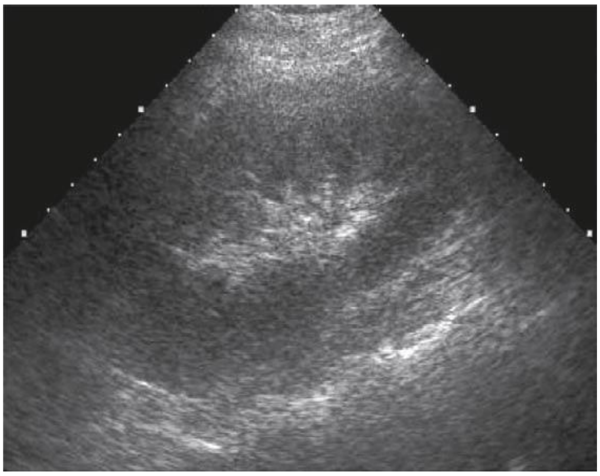


Figure2-4-8-1 Sagital image Diffuse Acute Pyelonephritis (Hung-Wen Kao, 2008)

2-4-8-2 Acute Focal Bacterial Nephritis (Lobar Nephronia): Studies of pyelonephritic kidneys suggest that each lobe is infected as a unit and that the severity of the infection may vary considerably from one renal lobe to another. The term acute, focal bacterial nephritis is applied to disproportionately severe infection of one or more lobes (figure 2-4-8-2) The severity of lobar infections in such cases falls somewhere between the usual form of pyelonephritis and renal abscess.

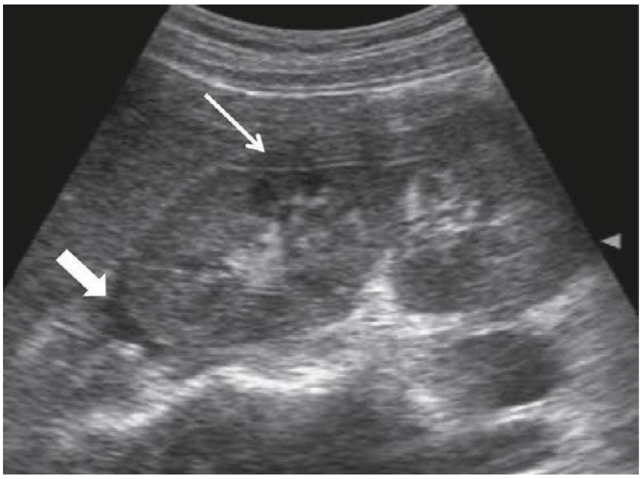


Figure 2-4-8-2 Sagital image Focal pyelonephritis, hypoechogenicity in the middle portion(thin arrow) and a small perinephric fluid collection (thick arrow). (Hung-Wen Kao, 2008)

2-4-8-3 Renal Abscess: Renal abscess is a collection of purulent material confined to the renal parenchyma. Patients at high risk for the development of a perirenal abscess include patients on hemodialysis, diabetics and intravenous drugson sonography, a renal abscess appears as a hypoechoic mass with thick irregular walls or a capsule and increased through-transmission. (Hung-Wen Kao, 2008)(Figure 2-4-8-3).

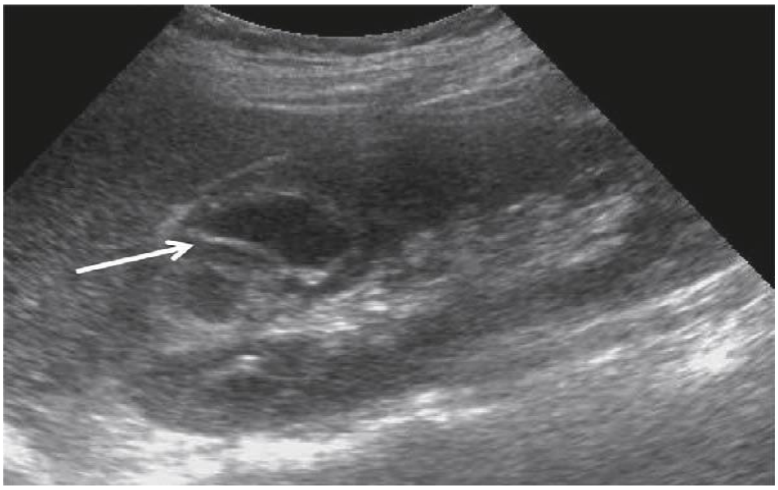


Figure 2-4-8-3 Sagital image Renal abscess. (heterogeneous hypoechoic mass (arrow) with a well-defined border(Renal Abcess). (Hung-Wen Kao, 2008)

2-5 Investigations Done for kidney:

2-5-1 Clinical Examinations : examination done by physician **.**

Symptoms of Kidney Problems:

Symptoms that may indicate a problem with kidneys include:

- high blood pressure
- blood in the urine
- frequent urges to urinate
- difficulty beginning urination
- painful urination
- swelling of the hands and feet due to a buildup of fluids in the body.

A single symptom may not mean something serious. However, when occurring simultaneously, these symptoms suggest that kidneys aren't working properly. Kidney function determine the reason. (Stang, 2015)

2-5-2 Laboratory Investigations : Concern about kidney function

2-5-2-1 Types of Kidney Function Tests:

To test kidney function, there are set of tests that can estimate glomerular filtration rate (GFR). GFR tells how quickly kidneys are clearing waste from your body.

2-5-2-1-1 Urinalysis: a urinalysis screens for the presence of protein and blood in the urine. There are many possible reasons for protein in urine, not all of which are related to disease. Infection increases urine protein, but so does a heavy physical workout. It may repeat this test after a few weeks to see if the results are similar.or may also ask to provide a 24-hour urine collection sample. This can help to see how fast a waste product called creatinine is clearing from body. (Stang, 2015)

2-5-2-1-2 Serum Creatinine: Creatinine is a nitrogenous compound formed as an end product of muscle metabolism. It is formed in muscle in relatively small amounts, passed into the blood and excreted in the urine. This blood test examines whether creatinine is building up in your blood. The kidneys usually completely filter creatinine from the blood. A high level of creatinine suggests a kidney problem..

normal range According to the National Kidney Foundation (NKF), a creatinine level higher than 1.2 for women and 1.4 for men is a sign of a kidney problem. (Gaillani, 2003).

2-5-2-1-3 **Blood Urea Nitrogen (BUN):** Urea is an end product of protein metabolism and is readily excreted by the kidneys. Therefore the blood urea concentration normally is fairly low. Blood urea nitrogen level measures renal function. The BUN level rises when the kidney's ability to excrete urea is impaired. It also rises with reduced renal blood flow as with dehydration and urinary tract obstructions. An elevated level of BUN may lead to mental confusion, disorientation and coma. Normal range ,normal BUN level is between 7 and 20. a higher value could suggest several different health problems**.** (Gaillani, 2003)

2-5-2-1-4 Estimated Glomerular Filtration Rate (GFR):

This test estimates how well the kidneys are filtering waste. the test determines the rate by looking at factors, such as:

- test results, specifically creatinine levels.
- age
- gender
- race
- height
- weight
- Any result lower than 60 may be a warning sign of kidney disease. (Stang, 2015)

2-5-3 Imaging of Urinary Tract :

The four basic examinations of the urinary tract are the: intravenous urogram (IVU), computed tomography (CT) nuclear medicine (NM) or radionuclide studies and sonography.

2-5-3-1 Intravenous Urography (Intravenous Pyelography or Excretory Urography): IVU is the radiographic examination of the kidneys, ureters and bladder after I.V. administration of a contrast medium. The IVU is only effective if the kidney are able to concentrate and excrete the contrast medium.The IVU provides both functional and anatomic information and it has the advantage of demonstrating the entire urinary tract on just a few films and it is considered an ideal method of demonstrating calculi. The major limitation of the IVU is its reliance on renal function. (Gaillani, 2003)

2-5-3-2Nuclear 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. (Gaillani, 2003)

2-5-3-3 Computerized Tomography: CT utilizes radiation to create a series of thin body sections which supply three dimensional cross sectional views of the kidneys as well as the adjacent organs. Sections of the kidneys are taken before as well as after an intravenous contrast medium is given. If the kidneys are functioning they will collect and excrete the contrast agent thus enabling an evaluation of renal function.CT provides exquisite anatomical detail and is able to differentiate between types of masses based on differences in their radiographic density. The disadvantages of CT are it is expensive to perform facilities are limited; and ionizing radiation may be aconcern with young children or pregnant patients and contrast collection and excretion rely on renal function. (Gaillani, 2003)

2-5-3-4 Ultrasound: Sonography is frequently called upon to rule out hydronephrosis in patients with renal failure since ultrasound is supreme in showing fluid filled structures. It also provides information regarding retroperitoneal masses or fluid collections that may be causing the urinary problems. Sonography does not require renal function in order to be effective.

Summary: Sonography is used primarily for anatomy the IVU and CT for anatomy and function and NM for function. (Gaillani, 2003)

2-6 Renal Sonography :

is the examination of renal by using ultrasound.

2-6-1 Role of Ultrasound :to identify the cause of:

- Flank pain
- Haematuria (frank or microscopic).
- Follow-up of previously identified pathology
- Classification of a mass (Solid V's cystic)
- Post surgical complications
- Guidance of aspiration, biopsy or intervention
- Post injury (America, 2014).

2-6-2 Ultrasound Techniques for the Kidneys:

The examination begins with the patient in the in supine position. scan are performed in the sagittal and transverse planes from anterior approach using 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 decubitus or lateral oblique positions for the left kidney. Coronal longitudinal and transverse scan may also be obtained and recommended for evaluation the renal pelvis and proximal ureter on hydro nephrotic patients. The highest frequency transducer permitting adequate penetration is used, this is usually 3 to 5 MHZ range, a phased array sector probe with its small foot print permit sub costal and intercostals scanning (Gaillani, 2003)

Ultrasound techniques for pediatric : the bladder should be scanned first ,as voiding may often occur during the examination , measurements of both kidneys – either length or renal volume –should be taken to highlight any difference in size and to provide a base line for further growth comparison, variety planes can be use ,often posterior approach is the best for obtaining accurate bipolar length ,ensure that renal pelvis dilatation is not physiologically rescanning after micturition ,measure the AP diameter of any renal pelvic dilatation in transverse section through the renal hilum .Always scan the bladder immediately after micturition, paying attention to ureteric orifices and looking for any ureteric or renal reflux. Measure any residual volume

,color Doppler may be helpful in identifying ureteric orifices, by locating the jets of urine entering the bladder (Gaillani, 2003)

2-6-3 Normal songraphic features of kidney(adult):

kidney is an ellipsoid structure when in its long axis as(figure 2-6-3-1) , (figure 2-6-3-2) which Demonstrate right and left kidney, the capsule is an echogenic white boundary separating the Kidney from adjacent structure anteriorly. and the musculature posteriorly, the renal Cortex is homogeneous fine textured and poorly echogenic, the cortex is equal to or less echogenic than the normal liver , the medulla consist pyramids which are anechoic structures with their bases adjacent to the renal cortex and their apices directed toward renal sinus, the renal sinus is the most echogenic portion of the adult kidney . (Bates, 2011)

2-6-4 Normal Sonographic feature for pediatric kidney:

after birth the renal cortex is relatively hyper echoic compared to adult kidney, in strong contrast to the hypoechoic medullary pyramids. The outline of the kidney is often lobulated due to persistent fetal lobulation .the renal pelvis is relatively hypoechoic, as the fat deposition in the renal sinus become more evident . the outline becomes smooth ,although fetal lobulations do persist in some adult kidneys (Bates, 2011)

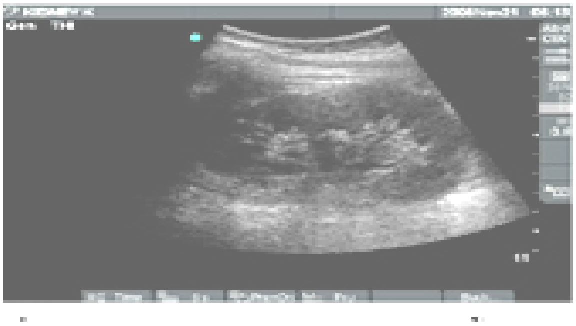


Figure 2-6-3-1 Right normal kidney
(Gaillani, 2003)

Figure 2-6-3-2Left normal kidney
(Gaillani, 2003)

2-6-5 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 (figure 2-6-5-1) .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 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 . (Gaillani, 2003)

2-6- 6 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 a simple 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. (Gaillani, 2003)

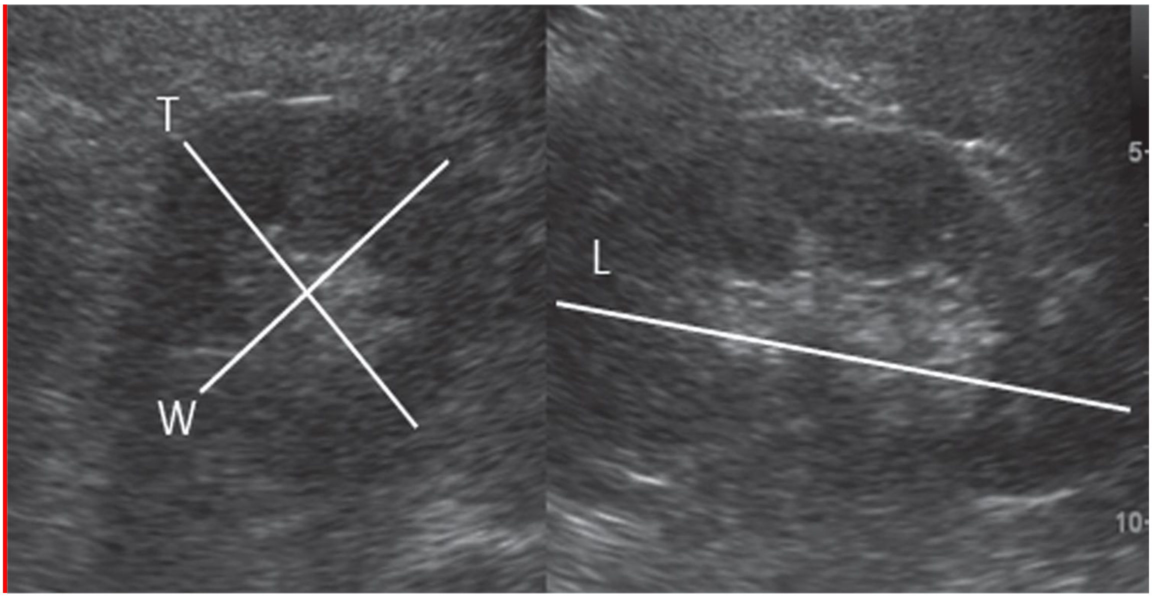


Figure 2-6-5-1 Basic Renal Dimensions L : length , W ; Width ,T,Thickness
(Aylin Okur 1, 2014)

2-6-7 Renal Ultrasound Protocol:

Equipment Selection :

Highest frequency curved linear array probe possible. Start with 7MHz and work down to 2 or 3 for larger patients. Assess the depth of penetration required and adapt. Pediatric and thin patients should be scanned with a 7 MHz. Good color / power / Doppler capabilities when assessing vessels or vascularity of a structure. (Ultrasoundpaedia, 2014)

Basic Imaging : a renal series should include the following minimum images:

- Both kidneys with length measurements
- Right kidney long with liver for comparison
- Both kidneys longitudinal medial and lateral
- Both kidneys transverse
    - sup

    - mid
    - inf
- Left kidney long axsis with spleen for comparison.

Document the normal anatomy. Any pathology found in 2 planes, including measurements and any vascularity. (Ultrasoundpaedia, 2014)

Hint Points:

- Kidney size (should not be >1cm difference between sides)
- Cortical thickness(not <10mm)
- Cortico-medullary differentiation
- Cortex at least as hypoechoic as the liver
- Pyramids slightly hypoechoic relative to the cortex
- No hydronephrosis
- Renal scarring(beware mistaking prominent lobulations as scars. (Ultrasoundpaedia, 2014)

Limitations:

- The mid to distal ureter is generally obscured by bowel gas,small lesions at the upper pole of the kidney may be difficult to see due to refractive edge shadowing. This can be overcome with thorough scanning echnique. (Ultrasoundpaedia, 2014).

2-7 Previous studies :

Rosenbaum et al (USA), they did a study about Songraphic Assessment of Renal length in Normal Children, the study carried in children hospital in Boston, Renal length was measured and graphed to provide growth chart , sonography performed for 203pediatric patients range age from several hours to 19 years mean renal length presented in table and are plotted figure the population divided in tow group Children less than one year : the regression equation : Length (CM) = 4.98 +0.155x age (months).Children more than one year ; the regression equation : Length (CM) = 6.79 + 0.22 x age (years) . (Rosenbaum, 1983)

Bokyung K.Han et al (USA), they did study about Sonographic Measurements and Appearance of Normal Kidneys in Children. It was carried in Children's Hospital Medical Center of University of Cincinnati College of Medicine, Cincinnati ,122 children (ages, newborn to 17 years) without urinary tract disease, 244 kidneys were examined sonographically. Renal length and volume were measured and correlated with age, body weight, height, and total body surface area, permitting preparation of nomograms with predicted means and 95% prediction intervals. Also evaluated were renal parenchymal echogenicity, medullary pyramids, and central sinus echoes, and the appearance of each was correlated with age,Initial analysis showed no significant difference in renal length and volume between right and left kidneys and between boys and girls. Therefore, all 244 kidneys were measured as a group and plotted against body size. Renal length and volume related to age, height, weight, and total body surface are presented in figures. (Bokyung K. Han, 1985).

Konu et al. (**Turky**),They did study about Normal Liver, Spleen, and Kidney Dimensions in Neonates, Infants, and Children: Evaluation with Sonography It was carried in Department of Radiology, School of Medicine,Gazi University, Ankara this prospective study involved 307 pediatric subjects(169 girls and 138 boys) with normal physical or sonographic findings who were examined because of problems unrelated to the measured organs.the subjects were 5 days to 16 years old. all measured organs were sonographically normal, at least two dimensions were obtained for each liver, spleen, and kidney, relationships of the dimensions of these organs with sex, age, body weight, height, and body surface area were investigated. Suggested limits of normal dimensions were defined., Dimensions of the measured organs were not statistically different in boys and girls. Longitudinal dimensions of all three organs showed the best correlation with, age, body weight, height, and body surface area. height showed the strongest correlation of all. This Correlation was a poly nominal correlation (OznurL.Konu@1, June17,1998).

William K. Loftus et al(China) they study about Renal length in Chinese children: Sonographic measurement and comparison with Western data the study carreid in China , two hundred fifty children undergoing routine abdominal sonography were examined prospectively and the maximum length of 2 kidney per child was recorded. ages ranged from newborn to 19 years, and there were 109 girls and 141 boys. Similar data from Australian children involved maximum lengths of both kidneys in 554 children ranging in age from newborn to 14 years. There were 361 girls and 193 boys. No children had known renal disease, there was no statistically significant difference between the mean renal lengths of girls and boys,Statistical comparison of the data from Hong Kong and Australia showed no significant difference except in the 8–12 month age group (this difference is unlikely to be clinically significant. (William K. Loftus, 1998)

Kadioglu(Turky) he did a study about Renal Measurements , including length parenchymal thickness, and modularly pyramids thickness in healthy children ,the study carried in Alca Radiologic diagnostic center – Istanbul ,the aim of study was to develop by use of ultrasound nomogram of renal of renal parenchymal thickness ,medullary pyramid thickness in healthy children . the prospective study was performed on 292 consecutive children (136 boys and 156 girls) referred for problem other than urinary tract their age between 1month to 18 years , the nomogram of renal parenchymal thickness , medullary pyramid thickness,renal length and the ratio of medullary pyramid thickness to parenchymal thickness were developed .when all groups pooled to gather ,statically significant difference were observed between right and left kidneys in term of parenchymal thickness and renal length (left kidneys were longer with thicker medullary pyramid and parenchyma , a slight significant difference in the ratio of medullary pyramid thickness to parenchymal thickness were observed, (Alev Kadioglu 2010) .

Anjali S Otiv, et al(India,) they study about Sonographic Measurement of Renal Size in Normal Indian Children Cross-sectional observational study carried in Pediatric teaching hospital, Mumbai, Participants was 1000 normal Indian children aged 1 month – 12 years)**,** Sonographic assessment of renal size (length, width and thickness) was performed using Philips real time mechanical sector scanner of 3.5-5 MHz frequency with electronic caliper. The mean renal dimensions and volume were calculated for each age group with ± 2SD. the renal length and calculated renal volume were correlated with somatic parameters like age, weight, height and body surface are, regression equations were derived for each pair of dependent and independent variables the results was no statistical difference was found in renal size between sexes and between right and left kidney. A strong correlation was seen between renal size with various somatic parameters, the best correlation was between renal size length and body height (coefficient of correlation=0.9). (Anjali S Otiv, 2011)

Kim et al (Korea), they did study about length and volume of morphologically normal kidneys in Korean children : Ultrasound measurement and estimation using body size , the study carried in severance children hospital ,younse , Seoul the aim of study to evaluate the relationship between anthropometric measurements and renal length and volume in Korean children who have morphologically normal kidney and create simple equation to estimate renal size using the anthropometric measurements .they examed 794 Korean children under 18 years of age (394 boys and 400 girl) without renal problem ,the maximum renal length (L) (cm) ,Anteroposterior diameter (D) (cm) and width (w) (cm) of each kidney measured. Kidney volume was calculated as 0.523 X L X D X W (CM3) ,height (cm) , weight (kg) and body mass index (m2/kg) were collected through medical record review .linear regression analysis used to create simple equation to estimate renal length and volume with those anthropometric indices that were mostly correlated with the ultrasound measured size Renal length showed the strongest significant correlation with patient height, renal volume showed strongest significant correlation with patient weight, the following equations were developed to describe these relations with estimated 95% range of renal length : Renal length = 2.383 + 0.045 x height (=+ 1.135) and = 2.374 + 0.047 X height (-+ 1.173) for the right and left kidney respectively .scatter plots between height and renal length and between weight and renal volume have been established from Korean children and simple equation them have been developed . (Jun-Hwee Kim, 2013).

Younus et al (Pakistan) they did a study of Sonographic Measurement of Normal Renal Size and Correlation with Somatic Variables in Subset of Karachi Pediatric Population. a six months crossectional hospital based assessment of kidney size (length and width) was evaluated with ultrasound the mean renal dimensions with standard deviation were estimated for every group of age ,the renal length and width were determinded and correspond with different somatic variables , descriptive statistics with regression analysis was done . the normal length and width and it,s ranges was obtained. Right kidney length moderately and significantly correlated with height and age respectively .how ever moderately insignificant with BMI , left kidney moderately and significantly correlated with height and weight negative insignificant with age and moderately weak insignificant relationship with BMI. (younus, 2015*)*

Rosan et al (Jordon) , the a study carried in Tertiary hospital ,the kidney of 331 children (156 males and 175 females) age between newborns and 14 years of age who had disease un related to urinary tract, all the examined kidneys were normal in size and shape and position the length of kidney were correlated with age , weight and height and was compared to previous international study .they found there was no significant statically difference between the length of right kidney and the left kidney ,and no difference between girls and boys , the was good correlation between the length of the kidneys and the somatic parameters of the patients .also there was agreement between the kidney length in this study those from previous Studies. (Liqa A Rousan, 2015)

C.U. Eze etal (Nigeria), they did study about Sonographic Assessment of Normal Renal Parenchymal and Medullary pyramid thicknesses among Children in Enugu, this was a cross sectional study, the subjects were 512 children aged 1-17 years scanned with ultrasound equipment with 3.5 MHz and 5 MHz curvilinear transducers. the RPT was measured perpendicularly to the long axis of the kidney from the medullary papilla to the renal capsule and MPT was measured from the apex to the base of the medullary pyramid on the same plane. the age and somatometric parameters of the subjects were recorded ,the results: mean±SD of RPT and MPT for the right kidney were 12.62±1.67 mm and 7.10±0.92 mm and the left kidney were 12.81±1.7 and 7.23±0.94 mm respectively. there was a significant difference between the right and left RPT and MPT ($p<0.05$). The right and left RPT correlated strongly with age,body surface area (BSA), height, and weight but moderately with body mass index (BMI). A moderate positive correlation was observed between MPT and age, BSA, height, and weight. however, a weak correlation was observed between MPT and BMI.Conclusion:Normograms of RPT and MPT in relation to age could be useful for grading hydronephrosis inchildren. (C.U. Eze a, febreuary 2016)

Chapter Three

Methodology

The data of this study were collected from children were either healthy, or patients coming to hospital complaining for diseases not related to urinary system , renal sonographic examinations done for 60 children their age from (1month-14year) 27 females and 33 males to estimate normal sonographic measurements of renal Size according to specific age, height and weight .

3-1 Material:

3-1 -1 Machines and tools *:* the study performed using real time machine(**Esaote Pie Medical**) with a convex scanner probe of 3. 5 MHZ, printer used for imaging with thermal paper .

Weighting scale: to measure weight of infant and older children on a beam balance.

Infantometer : to measure height in children below 2 years

Standiometer : is standing height to measure children above 2 years to the nearest 1 mm.

3-2 Study Area :

The study done in Mohammed Alamin Hamid Hospital in Khartoum state in sudan .

3-3 Study design :

Descriptive crossictional study .

3-4 Duration of study:

Study start on September 2015 till February 2016.

3- 5 Study sample *:*

60 cases of pediatric patients who came to department with diseases un related to urinary tract ,also children who came for vaccinations and normal children from co patients.

3-6 Study variables :

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

3-7 Study Data sheet :done by master collecting sheet.

3-8 Method of Data Collection :

3-8-1 Preparation of the patient:

No preparation for Renal ultrasound only empty bladder to avoid pelvi calyseal fullness .

3-8-2Technique used to collect data :

First age ,height and weight were recorded at the time of scan,the patient lie supine for gain setting ,apply coupling agent over the right upper abdomen.

- **Gain Setting:**

the gain setting should allow the diaphragm to be cleary seen ,the liver (when normal) should appear homogenous through out it,s depth . it should be possible to see cleary the normal tubular structure (the portal vein with bright edges) . hepatic arteries and bile ducts are not unless dilated ,

- **Position of patient for the Kidneys :**

all patients in prone position .

- **Scanning Technique**

are performed in the sagittal and transverse planes from posterior approach. Various maneuvers done to enhance demonstration of the kidneys.. Coronal longitudinal and transverse scan also obtained for evaluating the renal pelvis and proximal ureter .length of kidney measured from sagittal view was the maximum long axis ,width measured from transverse view an average of three width measurements taken at the hilum and one centimeter above and below the hilum,Breadth measured from ,anteroposterior measurement measured through the hilum,this done for both kidnys.120 kidney were measured Length ,width ,breadth for each kidney and volumes were calculated by a formula(Volume = Lx Wx Dx0.5233) L :(length of kidney) W : (width) D : depth

3-9 Data Analysis Method :

the data were analyzed by using SPSS soft ware for statical analysis as Excel under window

Chapter Four

Results

This chapter displayed the results of this study using tables and graphs, total of 60 children their age from (1month-14year) 27 (45%) females and 33 (55%) males Table(4-1) , Mean/SD for all variable displayed in Table(4-2),RT and LT kidney measurements (length , width ,breadth and volume) were analyzed, and comparison tests done (pair sample Test) presented in Table (4-3) .

Correlation done between RT kidney variables (length ,width ,breadth) ,and with a somatic (in dependant) variables (age , height, weight) each of one separately, presented in Table (4-4), Table(4-5), Table(4-6). Graphs done for Rt kidney length, with age ,height and weight ,Rt kidney length and age presented in Graph (4-1) ,Rt kidney length and height Graph (4-3) ,Rt kidney length and weight Graph(4-5) , Also Graphs done for Rt kidney volume with the same somatic variables produce , Graph (4-7) Rt kidney and age, Graph (4-9) RT kidney volume and height, Graph (4-11) Rt kidney volume and weight .

Correlation between LT kidney variables with the same somatic (in dependant) variables presented in Table (4-7) ,Table (4-8) Table (4-9) ,Graph done for LT kidney length with somatic variables, Graph (4-2) Lt kidney length and age ,Graph (4-4) Lt kidney length and height ,Graph (4-6) Lt kidney length and weight, Graphs also done for volume with same somatic variables produce, Graph (4-8) Lt kidney volume and age , Graph (4-10) Lt kidney volume and height , Graph (4-12) Lt kidney volume and weight.

RT and LT kidney length/SD and volume(SD) in all age group showed in Table (4-10) , Mean kidney length and volume for age group showed in (4-11),Mean kidney length and volume according height Showed in Table (4-12),Mean kidney length and volume according weight showed in Table (4-13) ,Mean kidney length and volume according to BMI showed in Table (4-14) .

Table 4-1 Age and Gender Distribution :

Age Group	Male	Female	Total
2 mo	2	2	4
4 mo	1	2	3
6 mo	1	2	3
8mo	2	2	4
10mo	2	0	2
1year	1	2	3
2 year	1	1	2
3year	3	1	4
4year	2	2	4
5year	1	2	3
6year	1	1	2
7year	2	1	3
8year	1	1	2
9year	1	1	2
10year	1	1	2
11year	2	3	5
12year	2	2	4
13year	2	1	3
14year	3	0	3
Total	33 55%	27 45%	60

Table (4-2) Mean/SD for all variable

	Minimum	Maximum	Mean	Std. Deviation
Age/Month	1	168	69.30	57.933
RTK Length	4.3	8.3	6.348	1.0046
RTK Width	2.6	4.9	3.763	.4672
RTK Breadth	2.1	3.8	3.183	.4607
RTK Volume	15.0	71.1	41.562	15.2756
LTK Length	4.0	8.7	6.658	1.1253
LTK Width	2.6	4.8	3.758	.5251
LTK Breadth	2.20	3.80	3.2218	.45476
LTK Volume	14.0	83.0	44.380	17.1132
Height	45	155	105.10	33.413
Weight	4.0	55.0	19.970	12.7203
BMI	11.5	23.3	16.320	2.5614

Table 4-3 Paired Sample Test Between RT Kidney Variables and LT Kidney Variables :

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
RTK Length - LTK Length	-.3100	.4554	.0588	-.4276	-.1924	-5.273	59	.000
RTK Width - LTK Width	.0050	.2677	.0346	-.0642	.0742	.145	59	.885
RTK Breadth - LTK Breadth	-.03850	.21696	.02801	-.09455	.01755	-1.375	59	.174
RTK Volume - LTK Volume	-2.8183	5.1798	.6687	-4.1564	-1.4802	-4.215	59	.000

Table 4-4 Correlation between age and RT kidney variables:

		Age/Month	RTK Length	RTK Width	RTK Breadth	RTK Volume
Age/Month	Pearson Correlation	1	.823**	.814**	.782**	.887**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	60	60	60	60	60
RTK Length	Pearson Correlation	.823**	1	.756**	.832**	.936**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	60	60	60	60	60
RTK Width	Pearson Correlation	.814**	.756**	1	.774**	.898**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	60	60	60	60	60
RTK Breadth	Pearson Correlation	.782**	.832**	.774**	1	.923**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	60	60	60	60	60

RTK Volume	Pearson Correlation	.887**	.936**	.898**	.923**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	60	60	60	60	60

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

Table 4-5 Correlation between Height and RT kidney variables:

		RTK Length	*RTK Width*	*RTK Breadth*	*RTK Volume*	*Height*
RTK Length	*Pearson Correlation*	*1*	*.756***	*.832***	*.936***	*.905***
	Sig. (2-tailed)		*.000*	*.000*	*.000*	*.000*
	N	*60*	*60*	*60*	*60*	*60*
RTK Width	*Pearson Correlation*	*.756***	*1*	*.774***	*.898***	*.829***
	Sig. (2-tailed)	*.000*		*.000*	*.000*	*.000*
	N	*60*	*60*	*60*	*60*	*60*
RTK Breadth	*Pearson Correlation*	*.832***	*.774***	*1*	*.923***	*.843***
	Sig. (2-tailed)	*.000*	*.000*		*.000*	*.000*
	N	*60*	*60*	*60*	*60*	*60*
RTK Volume	*Pearson Correlation*	*.936***	*.898***	*.923***	*1*	*.930***
	Sig. (2-tailed)	*.000*	*.000*	*.000*		*.000*
	N	*60*	*60*	*60*	*60*	*60*
Height	*Pearson Correlation*	*.905***	*.829***	*.843***	*.930***	*1*
	Sig. (2-tailed)	*.000*	*.000*	*.000*	*.000*	
	N	*60*	*60*	*60*	*60*	*60*

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

Table 4-6 Correlation between weight and RT kidney variables :

		RTK Length	RTK Width	RTK Breadth	RTK Volume	Weight
RTK Length	Pearson Correlation	1	.756**	.832**	.936**	.847**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	60	60	60	60	60
RTK Width	Pearson Correlation	.756**	1	.774**	.898**	.759**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	60	60	60	60	60
RTK Breadth	Pearson Correlation	.832**	.774**	1	.923**	.759**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	60	60	60	60	60
RTK Volume	Pearson Correlation	.936**	.898**	.923**	1	.871**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	60	60	60	60	60
Weight	Pearson Correlation	.847**	.759**	.759**	.871**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	60	60	60	60	60

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

Table 4-7 Correlation between age and LT kidney variables :

		LTK Length	LTK Width	LTK Breadth	LTK Volume	Age/Month
LTK Length	Pearson Correlation	1	.803**	.811**	.930**	.819**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	60	60	60	60	60
LTK Width	Pearson Correlation	.803**	1	.841**	.931**	.816**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	60	60	60	60	60
LTK Breadth	Pearson Correlation	.811**	.841**	1	.922**	.774**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	60	60	60	60	60
LTK Volume	Pearson Correlation	.930**	.931**	.922**	1	.873**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	60	60	60	60	60
Age/Month	Pearson Correlation	.819**	.816**	.774**	.873**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	60	60	60	60	60

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

Table 4-8 Correlation Between Height and LT Kidney Variables :

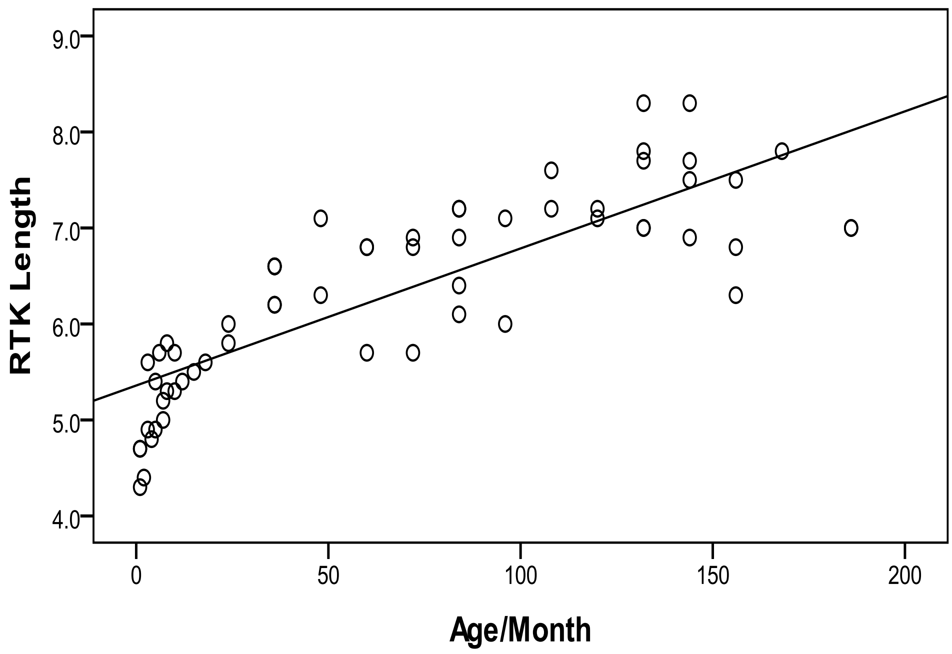
		LTK Length	LTK Width	LTK Breadth	LTK Volume	Height
LTK Length	Pearson Correlation	1	.803**	.811**	.930**	.895**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	60	60	60	60	60
LTK Width	Pearson Correlation	.803**	1	.841**	.931**	.853**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	60	60	60	60	60
LTK Breadth	Pearson Correlation	.811**	.841**	1	.922**	.842**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	60	60	60	60	60
LTK Volume	Pearson Correlation	.930**	.931**	.922**	1	.921**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	60	60	60	60	60
Height	Pearson Correlation	.895**	.853**	.842**	.921**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	60	60	60	60	60

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

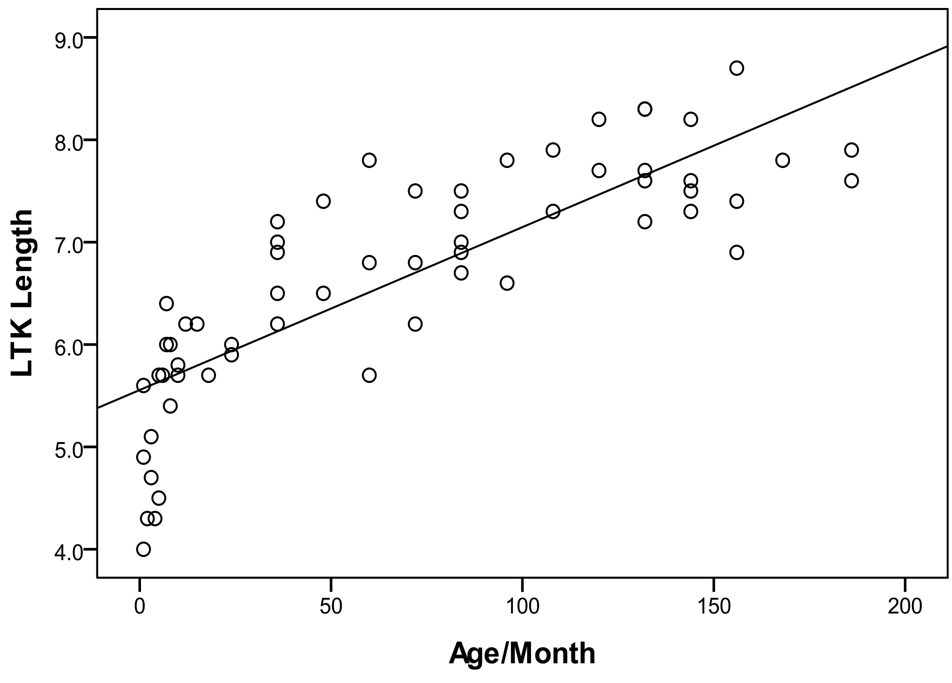
Table 4-9 Correlation Between Weight LT Kidney Variables:

		LTK Length	LTK Width	LTK Breadth	LTK Volume	Weight
LTK Length	Pearson Correlation	1	.803**	.811**	.930**	.796**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	60	60	60	60	60
LTK Width	Pearson Correlation	.803**	1	.841**	.931**	.765**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	60	60	60	60	60
LTK Breadth	Pearson Correlation	.811**	.841**	1	.922**	.732**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	60	60	60	60	60
LTK Volume	Pearson Correlation	.930**	.931**	.922**	1	.827**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	60	60	60	60	60
Weight	Pearson Correlation	.796**	.765**	.732**	.827**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	60	60	60	60	60

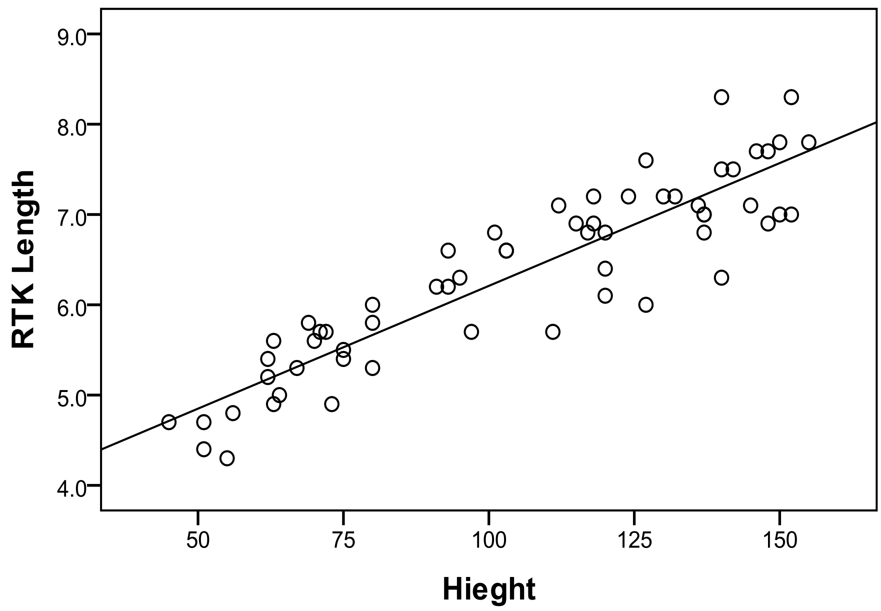
**. Correlation is significant at the 0.01 level (2-tailed).



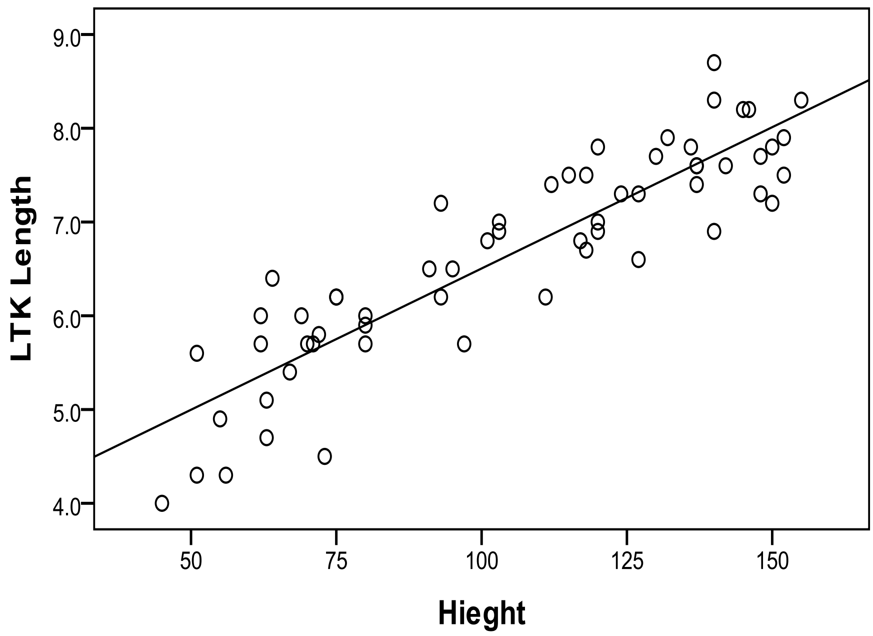
Graph 4-1 between Age and RT kidney length



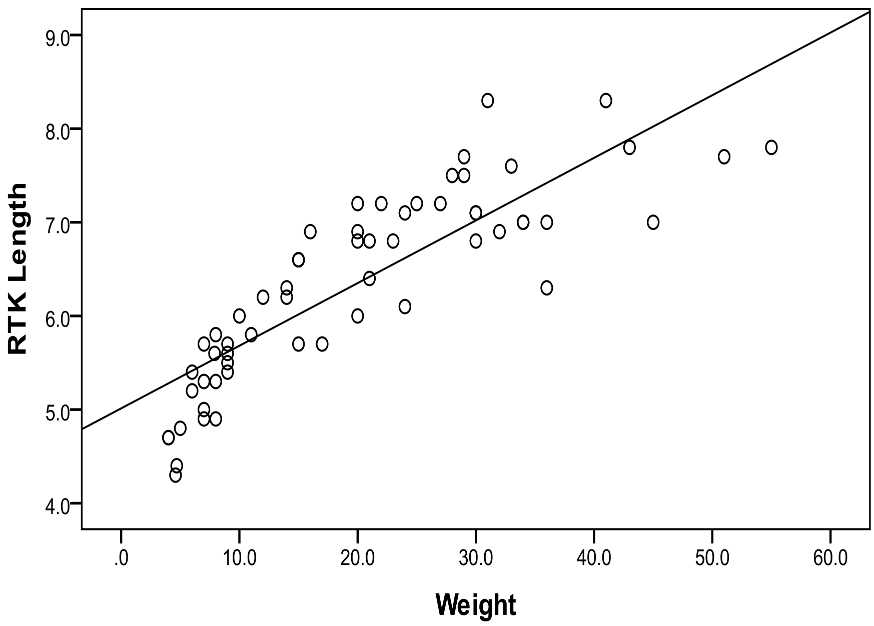
Graph 4-2 between Age and LT kidney length



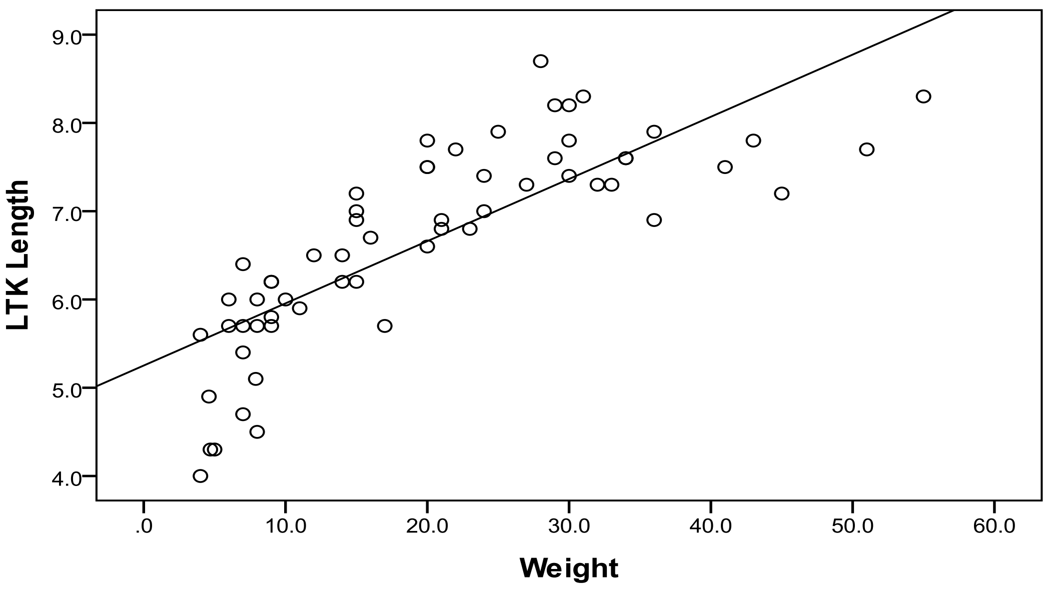
Graph 4-3 between Height and RT kidney Length



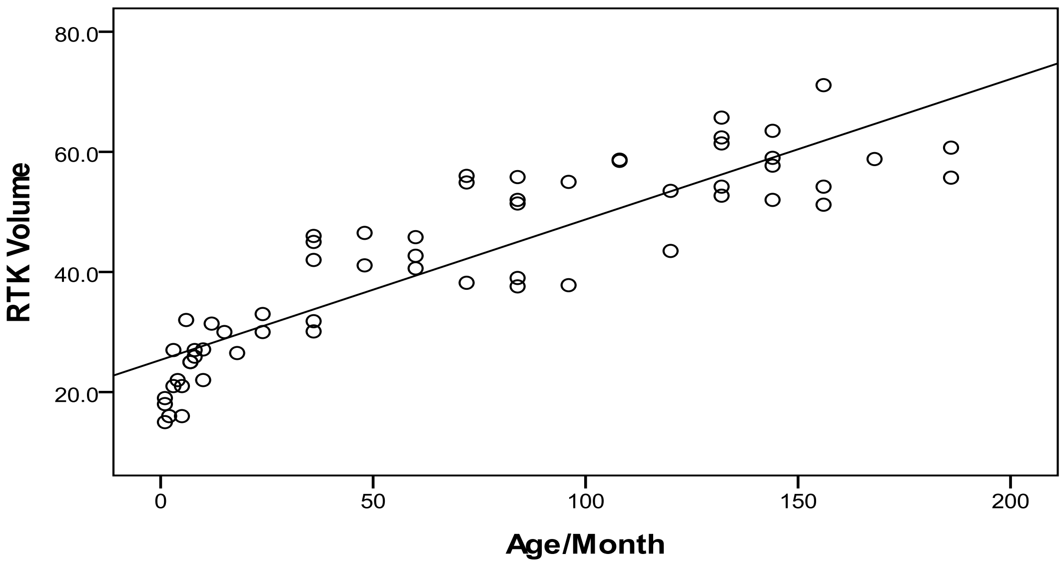
Graph 4-4 between Height and LT kidney length



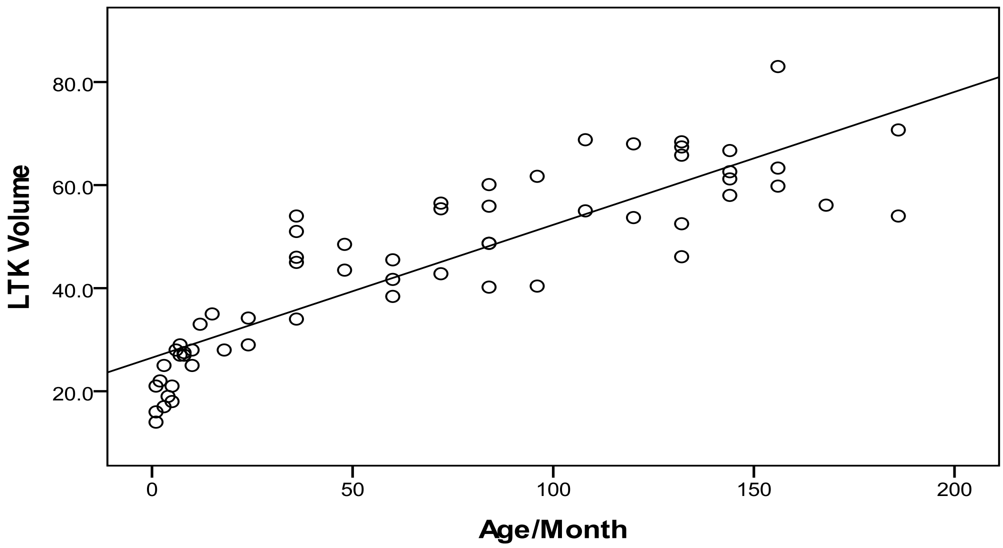
Graph 4-5 between Weight and RT kidney length



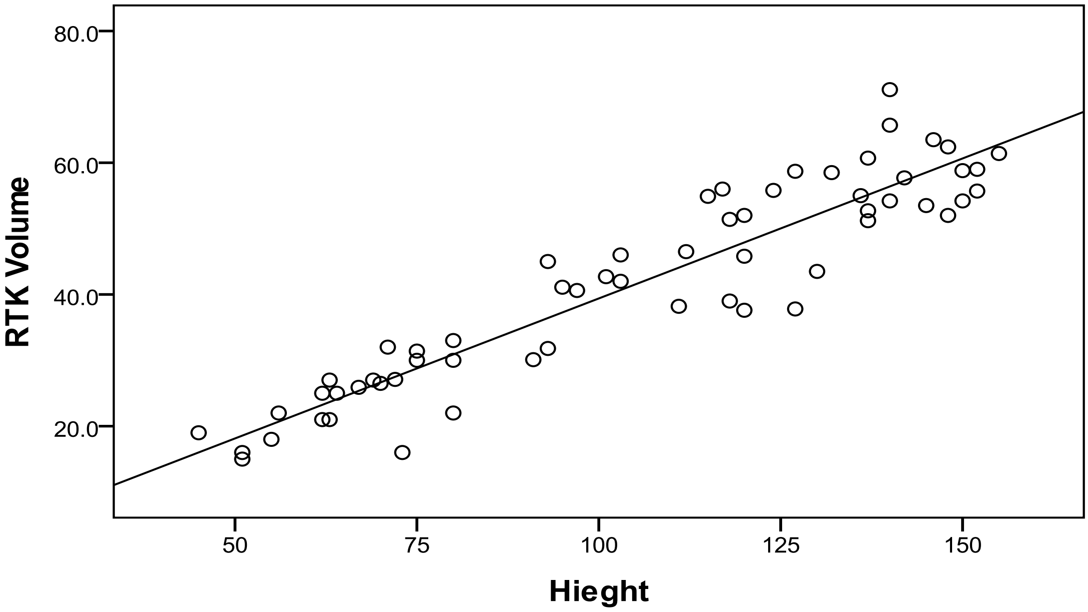
Graph 4-6 between Weight and LT kidney length



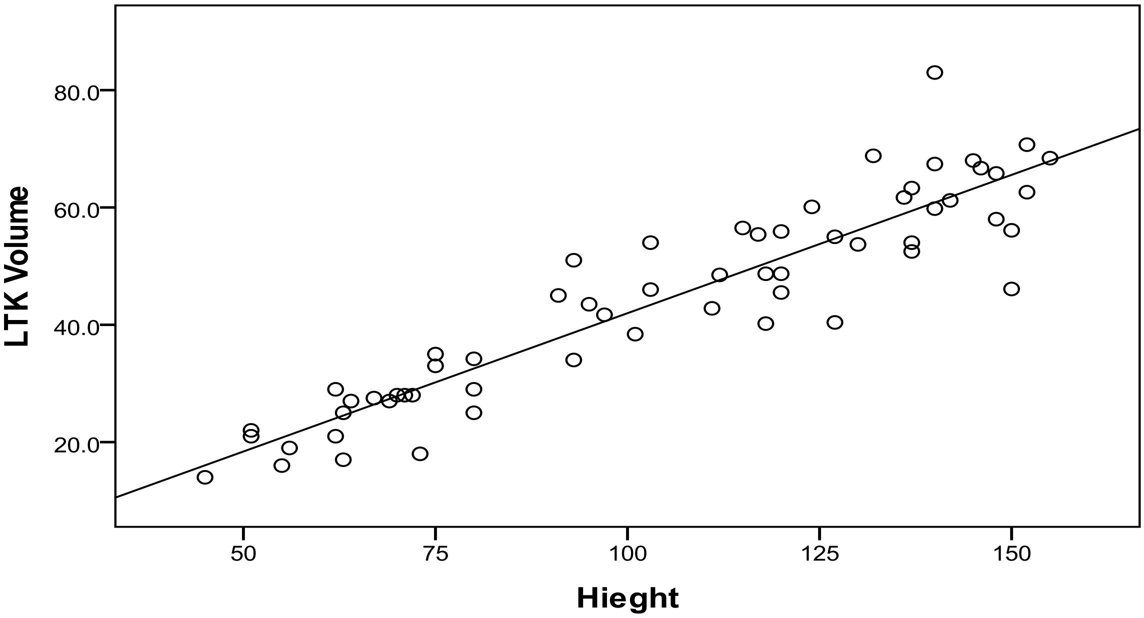
Graph 4-7 between Age and RT Kidney Volume



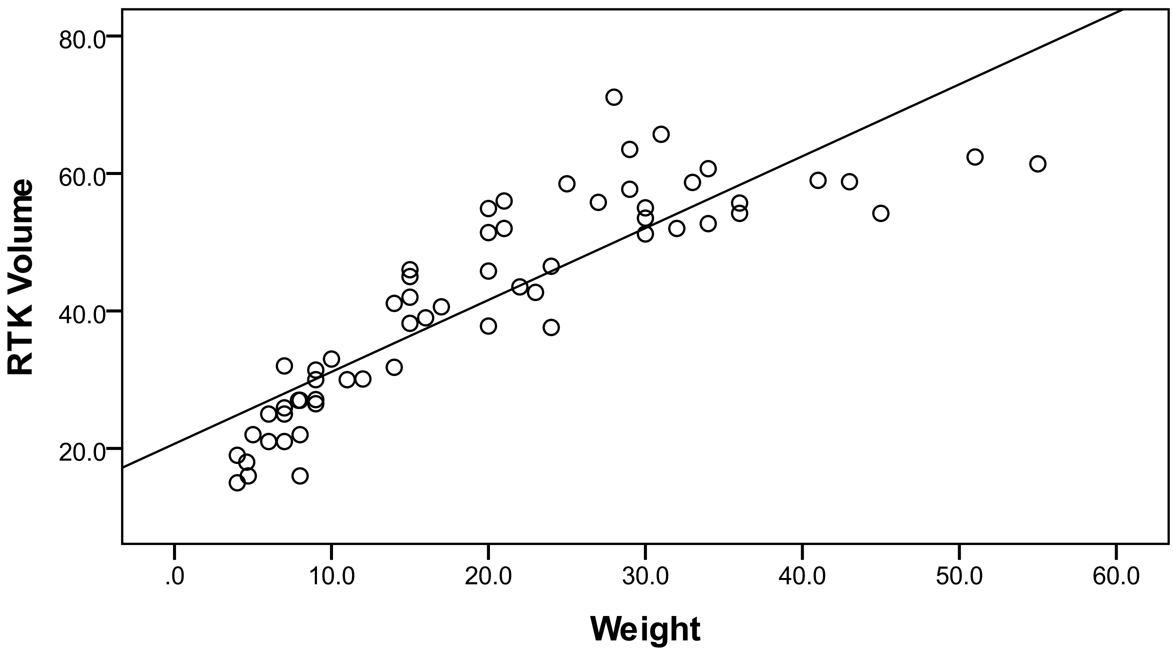
Graph 4-8 between Age and LT Kidney Volume



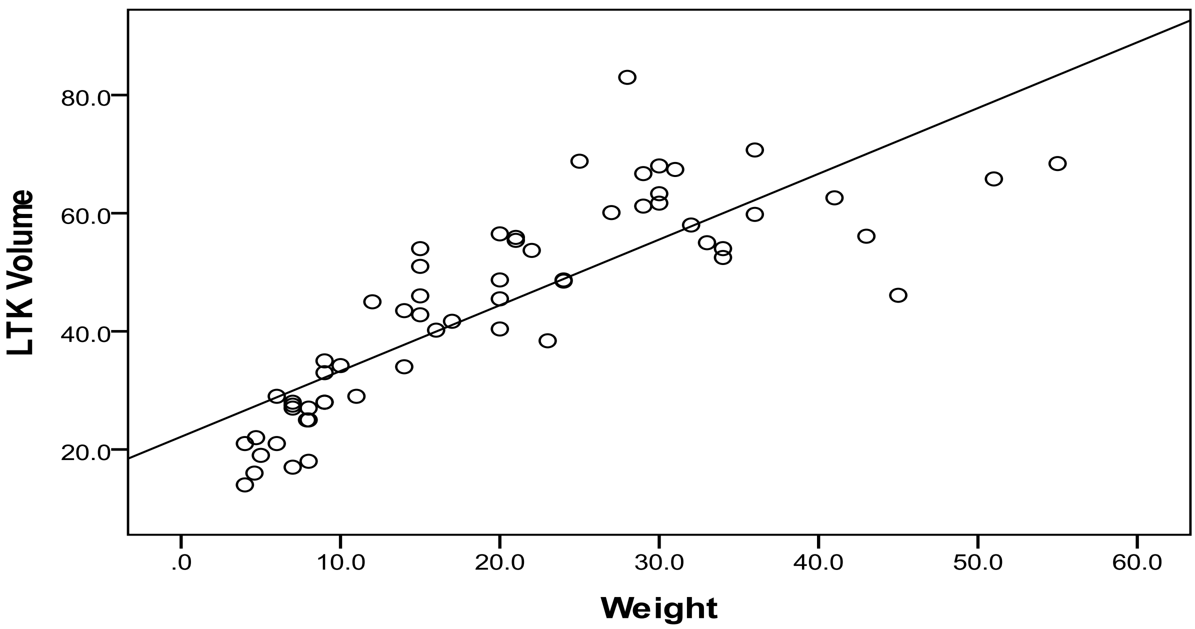
Graph 4-9 between Height and RT Kidney Volume



Graph 4-10 between Height and lT Kidney Volume



Graph 4-11 between Weight and RT Kidney Volume



Graph 4-12 between Weight and LT Kidney Volume

Table 4-10 NOMOGRAM for RT kidney Length and Volume , LT kidney Length and Volume Distribution according to Age and Gender :

AGE	***NO***	***R kidney length Mean***	***Lt kidney Length Mean***	***R kidney Volume Mean***	***Lt kidney Volume Mean***
2 mo	*4*	*4.5*	*4.7*	*17*	*18.2*
M	*2*	*4.7*	*4.8*	*17*	*17.5*
F	*2*	*4.3*	*4.6*	*17*	*19*
4mo	*3*	*5.1*	*4.7*	*23.3*	*20.3*
M	*1*	*5.6*	*5.1*	*27*	*25*
F	*2*	*4.8*	*4.5*	*21.5*	*18*
6 mo	*3*	*5.3*	*5.3*	*23*	*22.3*
M	*1*	*5.4*	*5.7*	*21*	*21*
F	*2*	*5.3*	*5.1*	*24*	*23*
8mo	*4*	*5.3*	*5.9*	*25.7*	*27.6*
M	*2*	*5.0*	*5.9*	*25.4*	*27.3*
F	*2*	*5.4*	*6*	*26*	*28*
10mo	*2*	*5.5*	*5.7*	*24.5*	*26.5*
M	*2*	*5.5*	*5.7*	*24.5*	*26.5*
F	*0*				
12mo	*3*	*5.5*	*6*	*29.3*	*32*
M	*1*	*5.5*	*5.9*	*28.2*	*31.5*
F	*2*	*5.4*	*6.2*	*31.4*	*33*
2y	*2*	*5.9*	*5.9*	*30*	*28.5*
M	*1*	*5.8*	*5.9*	*30*	*29*
F	*1*	*6*	*6*	*30*	*28*
3y	*5*	*6.4*	*6.8*	*39*	*46*
M	*4*	*6.5*	*6.8*	*41.2*	*46.2*
F	*1*	*6.2*	*6.2*	*30.1*	*45*
4y	*2*	*6.7*	*6.9*	*43.8*	*46*
M	*1*	*7.1*	*7.4*	*46.5*	*46.5*
F	*1*	*6.3*	*6.5*	*41.1*	*43.5*
5y	*3*	*6.4*	*7*	*43*	*41.9*
M	*1*	*6.8*	*7.8*	*42.4*	*45.5*
F	*2*	*6.2*	*6.6*	*43.2*	*49.1*
6y	*3*	*6.5*	*6.8*	*49.7*	*51.6*

M F	2 1	6.3 6.8	6.8 6.8	46.5 56	49.6 55.4
7y M F	5 2 3	6.8 7 6.6	7.1 7 7.1	47.2 47.4 47	50.7 50.1 51.1
8y M F	2 1 1	6.5 7 6.6	7.2 6.6 7.8	46.4 37.8 55	51 40.4 61.7
9y M F	2 1 1	7.4 7.2 7.6	7.6 7.9 7.3	58.6 58.5 58.7	61.9 68.8 55
10y M F	2 1 1	7.1 7.2 7.1	7.9 7.7 8.2	48.5 43.5 53.5	60.8 53.7 68
11y M F	5 2 3	7.6 7.6 7.5	7.8 7.7 7.9	59 54.2 58.8	58.2 46.1 62.2
12y M F	4 2 2	7.6 7.3 7.9	7.6 7.7 7.5	58 57.7 58.3	62.1 62.3 61.9
13y M F	3 2 1	6.9 6.5 7.5	7.7 7.1 8.7	58.8 52.7 71.1	68.7 61.5 83
14y M F	3 3 0	7.3 7.3	7.8 7.8	58.4 58.4	60.3 60.3

4-11 NOMOGRAM for kidney Length /SD and Volume/SD , VS Age:

AGE	***Kidney Length Mean/ SD***	***Kidney Volume Mean/SD***
2 mo	*4.5/(0.3)*	*17.5(1.3)*
4mo	*4.9(0.4)*	*24.7(3.8)*
6 mo	*5.1 (0.6)*	*19(2.8)*
8mo	*5.7(0.06)*	*27.7 (2.1)*
10 mo	*5.7(0.7)*	*26.8/(0.21)*
12mo	*5.6*	*26*
2 y	*5.7(0.17)*	*30.6(3)*
3 y	*5.9 (0.3)*	*29.5(0.7)*
4y	*6.6/(0.31)*	*42.5(3.7)*
5y	*7 (0.35)*	*44.9/(3.7)*
6y	*6.5 (0.80)*	*42.4/(2.8)*

7y	*6.6 (0.66)*	*50/(8.8)*
9y	*6.8 /(0.78)*	*48.9/(13.6)*
10y	*7.4 /(0.070)*	*60.2/(4.8)*
11y	*7.5/(0.14)*	*54.6/(8.5)*
12y	*7.6(0.60)*	*57.9/(7.7)*
13y	*7.6 (0.38)*	*60.1/(4.2)*
14y	*7.5(0.74)*	*63.9/(11.8)*

Table 4-12 Renal Length /SD and Renal Volume /SD VS Height:

Height(CM)	*Mean Renal Length/SD(CM)*	*Mean Renal Volume / SD(ML)*
45-65	*5 (0.5)*	*20.9 (4)*
66-85	*5.5(O.4)*	*27.7 (4.4)*
86-105	*6.5(0.4)*	*42 (5.5)*
106-125	*6.9(0.5)*	*48.9 (6.7)*
126-145	*7.3(0.5)*	*57 (9)*
146-165	*7.7(0.5)*	*60(5.5)*

Table 4-13 Renal Length /SD and Renal Volume VS Weight:

Weight (Kg)	*Mean Renal length /SD(CM)*	*Mean Renal Volume /SD(ML)*
---10	*5.2/(0.5)*	*24.1/(5.4)*
11- 20	*6.5/(0.5)*	*42.6/(6.9)*
21-30	*7.2/ (0.5)*	*56.3/(9.5)*
31-40	*7.3(0.3)*	*58.3/(3.5)*
41-50	*7.6/ (0.4)*	*56.1 /(5.5)*
51-60	*8.1 / (0.6)*	*64.5/(0.5)*

Table 4-14 Renal Length /SD and Renal Volume VS Body Mass Index*:*

BMI	*Mean Renal Length*	*Mean Renal Volume*
11.5-13.5	*6.2*	*34.9*
13.6-15.5	*6.8*	*49.4*
15.6-17.5	*6.2*	*38.8*
17.6-19.5	*6.2*	*39.7*
19.6-21.5	*6.6*	*44.3*
21.6-23.6	*7.5*	*56.5*

BMI:Body Mass Index

Chapter Five

Discussion

Conclusion

Recommendation

5-1 Discussion:

Ultrasound is the modality of choice to assess kidney size and morphology. It,s lacks ionizing radiation, can be performed bedside and in real time, is well tolerated by the patient and parents, and the measurements are reproducible . (Geelhoed JJ, 2009)

In the present study, renal dimensions (length , width , and breadth) was assessed in sagittal view, transverse view with normal children with prone position. The prime rationale was to evaluate the maximum renal dimensions in both planes. Sonography seems to be an optimal technique for estimating the renal parameters in children. There are many reports about US renal sizes and volumes and their relationships with body size to our knowledge, this study is one of the largest studies performed which evaluates the relationship between renal size and anthropometric indices.

In children, the growth of organs is dependent on the growth of the child's body, and thus, the organ growth can be correlated with somatic parameters, such as: height, weight, and body surface area in addition to age (Jun-Hwee Kim, 2013).

All previous shows significant correlation with age , height and weight in different degrees from moderate to strong ,Kunue etal (Turky,1998) ,Anjali S Otive (india,2012),Kime et al (2013),Younus et al (Pakistan ,2015) they found good correlation with age but best with height ,this study support that , we found that the kidney length,width ,breadth and volume had a strongest correlation with height but correlated well with all variables, and therefore, could be used interchangeably. But since it might be difficult to obtain the height and weight of the child at the time of examination; we considered correlation with age to be more practical.

Previous studies were not consistent in establishing a solid view in regard to which kidney was longer or whether there was no significant difference between their length and their volume , Bokyung K.Han et al (USA,1985) , Anjali S Otive (india,2012),Rosan et al (Jordon,2015) their study showed no significant difference between RT and Lt kidney size . Kadioglu (Turky,2010) ,C.U Eze (Nigeria ,2015) their studies showed a significant difference of size between the left and right kidneys. Most of the studies showed that the left was longer than the right (Jun-Hwee Kim, 2013) ,and some shows The right kidney was to be longer than the left in few cases (Creel S, 2015),This study showed, there was statistically significant differences were observed between right and left kidneys p value(0.00), but there is no significant difference between other kidney measurements like Rt kidney width and Lt kidney width ,Rt kidney breadth and Lt kidney breadth.

Although there are known differences in the body composition and rate of body growth among females and males , Bokyung K.Han et al (USA,1985), Kounu et al(Turky ,1998),William K.Lofttus et al(China, 1998) , Anjali S Otive (india,2012),Rosan et al (Jordon,2015) they found there was no significant difference in the kidney length and volume among boys and girls in all age groups in most of previous studies, this study support that there were no difference in length and volume among boys and girls in all age groups.

limitation to this study:

Is attributed to the fact that two sonographers of different levels of experience (1-5 years) performed,the sonographic measurements contributing to inter-observer bias. In addition to the small sample size from only the Mohamed Alamin Hamid Pediatric hospital that might not be entirely representative of the whole Sudanese pediatric.

5-2 Conclusion:

Determination of pathologic changes in size of kidney necessitates knowing the normal range of dimensions for this organ in healthy neonates, infants, and children. Presented data are applicable in daily routine sonography.

In conclusion of this study there is significant difference in the kidney length and volume between Rt and Lt kidney in Sudanese children ,but there is no significant difference in the kidney length and volume among boys and girls .

There were significant correlation between kidney measurements (length, width ,breadth or thickness , volume) and age weight , height ,BMI.

A reliable and practical reference for normal standard kidney length and volume values in Sudanese children is provided.

5-3 Recommendation :

Height seems to be the most important factor associated with organ growth in growing children. Further studies to evaluate adequate organ growth should be carried out.

Renal sonographic measurement for pediatric can be performed as a bedside investigation by the even more important are serial measurements of renal length over time.Agrowing kidney in a child is a healthy kidney, whereas a kidney static in size over time may be an early indicator of Chronic Kidney Disease.

Further Work up:

Since this study was limited because of small sample size so the further workup is to take large sample.

References

., Bruce M. Human Embryology and . ISBN. 2015. Kidney development. *Wikipedia.* 2015, 2015.

Adeyekum A, Ibadin M, Omoigberale A. **Adeyekum A, Ibadin M, Omoigberale A. 2007.** Benin : Nigeria. Saudi J Kidney Dis Transpl., 2007.

America, Radiological Society of North. 2014. General ultra sound. *Radiological information organization for pateint.* 2016, 2014, 2016.

Anjali S Otiv, K MEHTA, U ALI AND *M NADKARNI. 2011. Sonographic Measurement of Renal Size in Normal Indian Children. *INDIAN PEDIATRICS.* 2011, Vol. 2012.

Anjali S. Otiv, K. Mehta, U. Ali, M. Nadkarni. 2012. Sonographic measurement of renal size in normal indian children . *Indian Pediatric.* 2012, 2012.

Bate, Jane. 2010. *Abdominal Ultarasound.* 2010.

Bates, Jane A. 2011. Abdominal Ultrasound: How, Why and When. *Abdominal Ultrasound.* 2011.

Bokyung K. Han, Diane S. Babcock. 1985. Sonographic Measurements. *American Roentgen Ray Society.* 1985.

C.U. Eze a, *, V.P. Akpan b, c, I.U. Nwadike a. febreuary 2016. Sonographic assessment of normal renal parenchymal and medullary. *Elsevier Ltd.* febreuary 2016.

Carlson, Bruce M. 2015. Kidney development. *Wikipedia.* 2015, 2015.

Elisabetta Buscarini, Harald Lutz and Paoletta Mirk. 2013. *Manual of diagnostic ultra sound.* Geneva, : WHO, 2013.

Evaluation of pediatric renal size by sonography. **Creel S, Anderson J, Michael K, Pinkerman B.** s.l. : Journal of diagnostic medical.

Gailani, Sayed Amir. 2000. Renal Diseases . *Burwin.* 2000.

Gaillani, Sayed AMir. 2003. Burwin. *Sayed Amir Gaillani.* 2003.

Geelhoed JJ, Kleyburg-Linkers VE, Snijders. 2009. Reliability of renal ultrasound measurements in. 2009.

George A. Tanner, Ph.D. 2015. Kidney Function. *RENAL PHYSIOLOGY AND BODY FLUIDS.* 2015.

Hung-Wen Kao, Ching-Jiunn Wu*. 2008. Ultrasound renal infectious Diseases. *j Med Ultrasound .* 2008.

Jun-Hwee Kim, MD1, Myung-Joon Kim, MD, PhD1, Sok Hwan Lim1, Jieun Kim2, Mi-Jung Lee, MD, PhD1. 2013. Length and volume of morphologically normal kidneys in korean children : ultrasound measurment and estimation using body size. 2013, Vol. 2013, pp. 677- 681.

Kanitkar, Madhuri. 2012. Kidney Size- What is Normal? *Indian Academy of Pediatric.* 2012, Vol. 2012.

Kent M. Van De Graaff, Dennis Strete. 2001. Human Anatomy . 2001.

Kidney Growth. **Schmidt IM, Main KM, Damgaard IN, Mau C,. 2004.** s.l. : Pediatr Nephrolgy, 2004, Vols. 19: 992-1003.

Liqa A Rousan, Jehad Fataftah,Mamoon H Al-Omari,Wail A. Hayajneh,Mohammad Miqdady,Yousef S. Khader. 2015. Sonographic Assessment of Kidney Length in Jordanian. *The University of Jordan.* 2015.

Morgan, Dr Matt A. introduction ultra sound.

OznurL.Konu@1. June17,1998. Normal Liver, Spleen, and Kidney. ©*AmericanRoentgenRaySociet.* June17,1998, ,December1998.

Palmer, P.E.T. 1999. *Manual of Diagnostic ultra sound.* california : WHO, 1999, pp. 7 , 12 .

Renal Measurments, including length , parenchymal thickness , and medullary pyramid thickness in healthy children. **Kadioglu, Alev. 2010.** 2010, s.l. : Amirecan Journal for Radiology, 2010, American journal of Radiology, pp. 509 -512-513.

Richard Lee Drake, Wayne Vogl, Adam W. M. Mitchell. 2010. *Gray's Anatomy for Students.* Churchill Livingstone/Elsevier : s.n., 2010.

Rosenbaum, David M . 1983. 1983, American Journal of Radiology, pp. 467 -468.

Sonographic assessment of normal kidney in the first of the life . **Vujic A, Kosutic J, Bogdanovic R, Prijic S,. 2007.** s.l. : pediatric Nephrol , 2007.

Stang, Debra. 2015. kidney function. 2015.

Stephanie Sippel1, Krithika Muruganandan1*, Adam Levine1 and Sachita Shah2. 2011. Use of ultrasound in the developing world. *International Journal of Emergency Medicine 2011, 4:72.* 2011, p. 1.

Ultrasoundpaedia. 2014. *Ultrasoundpaedia.* 2014.

William K. Loftus, Roger J. Gent, Garry W. LeQuesne and Constantine Metreweli. 1998. Renal length in chinese children: Sonographic measurement and comparison with Western data. *Journal of Clinical Ultrasound.* 1998, Vol. 7, Dec 1998.

—. Renal length in chinese children: Sonographic measurement and comparison with Western data. *Journal of Clinical Ultrasound.* Vol. 7, Dec 1998.

Wrenger, Eike. 2012. *Sonography in Renal Disease.* 2012, p. 40.

younus, Naila. 2015. Sonographic measurment of normal renal size and correlation with somatic variables in subset of karachi population. 2015, p. 24.

Appendices

Appendex I

Data Sheet (Quitionare)

Index no---------

Age ----------- Gender --------------- Residence---------------- Weight -------

Height -------------- BMI ------------

Indication : -------------------------

R KIDNEY :

Length --------- Width -------- Thickness(Breadth) ----------------

Volume -------

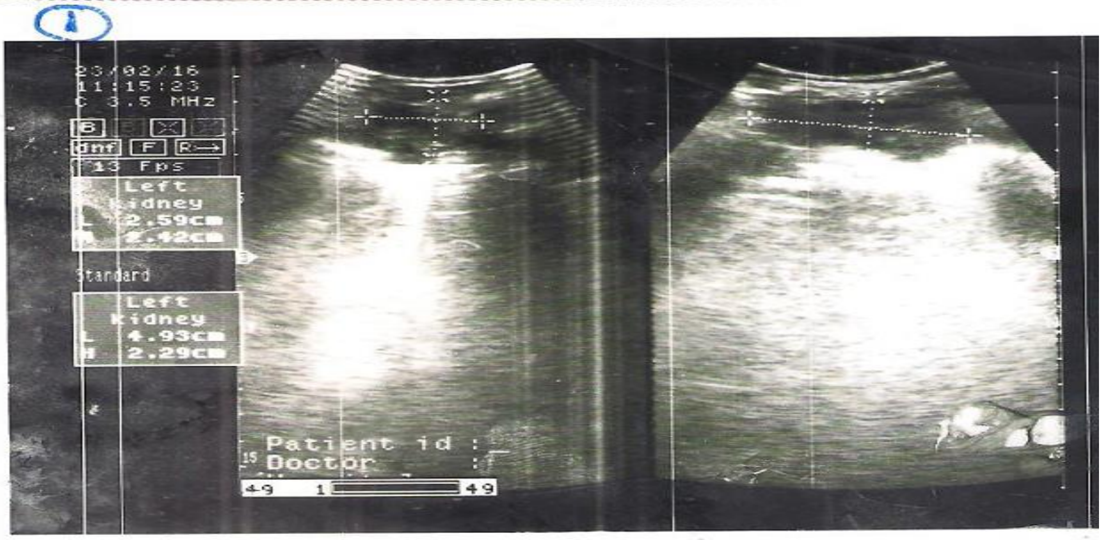
LT Kidney :

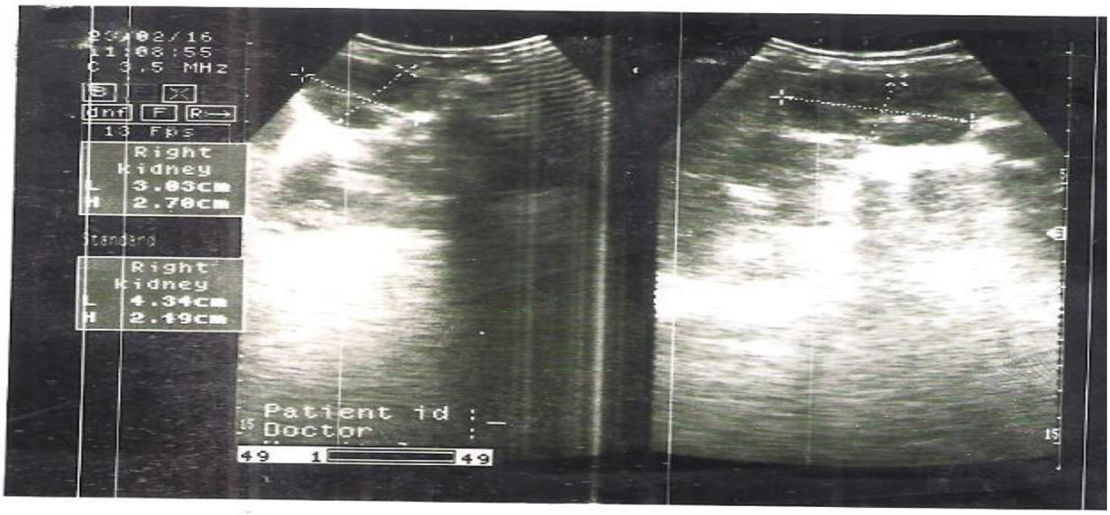
Length --------- Width ----------- Thickness(Breadth) ----------------

Volume ------

Appendix II

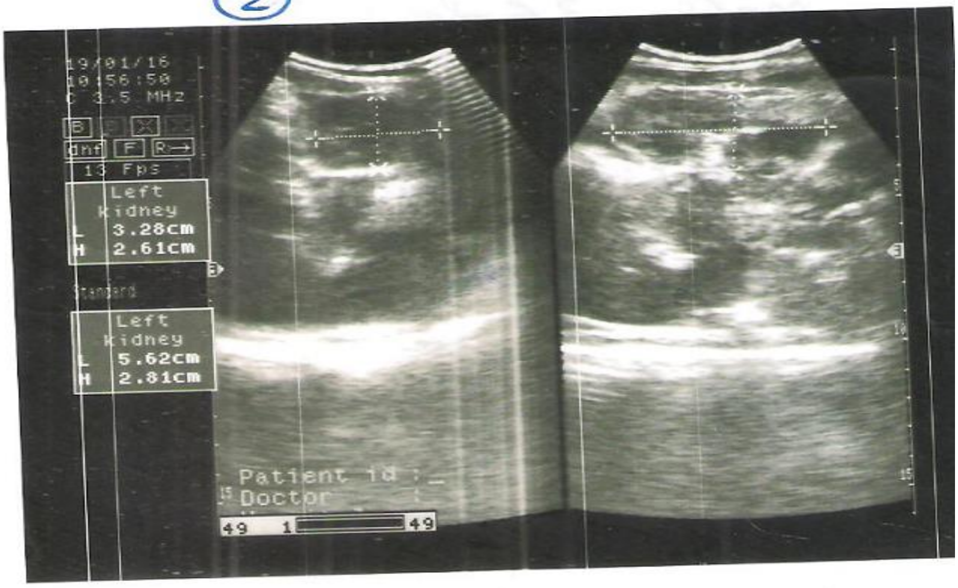
Images of Normal Pediatric Kidneys

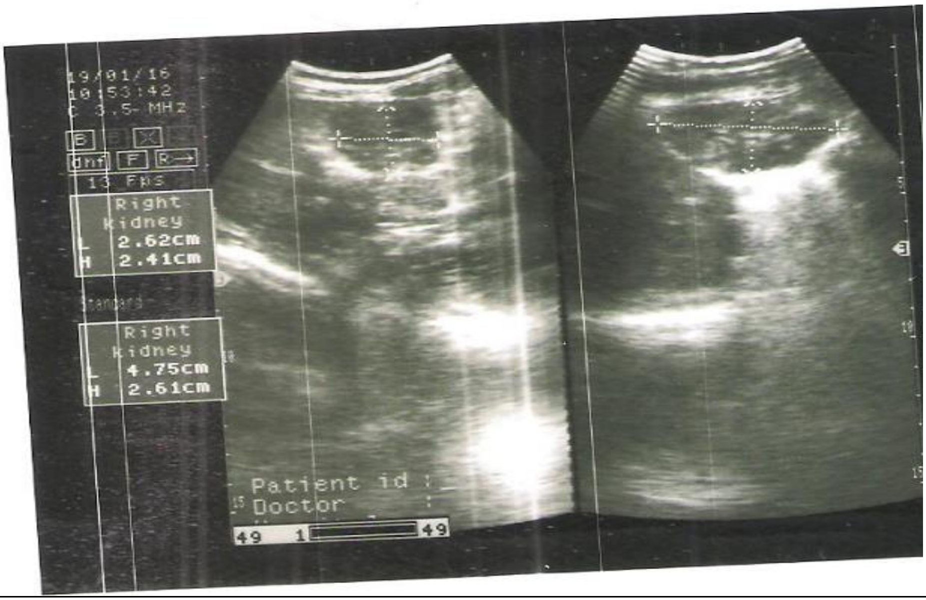




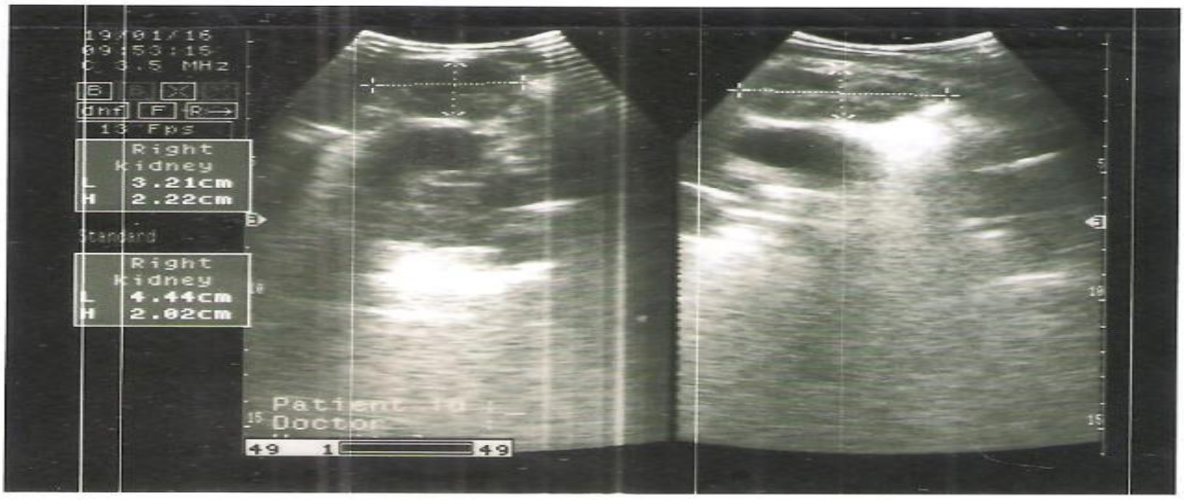
Normal Right and left kidney for baby female 1 month

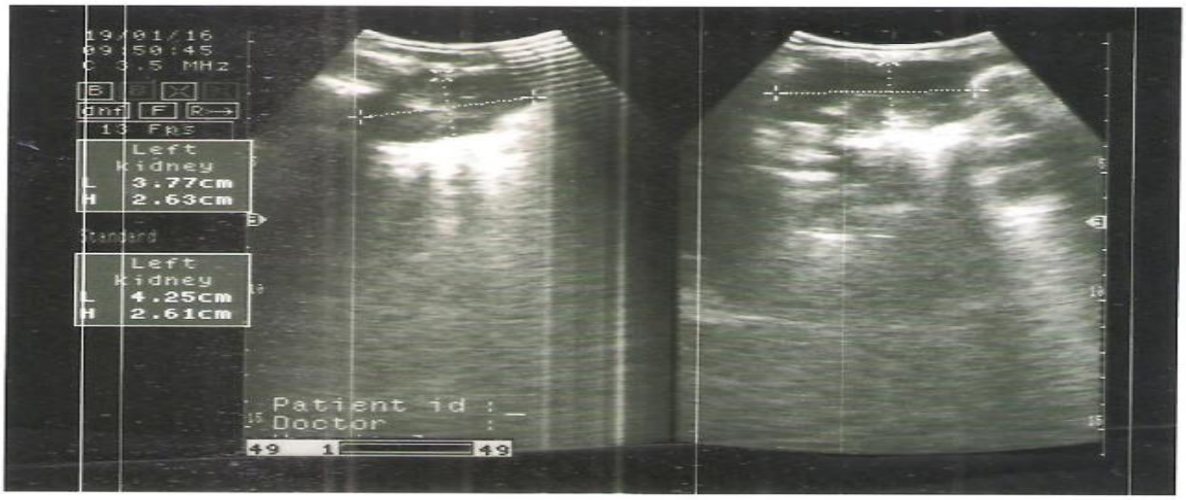
2



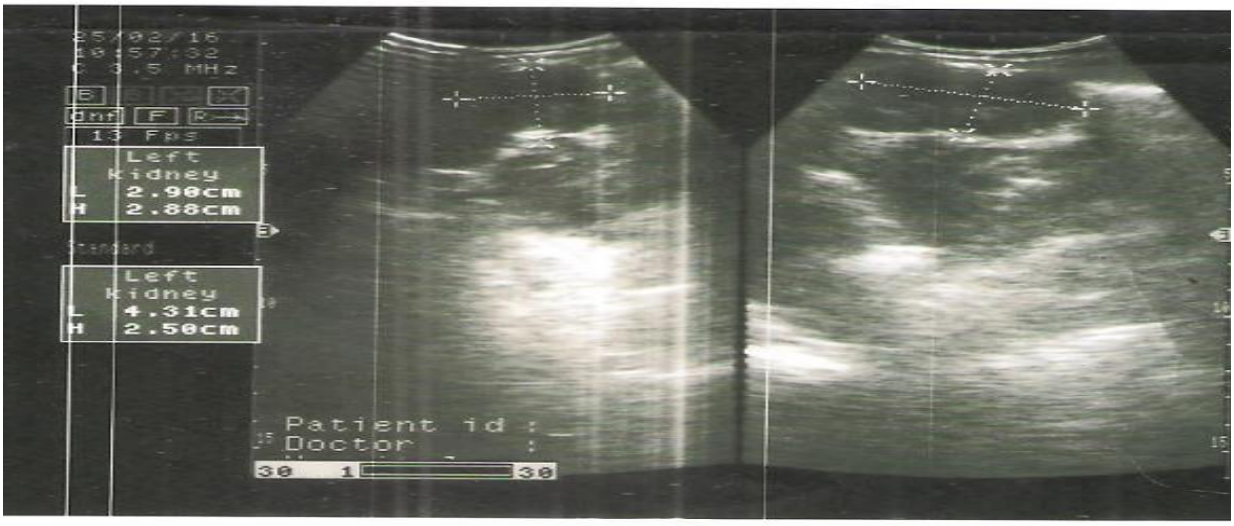


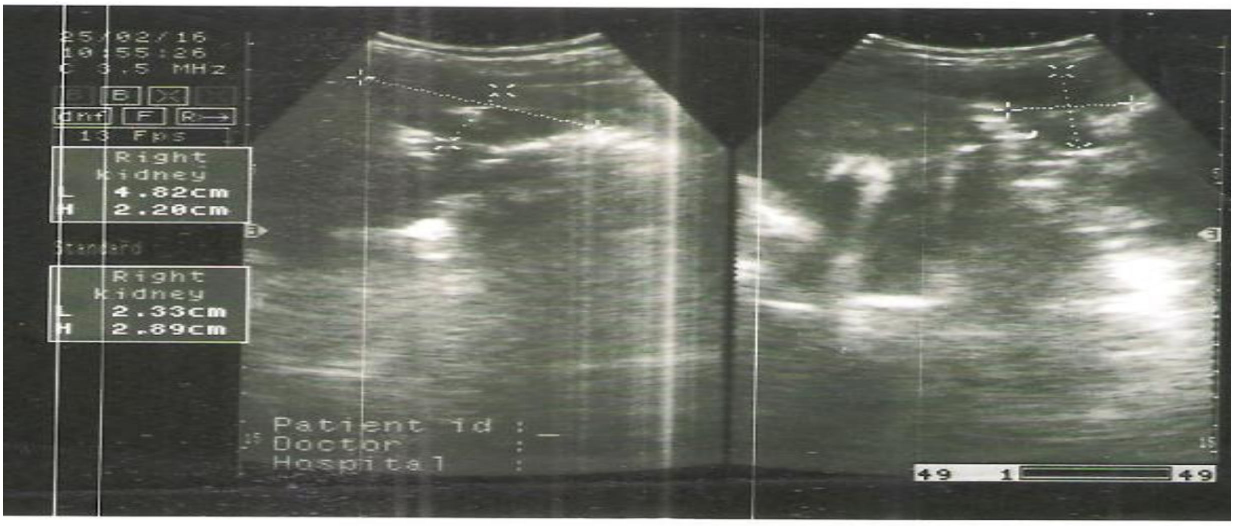
Normal Right and left kidney for baby male 1 month



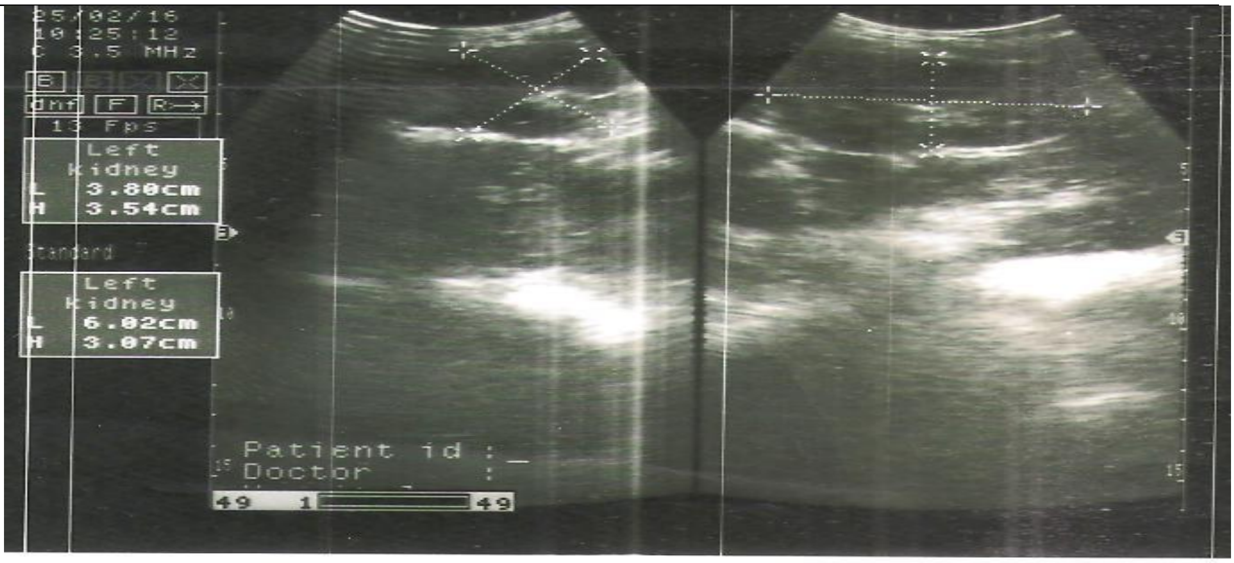


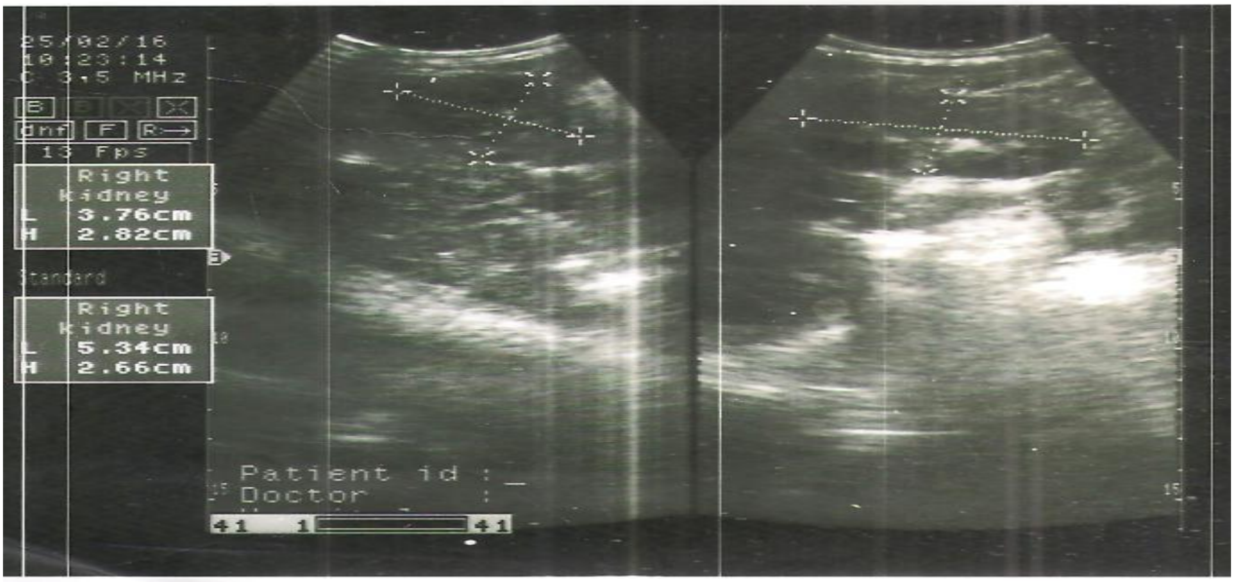
Normal Right and left kidney for baby female 2 months



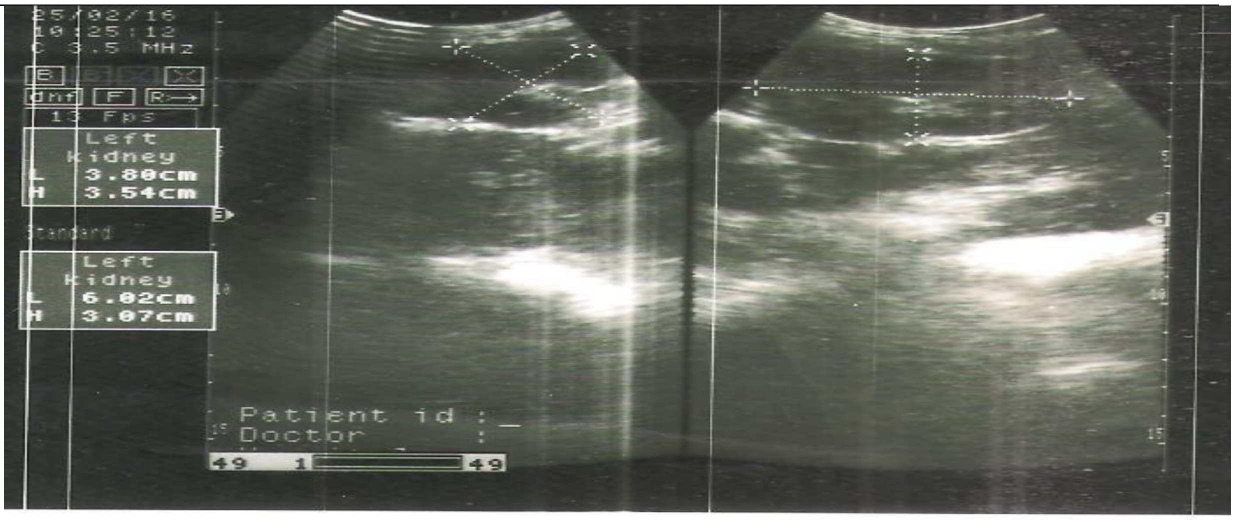


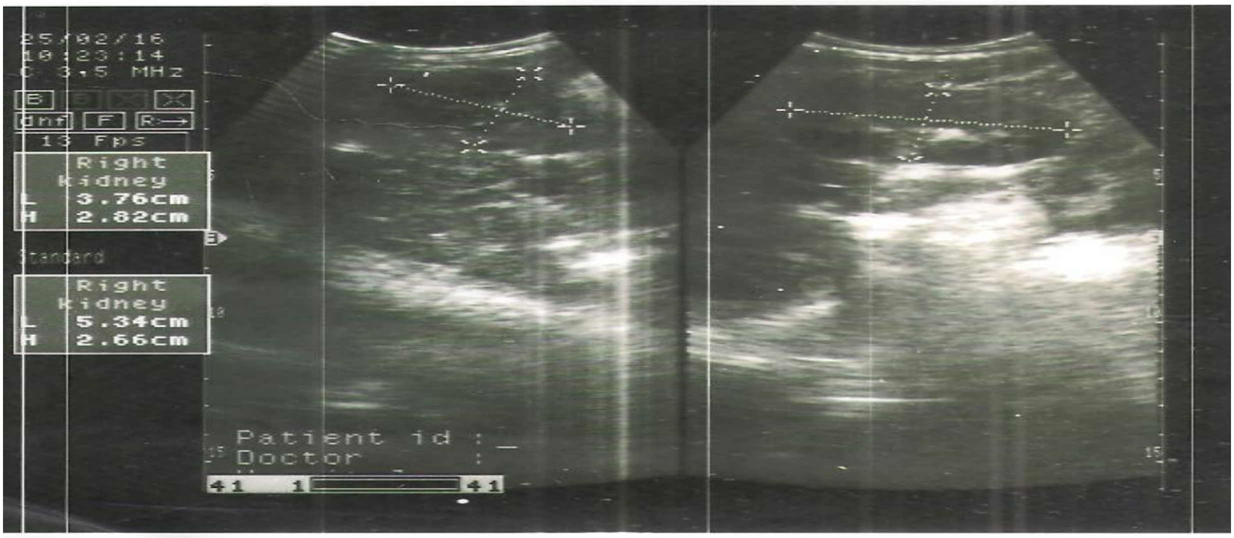
Normal Right and left kidney baby female 3 month



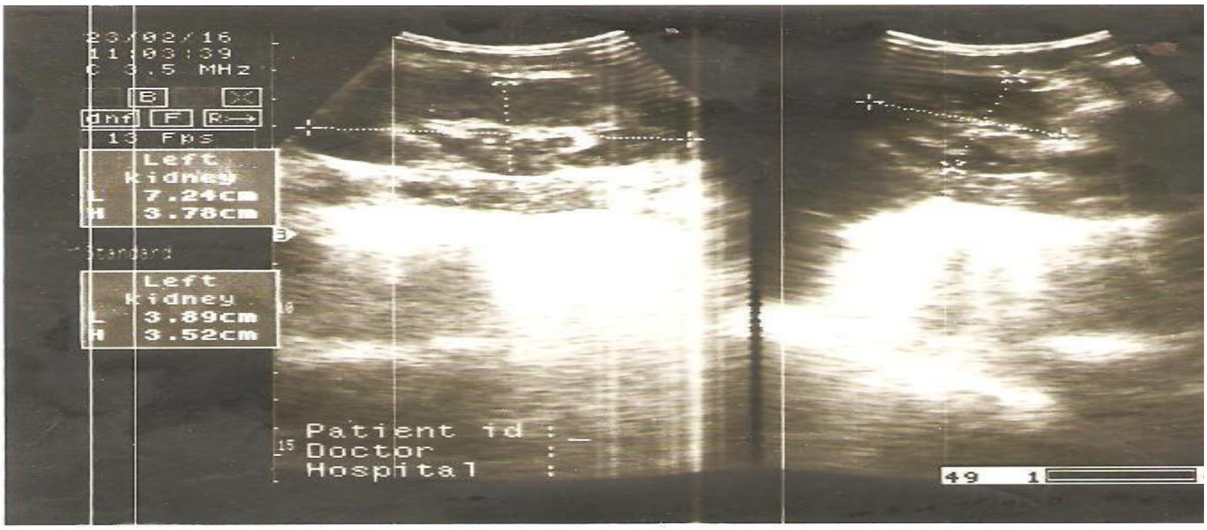


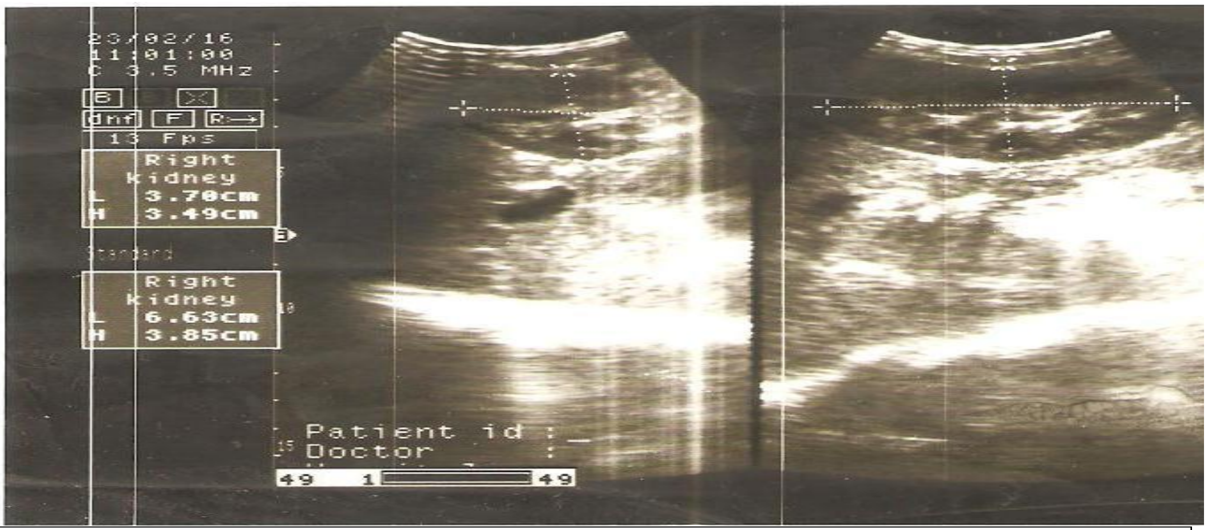
Normal Right and left kidney for baby male 3 month



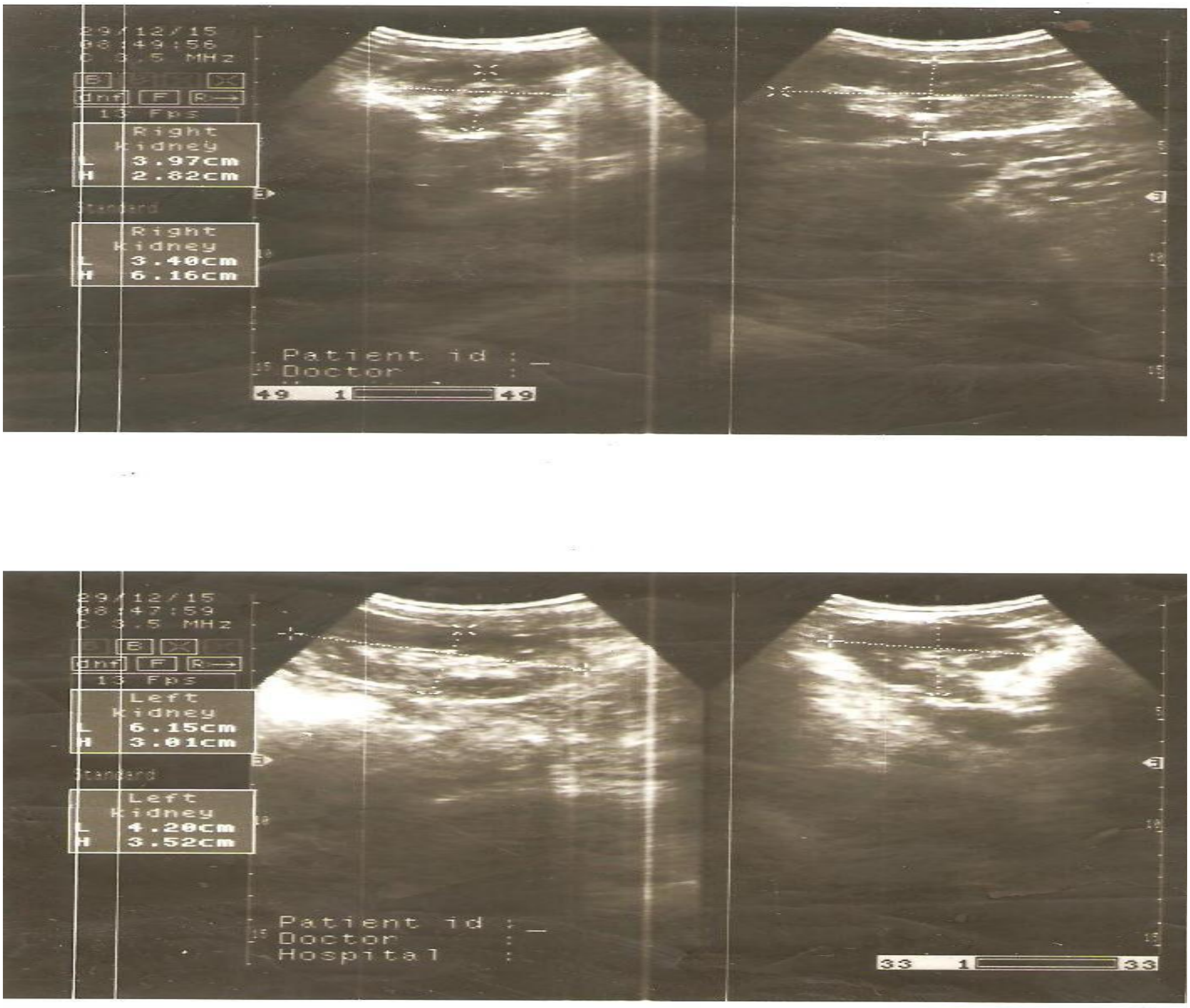


Normal Right and Left kidney for boy 15 month





Normal Right and Lef for boy 3 years



Normal Right and Left for girl 4 years

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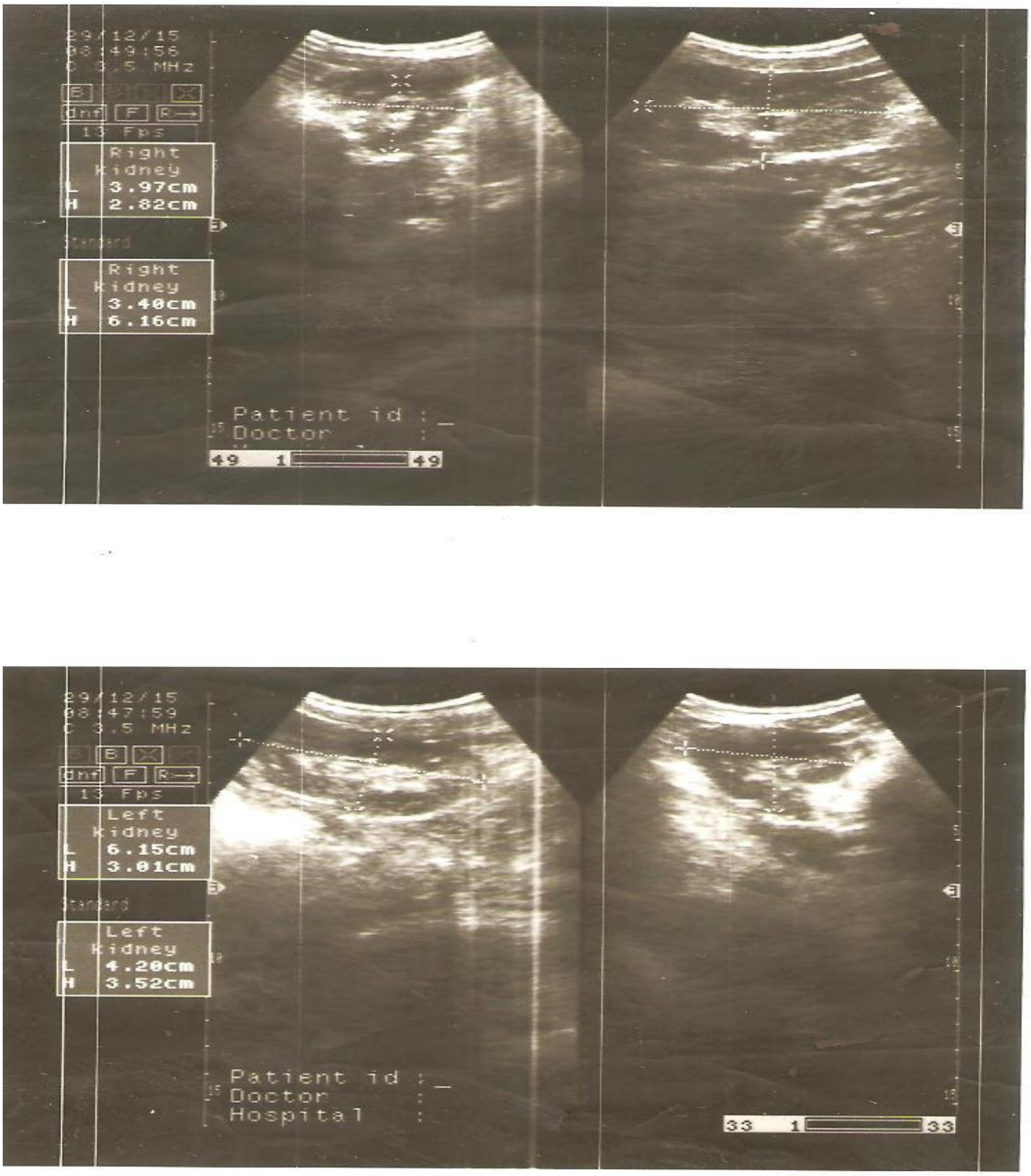

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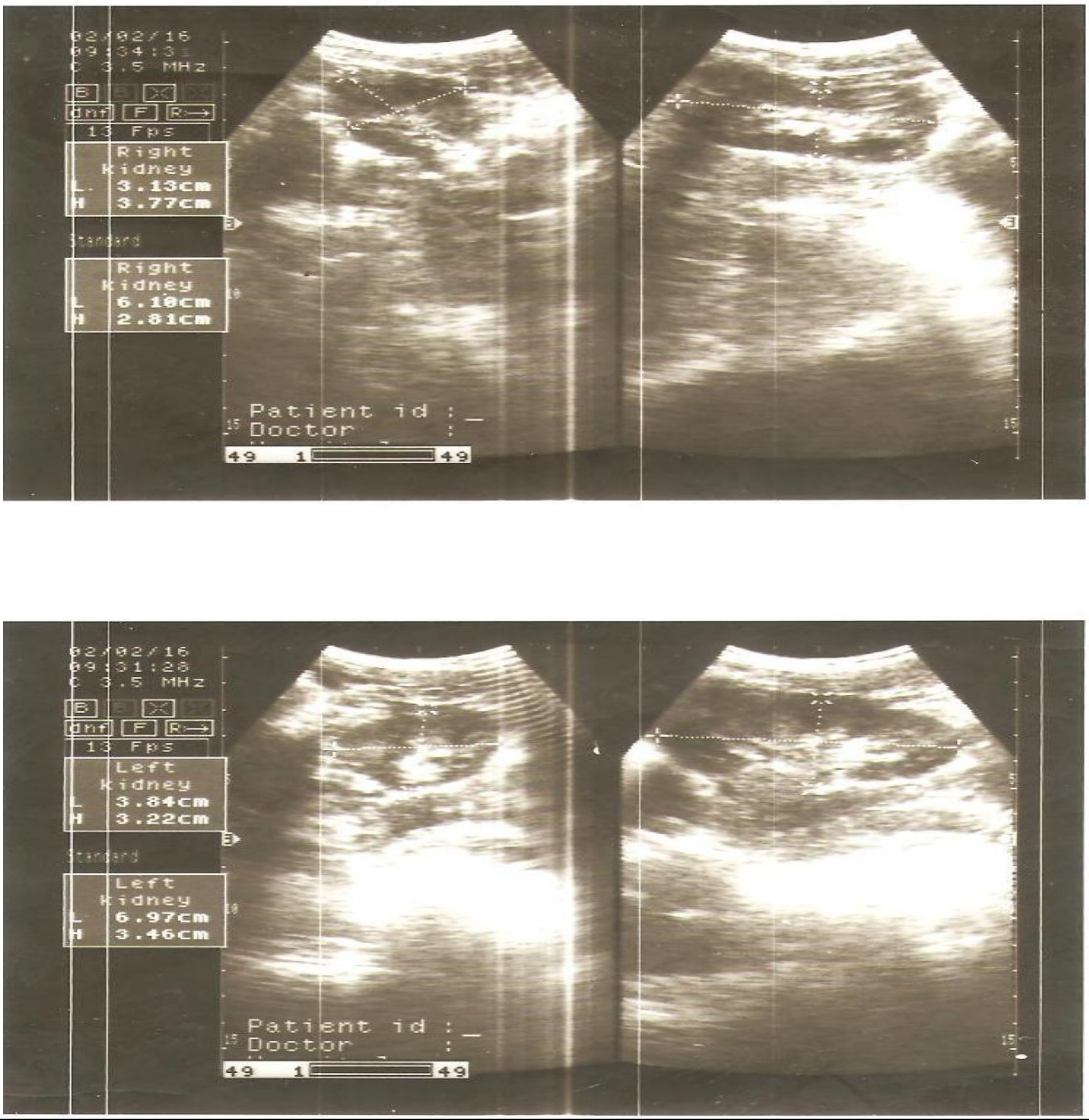
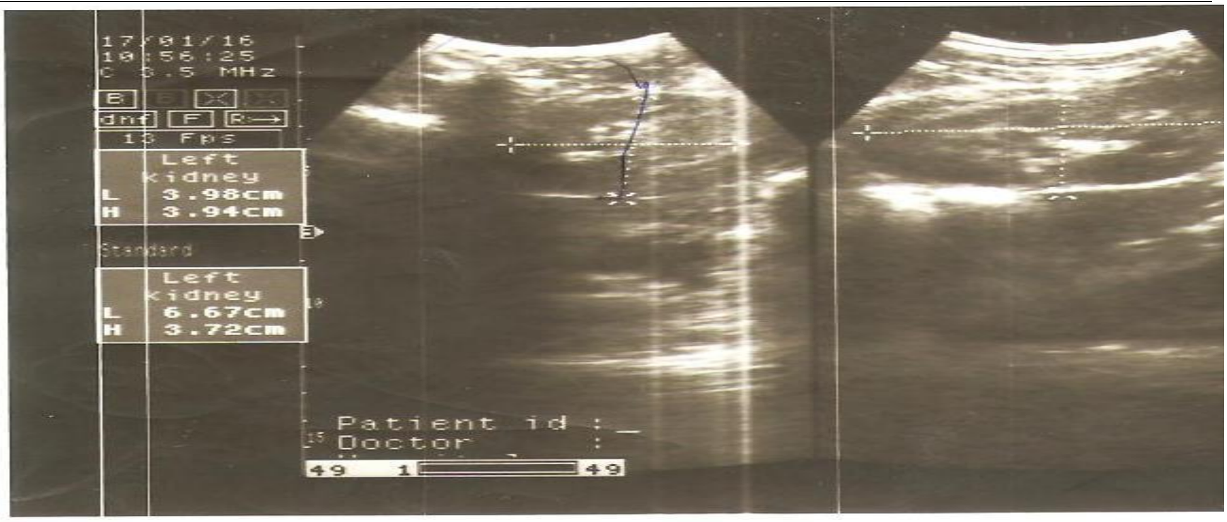
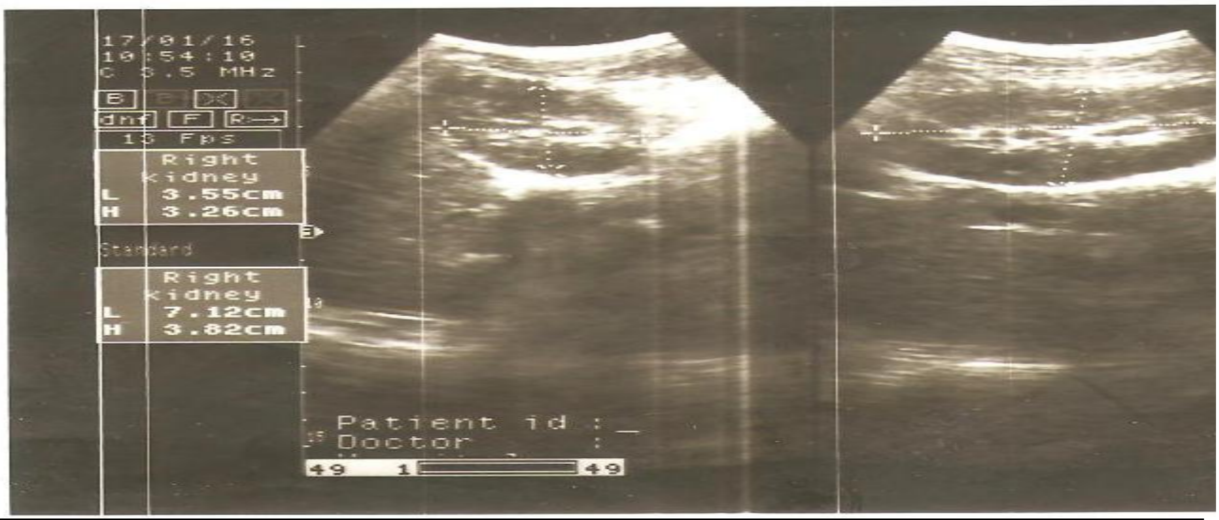
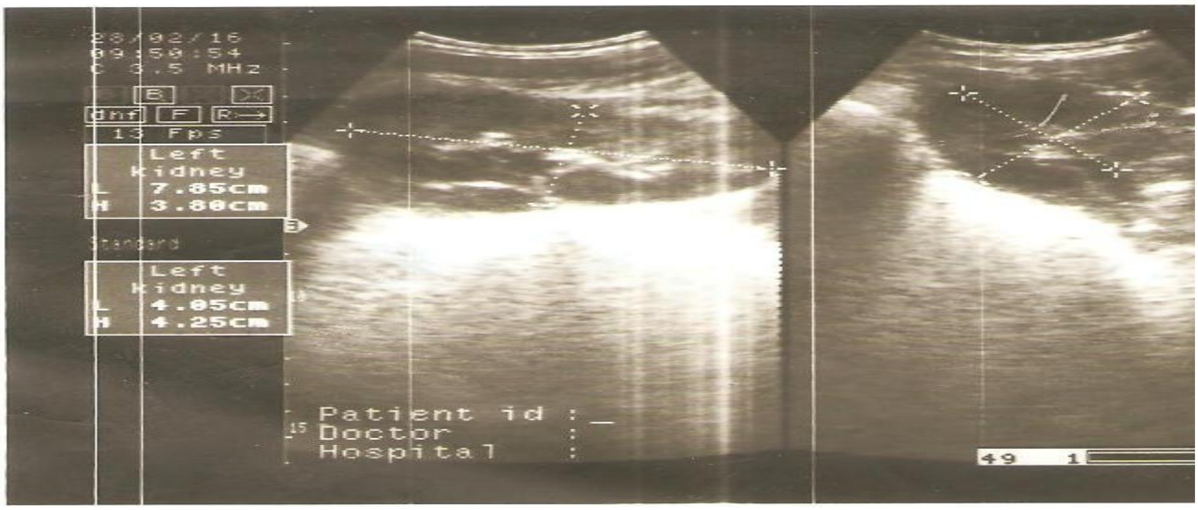


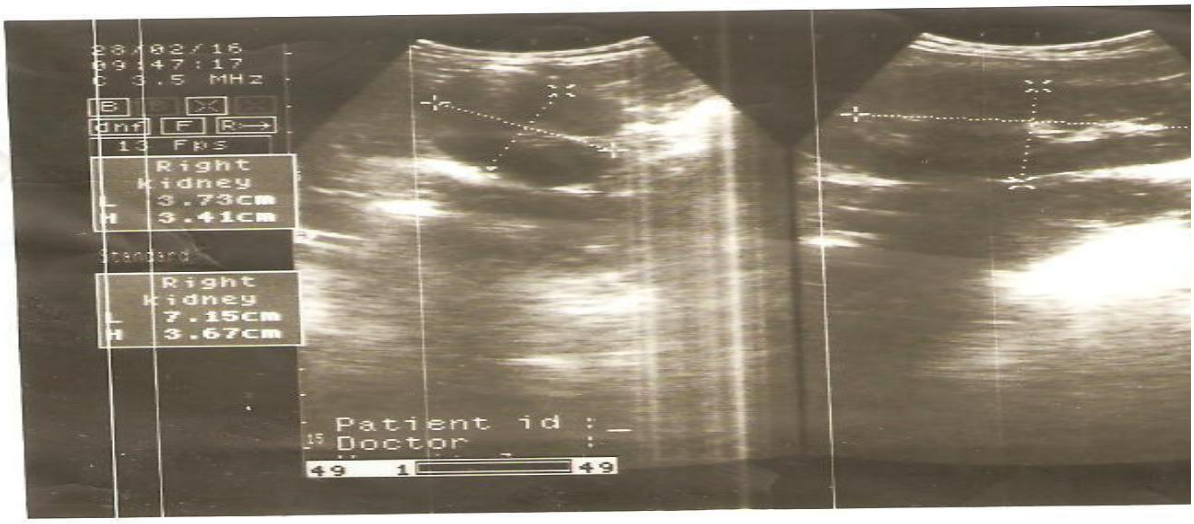
Normal Right and Left kidney for boy 7years



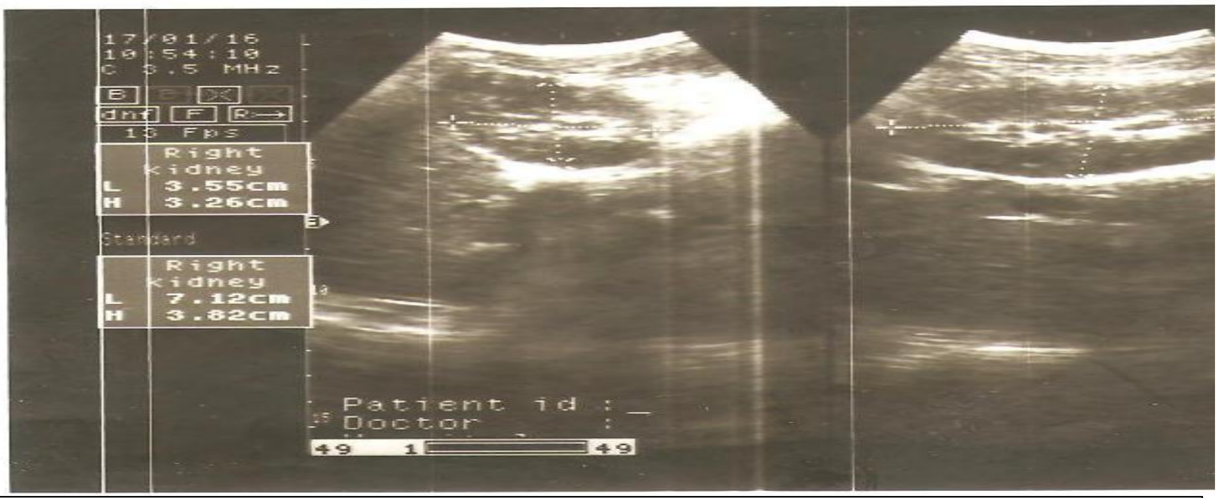


Normal Right and Left Kidney for boy 7 years

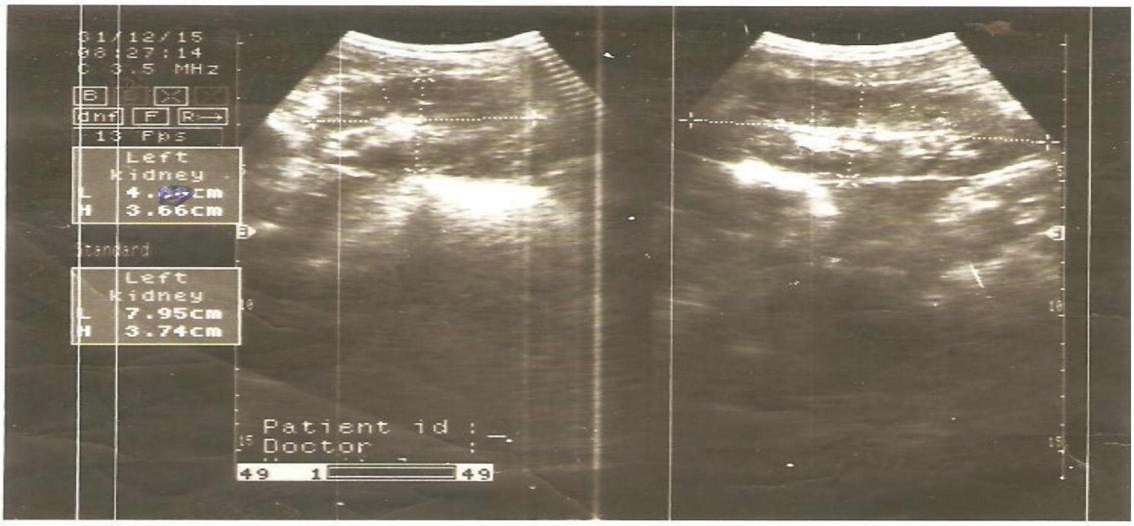




Normal Right and Left kidney for girl 8years



Normal Right and Left kidney for boy 8years



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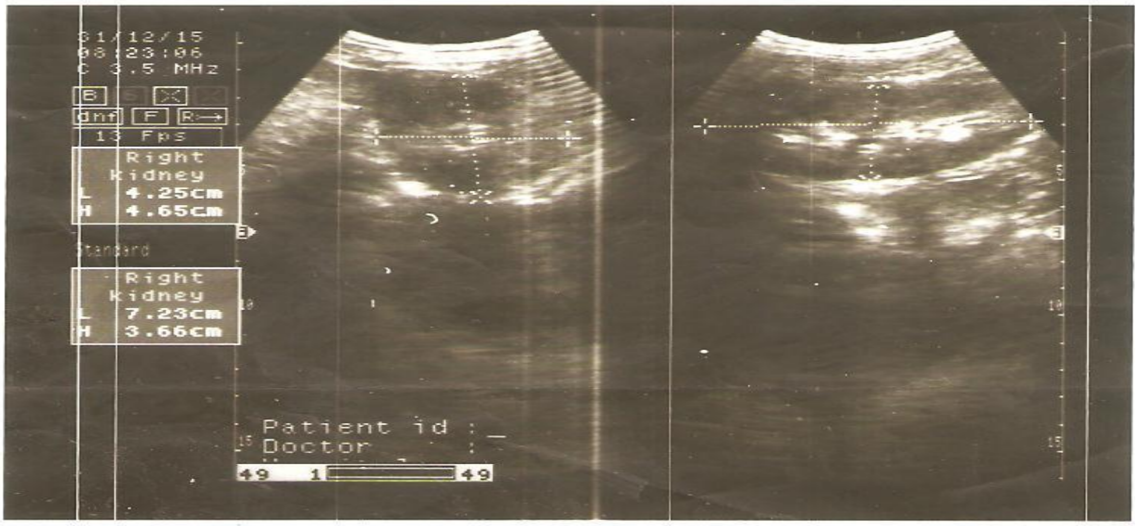
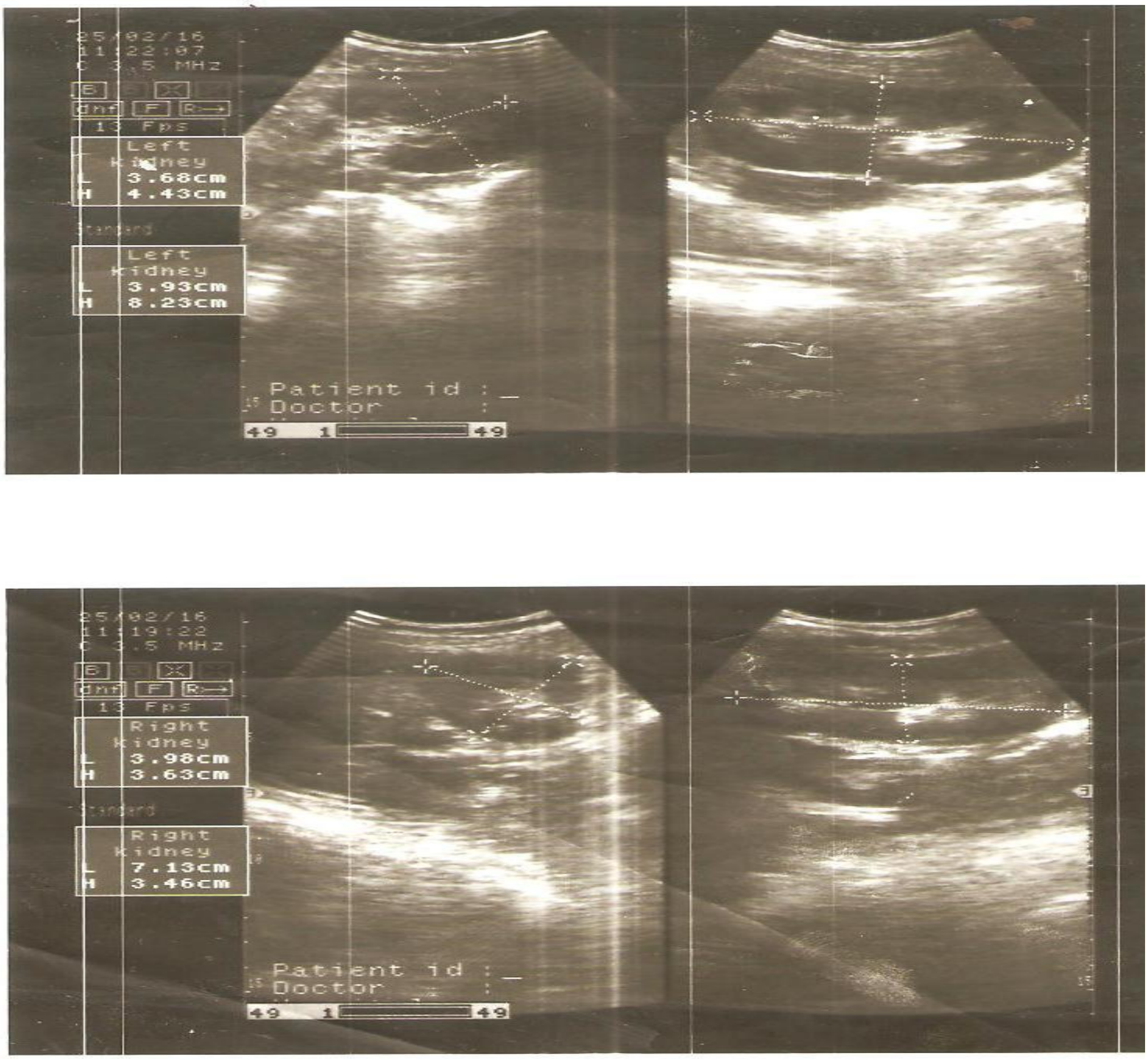
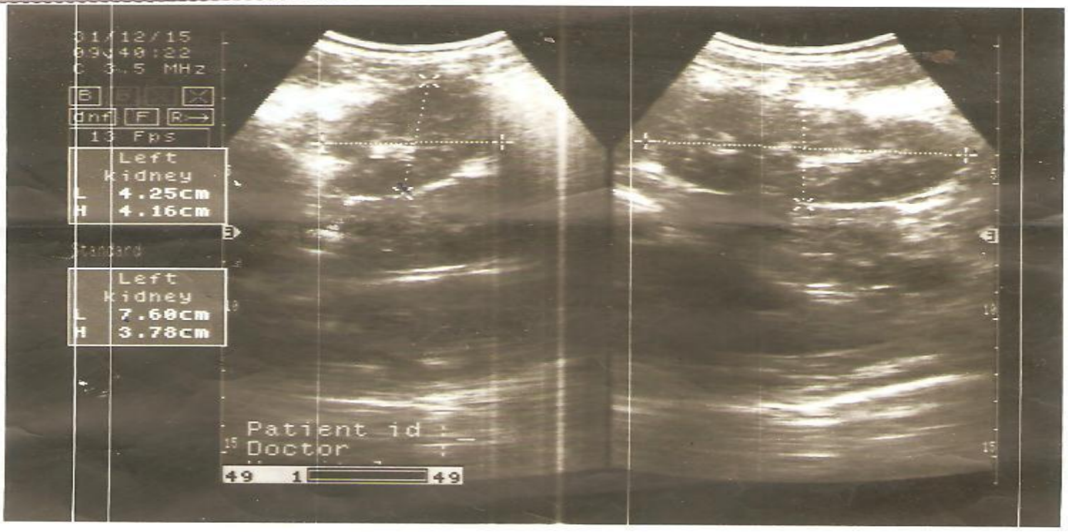
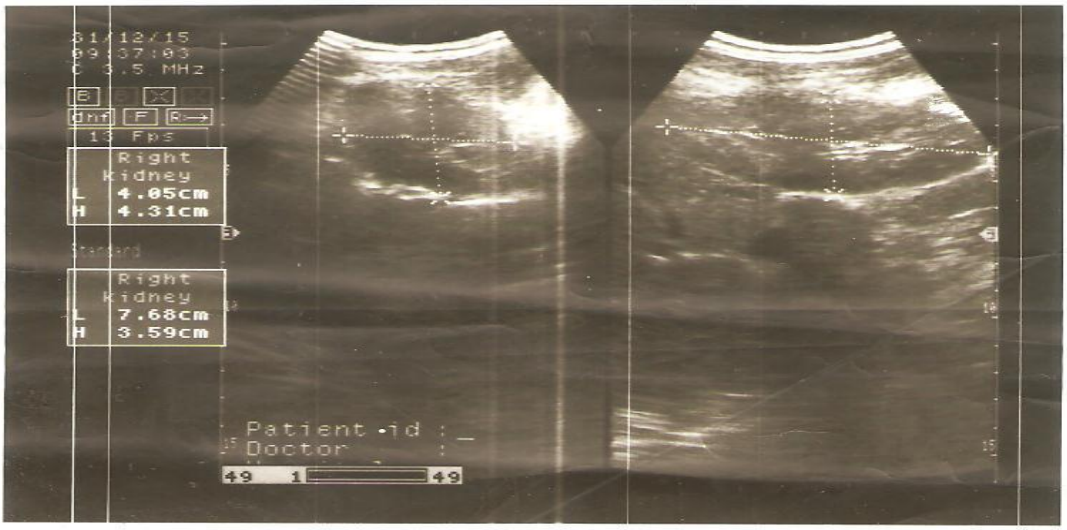


Normal Right and Left kidney for boy 9 years

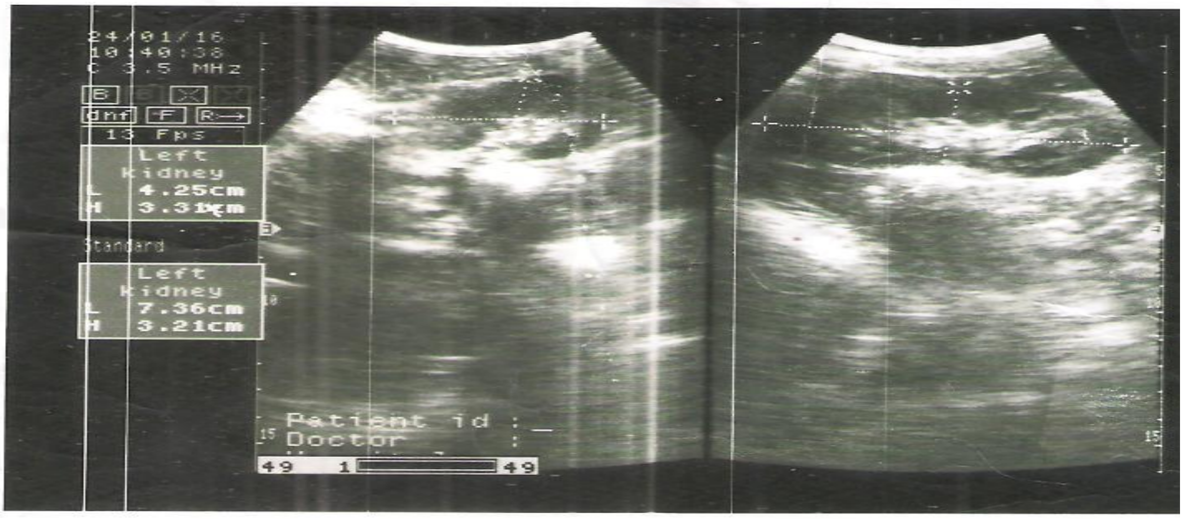


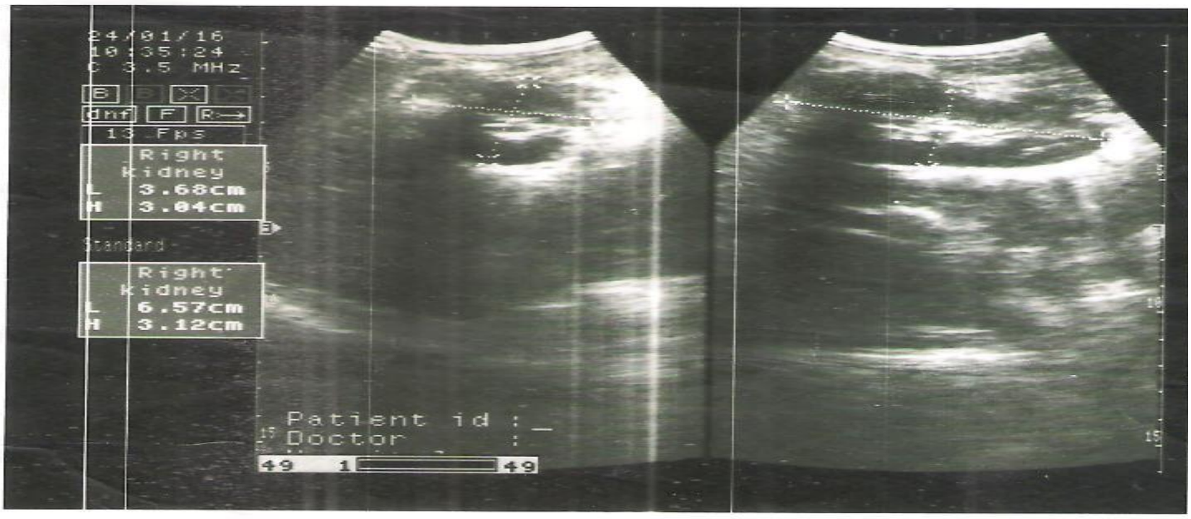
Normal Right and Left kidney for girl10 years





Normal Right and Left kidney for a girl 11 year





Normal Right and Left kidney for boy 13 year