Chapter One

1-1 Introduction

The urinary system consists of two kidneys, which remove wastes from the blood and produce urine, and two ureters, which act as tubal ducts leading from the hilus of the kidneys and drain into the urinary bladder. The bladder collects and stores urine, which is eventually discharged through the urethra. The urinary system is located posterior to the peritoneum lining the abdominal cavity in an area called the retroperitoneum. (SandaraL.Hagen, 2012).

The function of the kidneys is to excrete urine. More than any other organ, the kidneys adjust the amounts of water and electrolytes leaving the body so that these equal the amounts of substances entering the body. The formation of urine involves the following three processes:

Glomerular filtration, tubular reabsorption, and tubular secretion.

The clinical symptoms of a patient with specific renal pathology may be nonspecific. A patient's history of infection, previous urinary tract problems (renal stones), or hypertension or family history of renal cystic disease is useful information. A patient with a renal infection or disease process may present with any of the following symptoms: flank pain, hematuria, polyuria, oliguria, fever, urgency, weight loss, or general edema. (SandaraL.Hagen, 2012).

A renal sonogram is able to demonstrate the acoustic properties of a mass, delineate an abnormal lie of a kidney resulting from an extrarenal mass, or determine whether hydronephrosis is secondary to renal stones. In addition, sonography can define perirenal fluid collections, such as a hematoma or abscess, determine renal size and parenchymal detail, detect dilated ureters and hydronephrosis, and image renal congenital anomalies. (SandaraL.Hagen, 2012).

Improvement in resolution of ultrasound equipment and the development of higher-frequency transducers have resulted in the widespread use of sonography

for diagnosing and studying diseases of the kidney and renal tract disease in the pediatric patient. Sonography has the advantages of requiring no contrast material and of using nonionizing radiation. It is the primary imaging modality of the pediatric urinary tract. (Rumack, 2011).

1-2 Problem of the study

Pediatric renal disease are becoming a serious problem leading to increase morbidity and mortality in children, identification of common pediatric renal disease by using ultra sound help in recognition of risk factors and subsequent planning for adequate prevention as ultra sound is available, safe and cheep imaging tool. No study was obtained in our hospital.

1-3 General Objectives

To document the common findings of urinary tract in Sudanese by using ultra sound as diagnostic imaging modality.

1-4 Specific Objectives

- To identify the common site of disease in the urinary tract.
- To evaluate the size and echogenicity of kidneys and wall of urinary bladder.
- To correlate findings with age and gender.
- To highlight the common disease in renal disease in children to be diagnose by ultra sound as imaging modality.

1-5 Importance of the study

The size and echotexture of the kidneys, urinary bladder wall thickness and dilatation of ureters are important parameters in diagnosing renal disease by ultra sound, by conducting this study we can know the common renal pathology that affect children and help health worker to define the cause of it to get quickly management.

1-6 Ethical issue

- Permission from ultra sound department.
- Permission from patient included in the study.
- No person identification data or detail published

Chapter Two

Anatomy, Physiology, Sonography and Pathology of Urinary System

2-1 **Embryology of the urinary system**

Three sets of excretory organs develop in a human embryo in a cranial to caudal progression:

- Pronephroi; rudimentary and non-functional
- mesonephroi; well developed and function briefly.
- Metanephroi; become the permanent kidneys.

2-1-1 Mesonephroi

These are the interim kidneys until the permanent kidneys develop. The mesonephric ducts open into the cloaca. Medial to the two mesonephroi are the developing gonads; after the mesonephroi degenerate, the tubules become incorporated into the male genital system. They disappear in the female. The mesonephric ducts or Wolffian ducts have several adult derivatives in the male.

2-1-2 Metanephroi

These are the permanent kidneys and begin to develop in the fifth week. They develop from two sources:

The ureteric bud is an outgrowth from the mesonephric duct close to its entry into the fetal cloaca. The ureteric bud goes on to develop the ureter, renal pelvis, calices and collecting tubules. The collecting tubules undergo repeated branching which induces clusters of mesenchymal cells in the metanephric mass of mesoderm. These go on to form the metanephric tubules which ultimately progress to form the nephron.

The metanephric mass of intermediate mesoderm. The nephron is derived from the metanephric mass. (Rose De Bruyn, 2005).

The fetal kidneys are subdivided into lobes which give it the characteristic fetal lobulation. This disappears during infancy as the nephrons increase and grow. Initially the permanent kidneys lie close to each other in the pelvis. As the abdomen grows, the kidneys move cranially (towards the head) and gradually move further apart. Eventually they come to lie in the retroperitoneum on the posterior abdominal wall. As they ascend from the pelvis they receive a higher and higher blood supply so that eventually they receive blood supplied from the aorta. This also accounts for the multiple renal arteries which often supply the kidneys. When they come into contact with the adrenal gland the ascent stops. (Rose De Bruyn, 2005).

2-2 Anatomy of the urinary system

2-2-1 Kidneys. The urinary system is located posterior to the peritoneum lining the abdominal cavity in an area called the retroperitoneum. The kidneys lie in the retroperitoneal cavity near the posterior body wall, just below the diaphragm (Figure 2-1). The lower ribs protect both kidneys. The right kidney lies slightly lower than the left kidney because the large right lobe of the liver pushes it inferiorly. The kidneys move readily with respiration; on deep inspiration, both kidneys move downward approximately 1 inch. The kidneys are dark red, bean-shaped organs that measure 9 to 12 cm long, 5 cm wide, and 2.5 cm thick. The outer cortex of the kidney is darker than the inner medulla because of the increased perfusion of blood. The inner surface of the medulla is folded into projections called renal pyramids, which empty into the renal pelvis. The arcuate arteries are located at the base of the pyramids and separate the medulla from the cortex. Numerous collecting tubules bring the urine from its sites of formation in

the cortex to the pyramids. The renal tubules, or nephrons, are the functional units of the kidney. On the medial surface of each kidney is a vertical indentation called the renal hilum, where the renal vessels and ureter enter and exit. Within the hilus of the kidney are other vascular structures, a ureter, and the lymphatics. The renal artery is the most posterior and superior structure. (Sandra L. Hagen, 2012)

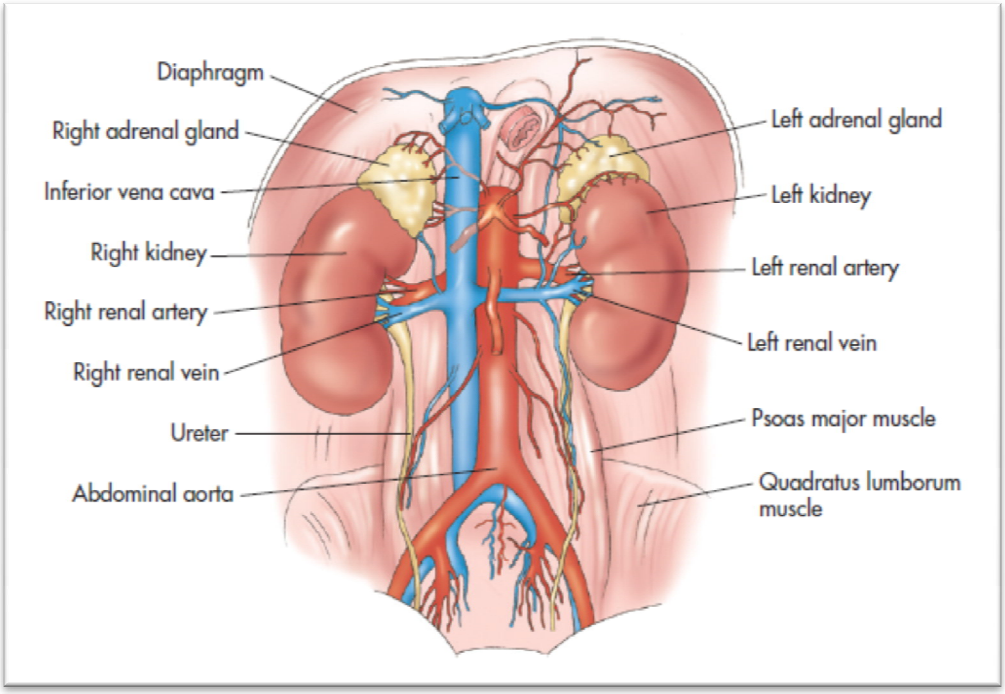


Fig (2-1): Relationships of the kidneys, suprarenal glands (adrenal), and vascular structures to one another. (Sandra L. Hagen, 2012)

The two branches of the renal vein are anterior to the renal artery (Figure 2-2). The ureter is located slightly inferior to the renal artery. When present, the third branch of the renal artery may be seen to arise from the hilus. The lymph vessels and sympathetic fibers also are found within the renal hilus. A fibrous capsule called the true capsule surrounds the kidney. Outside of this fibrous capsule is a covering of perinephric fat. The perinephric fascia surrounds the perinephric fat and encloses the kidneys and adrenal glands. The perinephric fascia is a condensation of areolar tissue that is continuous laterally with the fascia transversalis. The renal fascia, known as Gerota's fascia, surrounds the true capsule and perinephric fat.

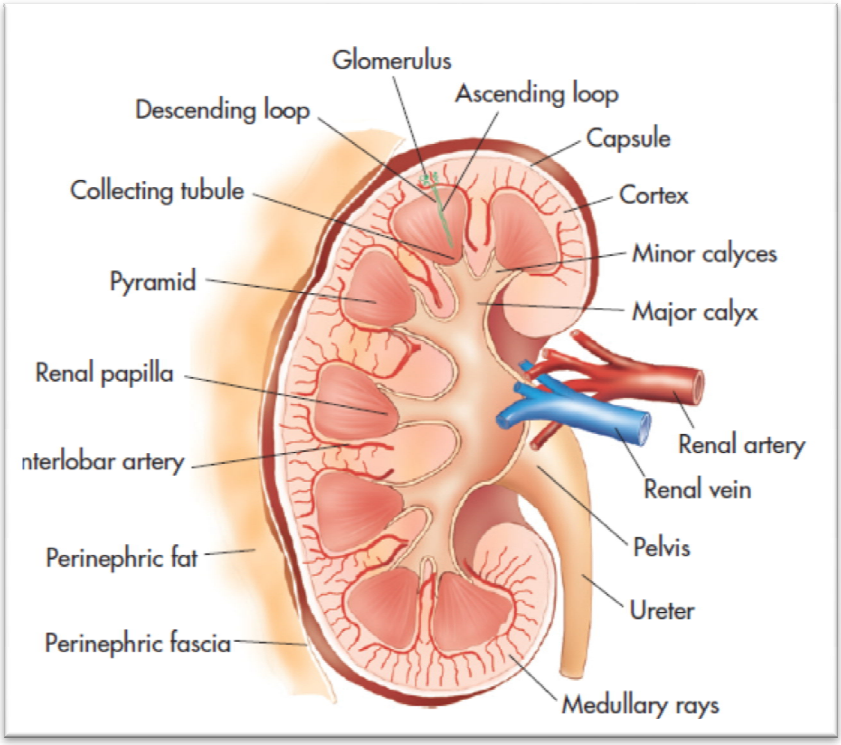


Fig (2-2): The kidney cut longitudinally to show the internal structure. (Sandra L. Hagen, 2012).

Anterior to the right kidney are the right adrenal gland, liver, Morison's pouch, second part of the duodenum, and right colic flexure (Figure 2-3). Anterior to the left kidney are the left adrenal gland, spleen, stomach, pancreas, left colic flexure, and coils of jejunum. Posterior to the right kidney are the diaphragm, costodiaphragmatic recess of the pleura, twelfth rib, psoas muscle, quadratus lumborum, and transversus abdominis muscles. The subcostal (T12), iliohypogastric, and ilioinguinal (L1) nerves run downward and laterally. Posterior to the left kidney are the diaphragm, costodiaphragmatic recess of the pleura, eleventh and twelve ribs, psoas muscle, quadratus lumborum, and transverses abdominis muscles. The same nerves are seen near the left kidney as in the right.

Within the kidney, the upper expanded end of the ureter, known as the renal pelvis of the ureter, divides into two or three major calyces, each of which divides further

into two or three minor calyces (see Figure 2-2). The apex of a medullary pyramid, called the renal papilla, indents each minor calyx. The kidney consists of an internal medullary portion and an external cortical substance. The medullary substance consists of a series of striated conical masses, called the renal pyramids. The pyramids vary from 8 to 18 in number, and their bases are directed toward the outer circumference of the kidney. Their apices converge toward the renal sinus, where their prominent papillae project into the lumina of the minor calyces. Spirally arranged muscles surround the calyces and may exert a milking action on these tubes, aiding in the flow of urine into the renal pelvis. As the pelvis leaves the renal sinus, it rapidly becomes smaller and ultimately merges with the ureter.

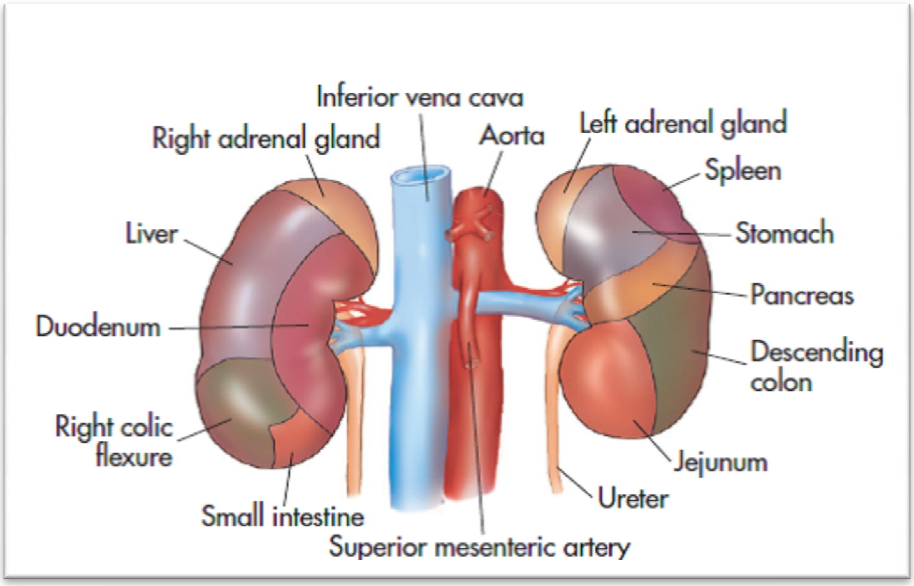


Fig (2-3): Anatomic structures related to the anterior surfaces of the kidneys. (Sandra L. Hagen, 2012).

2-2-2 Ureter. The ureter is a 25 cm tubular structure whose proximal end is expanded and continuous with the funnel shape of the renal pelvis. The renal pelvis lies within the hilus of the kidney and receives major calyces. The ureter emerges from the hilus of the kidney and runs vertically downward behind the parietal

peritoneum along the psoas muscle, which separates it from the tips of the transverse processes of the lumbar vertebrae. It enters the pelvis by crossing the bifurcation of the common iliac artery anterior to the sacroiliac joint. The ureter courses along the lateral wall of the pelvis to the region of the ischial spine and turns forward to enter the lateral angle of the bladder. The ureter from the ureteropelvic junction to the bladder is not routinely visualized on a sonogram. The superior and distal ends of the ureters are more readily visualized than the midsection. The ureters are located in the retroperitoneal cavity and are obscured by bowel gas. Three constrictions are seen along the ureter's course:

The first where the ureter leaves the renal pelvis, The second where it is kinked as it crosses the pelvic brim, and (3) where it pierces the bladder wall.

2-2-3 Urinary Bladder.

The urinary bladder is a large muscular bag. It has a posterior and lateral opening for the ureters and an anterior opening for the urethra. The interior of the bladder is lined with highly elastic transitional epithelium. When the bladder is full, the lining is smooth and stretched; when it is empty, the lining is a series of folds. In the middle layer, a series of smooth muscle coats distend as urine collects and contract to expel urine through the urethra. Urine is produced almost continuously and accumulates in the bladder until the increased pressure stimulates the organ's nervous receptors to relax the urethra's sphincter and urine is released from the urinary bladder. The urinary bladder is visualized sonographically when it is distended with fluid.

2-2-4 Urethra.

The urethra is a membranous tube that passes from the anterior part of the urinary bladder to the outside of the body. It includes two sphincters: the internal sphincter

and the external sphincter. The urethra is not routinely visualized sonographically. (Sandra L. Hagen, 2012).

2-2-5 Vascular Supply:

The arterial supply to the kidney is provided through the main renal artery. This vessel is a lateral branch of the aorta and rises just inferior to the superior mesenteric artery (Figure 14-4). Each artery is divided into three branches to enter the hilus of the kidney—two anterior and one posterior to the pelvis of the ureter.

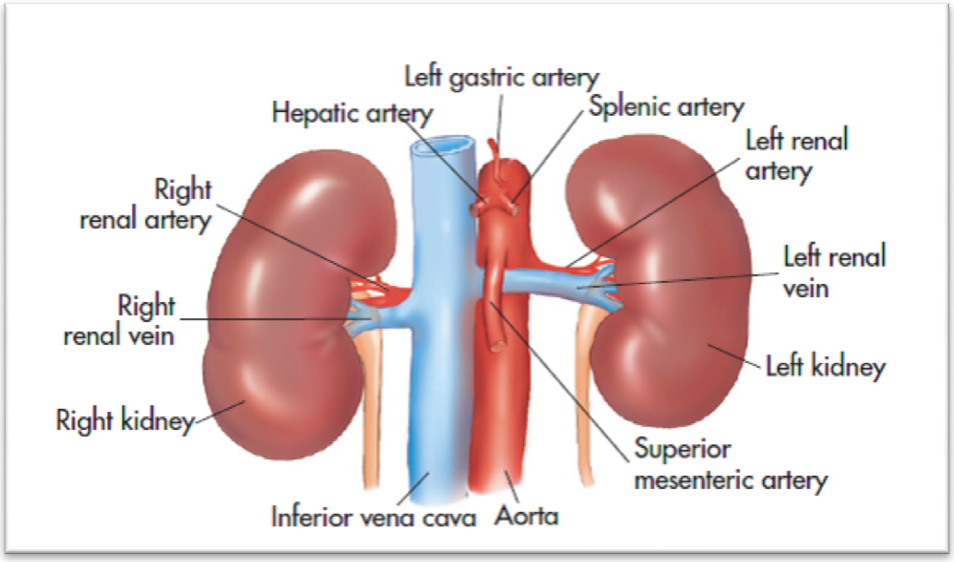


Fig (2-4): Vascular relationships of the great vessels and their tributaries to the kidneys. (Sandra L. Hagen, 2012).

The branches of the renal artery may vary in size and number. In most cases, the renal artery is divided into two primary branches: a larger anterior and a smaller posterior. These arteries break down into smaller segmental arteries, then into interlobar arteries, and finally into tiny arcuate arteries. Five to six veins join to form the main renal vein. This vein emerges from the renal hilus anterior to the renal artery. The renal vein drains into the lateral walls of the inferior vena cava (Figure 2-4). The lymphatic vessels follow the renal artery to the lateral aortic lymph nodes near the origin of the renal artery. Nerves originate in the renal sympathetic plexus and are distributed along the branches of the renal vessels.

Blood supply to nephrons begins at the renal artery. The artery subdivides within the kidneys. A small vessel (afferent arteriole) enters Bowman's capsule, where it forms a tuft of capillaries, the glomerulus, which entirely fills the concavity of the capsule. Blood leaves the glomerulus via the efferent arteriole, which subdivides into a network of capillaries that surround the proximal and distal tubules and eventually unite as veins, which become the renal vein. The renal vein returns the cleansed blood to the general circulation. Movements of substances between the nephron and the capillaries of the tubules change the composition of the blood filtrate moving along in the tubules. From the nephrons, the fluid moves to collecting tubules and into the ureter, leading to the bladder, where urine is stored. The arterial supply to the ureter is provided by the following three sources: the renal artery, the testicular or ovarian artery, and the superior vesical artery. (Sandra L. Hagen, 2012).

2-3 Physiology of the urinary system

The formation of urine is the function of the kidneys, and the rest of the system is responsible for eliminating the urine. Body cells produce waste products such as urea, creatinine, and ammonia, which must be removed from the blood before they accumulate to toxic levels. As the kidneys form urine to excrete these waste products, they also accomplish several other important functions:

- Regulation of the volume of blood by excretion or conservation of water.
- Regulation of the electrolyte content of the blood by the excretion or conservation of minerals.
- Regulation of the acid–base balance of the blood by excretion or conservation of ions such as H+ ions or HCO3-ions.
- Regulation of all of the above in tissue fluid.

The process of urine formation, therefore, helps maintain the normal composition, volume, and pH of both blood and tissue fluid by removing those substances that would upset the normal constancy and balance of these extracellular fluids.

2-3-1 The nephron

The nephron is the structural and functional unit of the kidney. Each kidney contains approximately 1 million nephrons. It is in the nephrons, with their associated blood vessels, that urine is formed. Each nephron has two major portions: a renal corpuscle and a renal tubule.

2-3-2 Urine formation

- The kidneys form urine from blood plasma. Blood flow through the kidneys is a major factor in determining urinary output.
- Glomerular filtration is the first step in urine formation. Filtration is not selective in terms of usefulness of materials; it is selective only in terms of size. High blood pressure in the glomeruli forces plasma, dissolved materials, and small proteins into Bowman’s capsules; the fluid is now called renal filtrate.
- Tubular reabsorption is selective in terms of usefulness. Nutrients such as glucose, amino acids, and vitamins are reabsorbed by active transport and may have renal threshold levels. Positive ions are reabsorbed by active transport and negative ions are reabsorbed most often by passive transport. Water is reabsorbed by osmosis, and small proteins are reabsorbed by pinocytosis. Reabsorption takes place from the filtrate in the renal tubules to the blood in the peritubular capillaries.
- Tubular secretion takes place from the blood in the peritubular capillaries to the filtrate in the renal tubules and can ensure that wastes such as creatinine or excess H_ ions are actively put into the filtrate to be excreted.

- Hormones such as aldosterone, ANP, and ADH influence the reabsorption of water and help maintain normal blood volume and blood pressure. The secretion of ADH determines whether concentrated or dilute urine will be formed.
- Waste products remain in the renal filtrate and are excreted in urine. (Valerie C-Scanlon, 2007).

2-3-3 Glomerular filtration rate

The **glomerular filtration rate** (GFR) is the amount of renal filtrate formed by the kidneys in 1 minute, and averages 100 to 125 mL per minute. GFR may be altered if the rate of blood flow through the kidney changes. If blood flow increases, the GFR increases, and more filtrate is formed. If blood flow decreases (as may happen following a severe hemorrhage), the GFR decreases, less filtrate is formed, and urinary output decreases. (Valerie C-Scanlon, 2007)

2-4 Renal sonography

2-4-1 Examination Technique

The examination of the urinary tract in the pediatric patient should include images of the kidneys, ureters if visualized, and urinary bladder. The child's parents are asked to bring the patient for the study with a full urinary bladder. The child may be given fluid to drink and asked not to void for 1/2 hour before the examination. For a young child who is not yet toilet-trained, the examination may be timed to bladder filling, with the patient being given fluids to drink while in the ultrasound department. The bladder must be checked first and frequently; the patient may fill and void suddenly. Although children vary in their ability to hold still for a sufficient period, sedation is rarely needed. Infants under 1 year of age can be fed or given a pacifier during the examination. The patient older than 1 year can be distracted or entertained during the examination by watching movies, playing with toys, or reading a book. The addition of cine loop with clips often compensates for

the movement of the child. A variety of ultrasound equipment can be used. The highest-frequency transducer that will penetrate the area being examined is optimal. In an infant, this is usually a **14-6 MHz** transducer, and in a child, a **6.0-MHz** transducer. Harmonic imaging may aid in visualization of the difficult-to-scan patient. Different types of transducers are used for different parts of the body. Scans of the kidneys from the back are best performed with a linear or curved linear transducer, whereas frontal scans of the kidney are best performed with a curved linear or sector transducer that penetrates between the ribs. Views of the bladder are performed with a curved linear transducer. The ureters are evaluated as they leave the renal pelvis and enter the bladder. The images are recorded on digital storage. Routine examination includes longitudinal and transverse views of both kidneys. In the pediatric patient the kidneys are imaged in the supine and prone positions. The supine sagittal or coronal image allows optimal visualization of the upper pole, which may be obscured by ribs in the prone position. The echogenicity of the kidney can also be compared to the adjacent liver and spleen. Decubitus positioning is helpful to visualize the upper pole for measurement when the upper kidney is obscured by the ribs. The prone image allows optimal visualization of the lower pole of the kidney, but the upper pole may be obscured by overlying ribs or aerated lung in the costophrenic angle. (Rumack, 2011)

2-4-2 Normal Sonographic Appearances of Pediatric Kidneys

Children's kidneys appear different from adults.

- Infantile kidneys are **large** compared to overall body size - typically 4 to 5 cm long at birth.
- The echogenicity of the renal cortex **exceeds** normal liver echogenicity usually for the first 3 years of life.
- The renal pyramids appear large because the cortex is relatively thin and hyperechoic. As the cortex develops, the pyramidal / cortical proportions

gradually assume the adult proportions. This is accomplished during the first year of life. The renal sinus is **poorly echogenic** because it contains little fat. "Fat accumulation occurs gradually, and sinus echogenicity achieves adult proportions by about age 10 years.

- The majority of infants have a slight separation of the central echo complex, reflecting the presence of a small amount of urine. The cause is unknown. There is no absolute measurement to separate normal distention from hydronephrosis. Many sonographers consider 10 mm separation the upper limit of normal. "Unlike in adult practice, detection of children with vesicoureteric reflux is important and may only be reflected by minor separation of the central sinus echoes without renal scarring. Therefore, separation of the central echo complex may be clinically significant even though it measures less than 10 mm. (Brwin, 2001).

2-4-3 Normal renal measurement in pediatric:

The most commonly used measurement standard is renal length compared with chronological age. Normal renal length of the pediatric kidney may be determined using the following guide:

Over one year - renal length in cm. = 6.79 + (0.22 x age in years)

Less than one year - renal length in cm. = 4.98 + (0.155 x age in months)

"Asymmetry in renal lengths exceeding 5 mm in infants and 10 mm in older children should raise the suspicion of an underlying problem even if both kidneys are within the normal range. (Brwin, 2001).

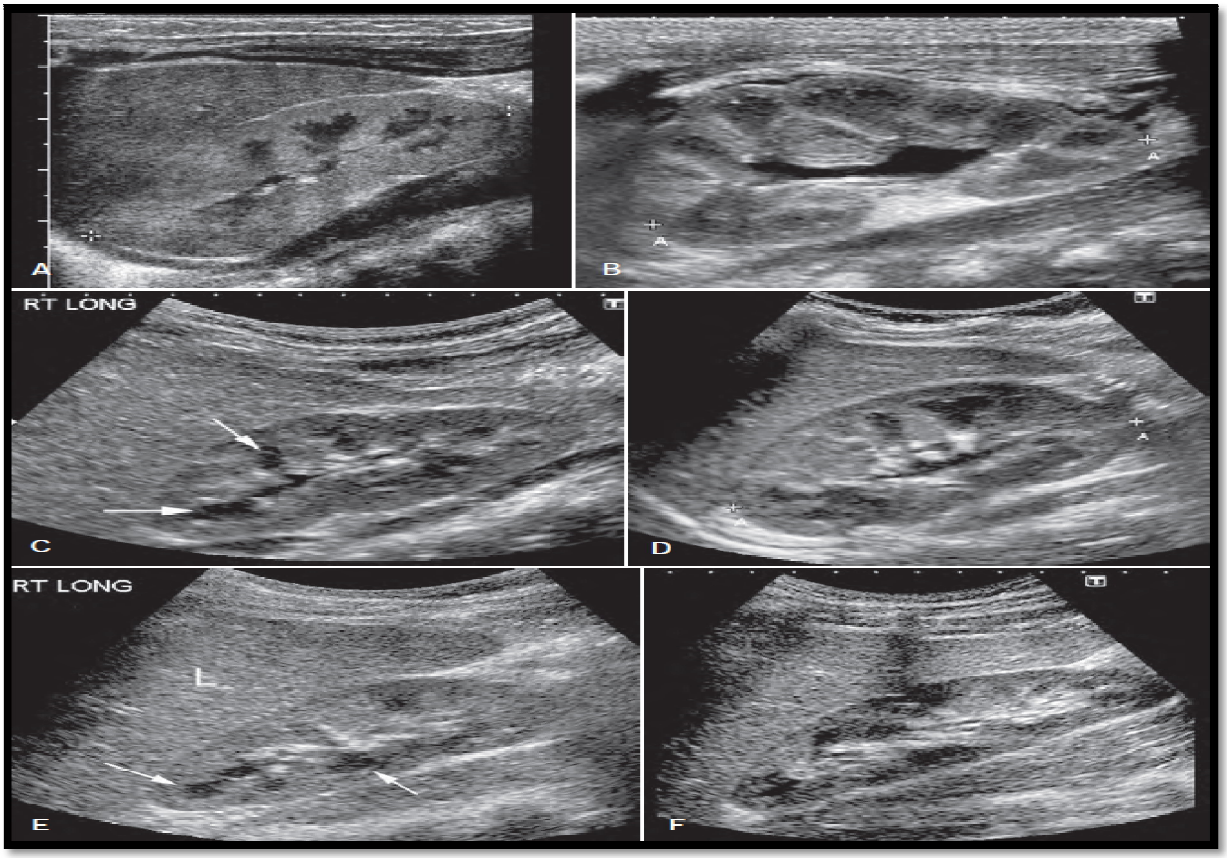


Fig (2-5):Normal renal appearances at different ages. A, Premature infant. Cortex is prominent and more echogenic than the liver. **B, Term infant.** Normal fetal lobulations of renal cortex are isoechoic or slightly hyperechoic to liver and spleen. Prominent renal pyramids are hypoechoic. **C, Infant.** Central echo complex is not prominent because of less peripelvic fat; the renal cortex equals the liver in echogenicity; and the medullary pyramids *(arrows)* are relatively larger and appear more prominent. **D, 2-year-old child.** Renal cortex is slightly less echogenic than liver. Renal sinus fat begins to develop central echogenicity around vessels. **E, 10-year-old child.** Normal cortex produces low-level echoes, whereas the medullary pyramids *(arrows)* are relatively hypoechoic and are arranged around the central echo complex consisting of strong specular echoes. The renal cortex is equally or less echogenic than the adjacent liver *(L).* **F, 14-year-old child.** Renal cortex is less echogenic than liver or spleen. Pyramids are much less prominent. Renal sinus fat is increased.(Rumack,2011)

2-4-4 Normal sonographic appearance of urinary bladder:

The normal urinary bladder is thin walled in the distended state (<3 mm). When empty, the wall thickness increases but is still less than 5 mm.The distal ureters may be visible at the bladder base, especially if the child is well hydrated (Fig. 2-6). (Rumack, 2011).

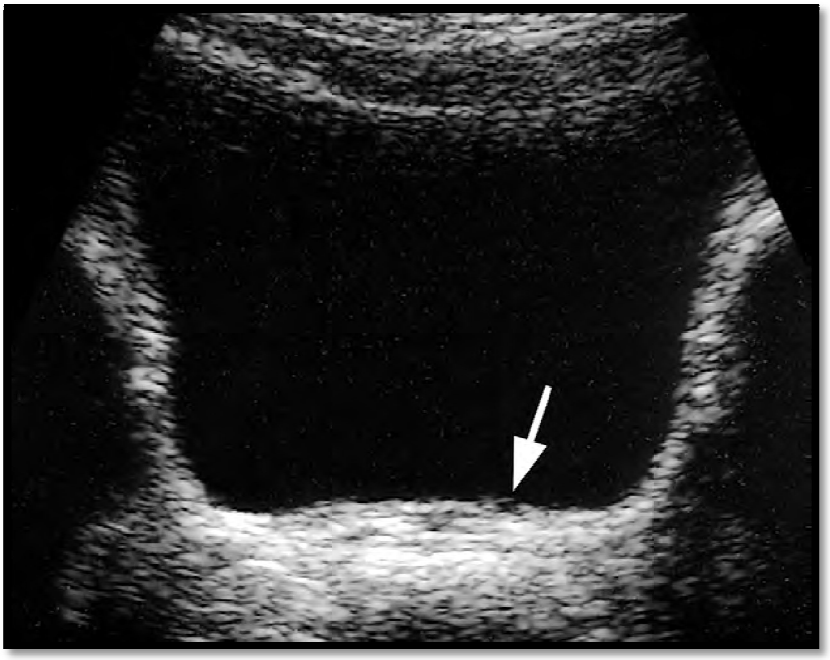


Fig (2-6): **Normal urinary bladder and ureter.** Transverse sonogram of distended bladder with thin wall (<3 mm). Distal ureteric insertion visible at trigone *(arrow).* (Rumack, 2011).

2-5 Pathology of urinary system

2-5-1 Congenital malformation

2-5-1-1 Renal agenesis:

Unilateral renal agenesis is relatively common, occurring in about 1 in 1000 newborn infants. Some cases may, in fact, be as a result of an involuted multicystic kidney in later life. Males are more affected than females, and the left is more commonly the one that is absent. The contralateral kidney usually undergoes compensatory hypertrophy. Unilateral renal agenesis should be suspected in infants with a single umbilical artery (Fig. 2-7).

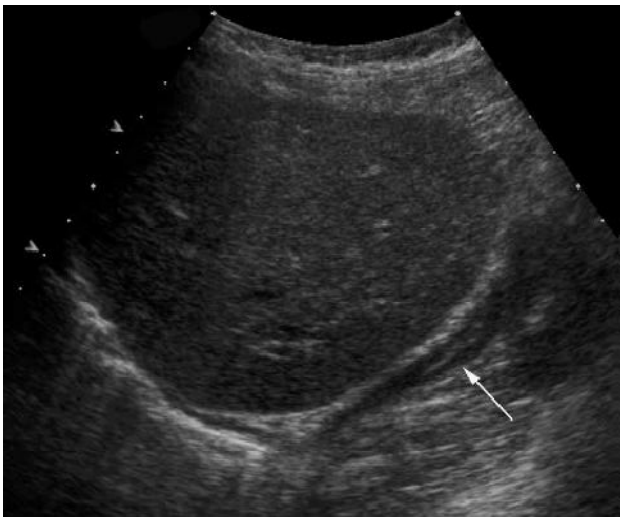


Fig (2-7): Renal agenesis. Longitudinal sonogram of the right flank showing the liver and the linear hypoechoic psoas muscle. Note that there is no kidney. The psoas muscle is a very valuable landmark when searching for absent kidneys, and the flank down to the pelvis and behind the bladder should be examined.(Rose de Bruyn,2005)

Bilateral renal agenesis Bilateral renal agenesis is incompatible with life. Prenatally it is associated with oligohydramnios because no urine is formed. These infants have characteristic facial appearances with low set ears, wide set eyes, flat and broad noses and a receding chin. Most die shortly after birth.

2-5-1-2 Ectopic kidneys One or both kidneys may be in an abnormal position if they fail to progress along their normal migratory path. Most kidneys are located in

the pelvis, in which case they may fuse to form a pancake kidney. Ectopic kidneys may present as a mass, and some have been inadvertently removed. Occasionally a kidney may continue to migrate cranially, in which case it may be found in the chest. Ectopic kidneys receive their blood supply from blood vessels near them (for example iliac arteries if they lie in the pelvis) and are often supplied by multiple vessels (Fig. 2-8). .(Rose de Bruyn,2005).

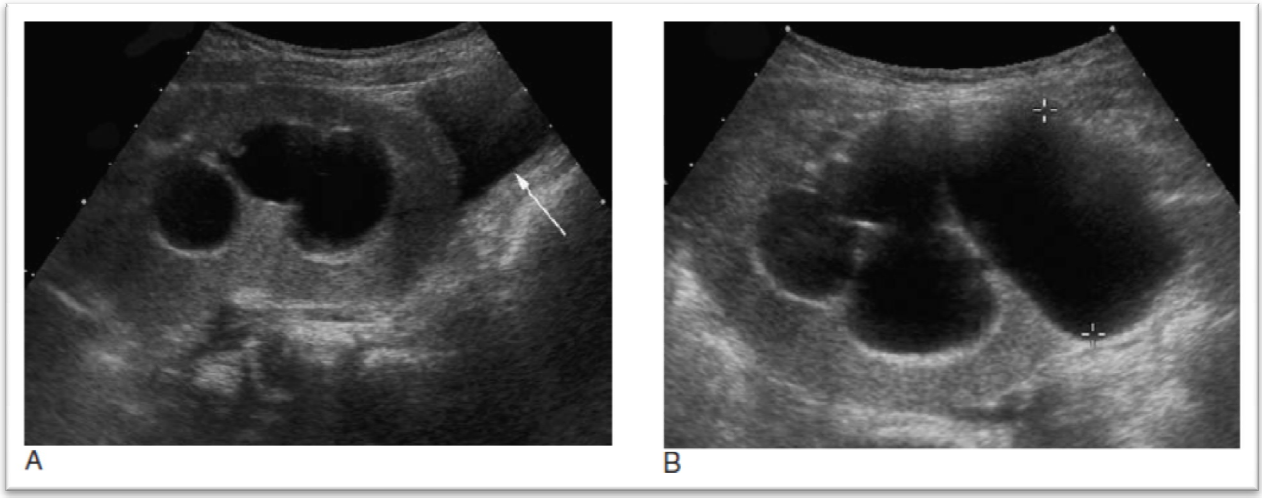


Fig (2-8): Ectopic kidney. (A) Longitudinal sonogram of the pelvis showing the bladder (arrow) and pelvic kidney. The ectopic kidney is lying just above the bladder, and the calices and renal pelvis are dilated. (B) Transverse sonogram at the hilum of the ectopic kidney showing the dilated calices and renal pelvis (between calipers). Ectopic kidneys have a higher incidence of complications such as vesicoureteric reflux and pelviureteric junction obstruction. . (Rose de Bruyn, 2005)

2-5-1-3Horseshoe Kidney

With a horseshoe kidney the longitudinal axis of the kidneys is abnormal, with the lower poles located more medially than usual and fusing in the midline anterior to the spine (Fig. 2-9). The fusion may be a fibrous band or actual fusion of the renal parenchyma. The lower poles of the kidneys are rotated medially and may be positioned somewhat lower than usual. (Rumack,2011)

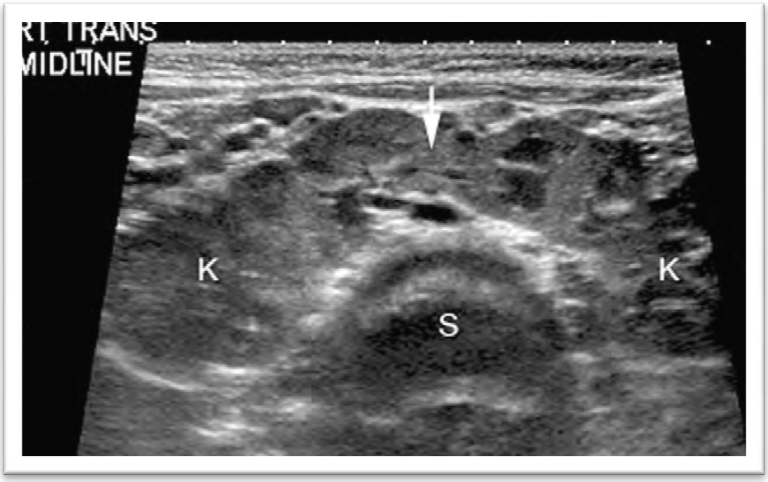


Fig (2-9): Horseshoe kidney. Transverse supine scan demonstrates lower poles of kidneys *(K)* more medial than usual in the midline anterior to the spine *(S).* Fusion is by band of renal parenchyma *(arrow).* (Rumack, 2011)

2-5-1-4 Multicystic Dysplastic Kidney Disease

Multicystic dysplastic kidney disease (MCDK) may also be referred to as multicystic dysplastic renal disease and multicystic renal dysplasia. MCDK is thought to be caused by an early, first trimester obstruction of the ureter.10 There is typically no normal functioning renal tissue present in the kidney affected by MCDK. Therefore, if this condition is bilateral, it is fatal.

Sonographic findings of (MCDK) are unilateral, smooth-walled, noncommunicating cysts of varying sizes located within the renal fossa and compensatory hypertrophy of the contralateral kidney. (Steven M. Penny,2011)

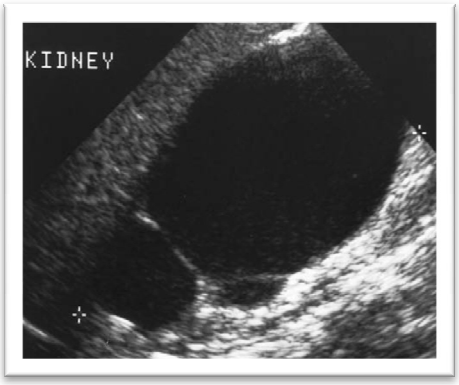


Fig (2-10): Multicystic dysplastic kidney. The parenchyma of this multicystic dysplastic kidney has beencompletely replaced by large cysts. (Steven M. Penny, 2011).

2-5-1-5 Autosomal Recessive Polycystic Kidney Disease

Autosomal recessive polycystic kidney disease (ARPKD) may also be referred to as autosomal recessive polycystic renal disease and infantile polycystic kidney disease. ARPKD is characterized by dilation of the renal collecting tubules. This disorder is often recognized in the fetus and can be confirmed with a postnatal sonographic examination. If prenatal death does not occur, patients often die secondary to complication of renal failure and hepatic disease. The typical sonographic findings of a newborn affected by ARPKD are bilateral, enlarged, echogenic kidneys, with a loss of corticomedullary differentiation. (Steven M. Penny, 2011).

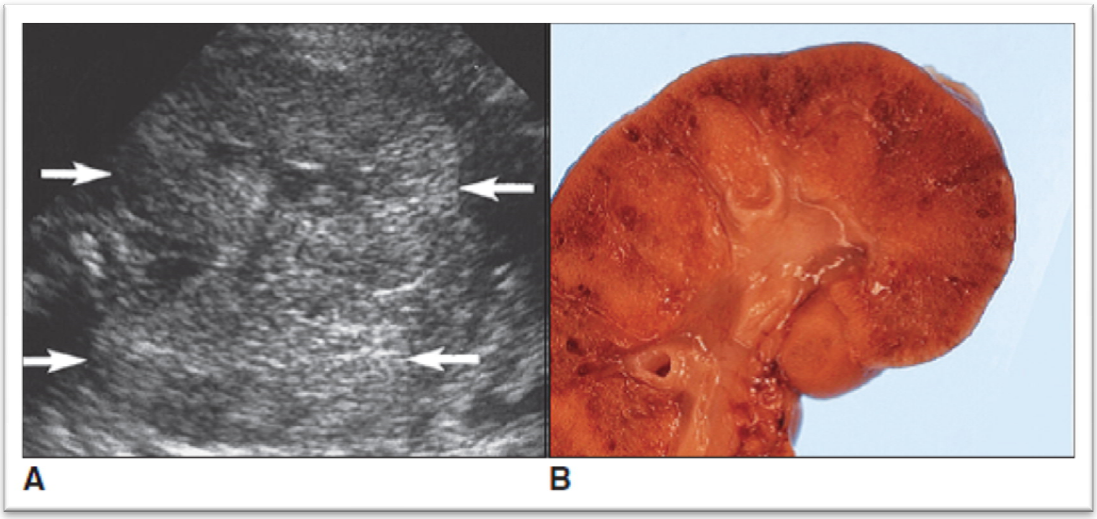


Fig (2-11): Autosomal recessive polycystic kidney disease. **A,** Kidneys are enlarged with increased echogenicity at 27 weeks of gestation. **B,** Gross pathology of the disease showing diffuse microscopic cysts.(Sandra L. Hagen,2012).

2-5-1-6 Posterior urethral valves

This is the commonest urethral abnormality occurring in boys. There is a thick membrane in the posterior urethra which behaves as a valve so that, while a catheter can be passed into the bladder, the infant is unable to adequately void and empty the bladder. This causes a typical dilation of the posterior urethra, proximal to the obstructing valve (Fig. 2-12). . (Rose de Bruyn,2005)

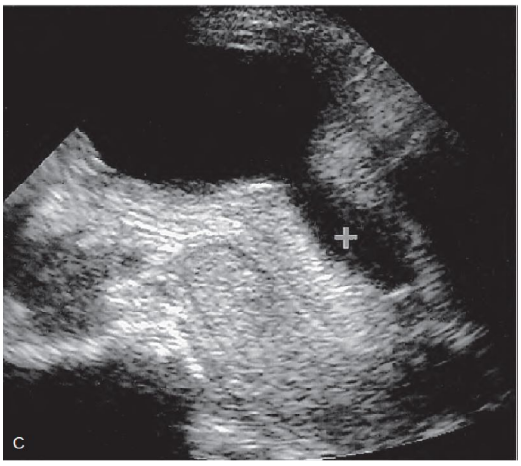


Fig (2-12): Longitudinal scan of mid bladder base, shows dilated posterior urethra (+).(Rumack,2011).

2-5-2 Renal failure

The excretory and regulatory functions of the kidneys are decreased in acute and chronic renal failure. Acute renal failure (ARF) is a common medical condition that can be caused by numerous medical diseases or pathophysiologic mechanisms. ARF is typically an abrupt transient decrease in renal function often heralded by oliguria.

2-5-2-1 Acute Renal Failure.

Acute renal failure may occur in perirenal, renal, or post renal failure stages. The perirenal stage is secondary to hypoperfusion of the kidney. The renal stages may be caused by parenchymal diseases (i.e., acute glomerulonephritis, acute interstitial nephritis, or acute tubular necrosis). They may also be caused by renal vein thrombosis or renal artery occlusion. In post renal failure, radiologic imaging plays a major role. This condition is usually the result of outflow obstruction and is potentially reversible. Post renal failure is usually increased in patients with malignancy of the bladder, prostate, uterus, ovaries, or rectum. Less frequent causes include retroperitoneal fibrosis and renal calculi.

Sonographic Findings:

The cause of acute renal disease urinary outflow obstruction can be differentiated from parenchymal disease. The kidneys may appear normal in size or enlarged and may be hypoechoic with parenchymal disease. Obstruction is responsible for approximately 5% of cases of acute renal failure. The most important issue is the presence or absence of urinary tract dilatation. The degree of dilatation does not necessarily reflect the presence or severity of an obstruction. A sonographer should try to determine the level of obstruction. A normal sonogram does not totally exclude urinary obstruction. In the clinical setting of acute obstruction secondary to calculi, a non distended collecting system can be present.

Acute Tubular Necrosis.

Acute tubular necrosis (ATN) is the most common medical renal disease to produce acute renal failure, although it can be reversible. Sonographic Findings. The sonogram shows bilaterally enlarged kidneys with hyperechoic pyramids; this can revert to a normal appearance. Differential considerations include nephrocalcinosis. In pediatric patients, the renal pyramids are highly echogenic without shadowing. The calculi may be too small to cause dilatation and shadowing of the pyramids (Figure 2-13). As renal function improves, echogenicity decreases. This can occur in the medulla or the cortex. If the condition reverses, it is probably acute tubular necrosis. Chronic Renal Disease. Chronic renal disease is the loss of renal function as a result of disease, most commonly parenchymal disease. Three primary types of chronic renal failure are known: nephron, vascular, and interstitial abnormalities. Glomerulonephritis, chronic pyelonephritis, renal vascular disease, and diabetes are a few of the diseases that lead to renal failure. (Sandara L. Hagen, 2012)

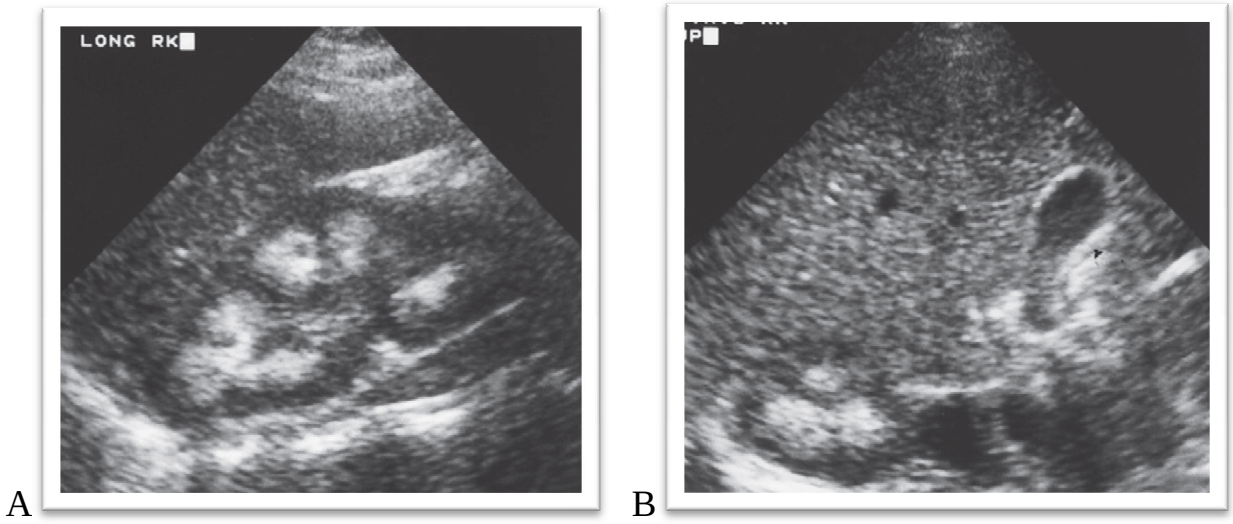


Fig (2-13) Transverse (A) and longitudinal (B) scans of the pediatric patient with acute tubular necrosis and nephrocalcinosis. The echogenic renal pyramids are well seen.(Sandara L. Hagen, 2012)

2-5-2-2 Chronic Renal Failure.

The gradual decrease in renal function over time is referred to as chronic renal failure (CRF). The most common cause of CRF is diabetes mellitus. Other causes of CRF include, but are not limited to, glomerulonephritis, chronic pyelonephritis, metabolic disorders, chronic urinary tract obstruction, and tuberculosis. CRF leads to end-stage renal disease. Clinical findings include diabetes, malaise, elevated BUN, elevated creatinine, fatigue, hypertension, and hyperkalemia. Patients are typically placed on dialysis or a donor kidney may be needed. Sonographically, the kidneys will appear small, echogenic, and may contain cysts (Fig. 2-14). There is also typically loss of normal corticomedullary differentiation.(Steven m. Penny, 2011)

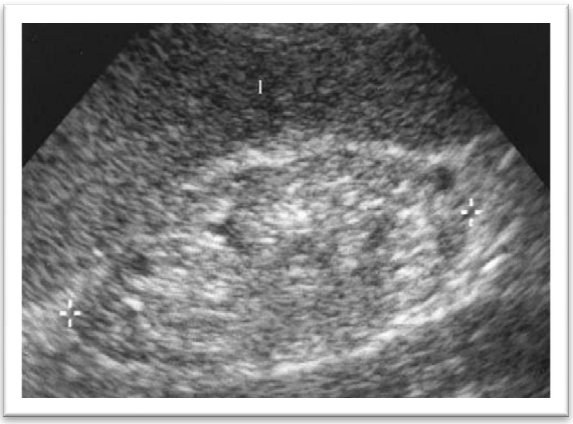


Fig. (2-14): Chronic renal failure. The kidney (between calipers) is significantly more echogenic than the adjacent liver parenchyma (*l)*. The kidney is small, and there is also loss of the normal corticomedullary differentiation. (Steven m. Penny, 2011)

2-5-3 Hydronephrosis and renal obstruction

Hydronephrosis is a general term that is defined as the dilation of the renal collecting system secondary to the obstruction of normal urine flow. Accordingly, Hydronephrosis is dilation of the calices, infundibula, and renal pelvis. Hydronephrosis may also be referred to as pyelocaliectasis, and described more specifically according to which part of the kidney is dilated. It may also be described as mild, moderate, and severe or marked. Mild hydronephrosis is noted as distension of the renal pelvis, whereas moderate hydronephrosis is described as further progression of distension into the calices and medullary pyramids. Marked hydronephrosis extends into the cortex and causes severe thinning of the parenchyma. (Steven m. Penny, 2011).

2-5-4 Renal infections

A spectrum of severity is possible in renal infection. The disease can progress from pyelonephritis to focal bacterial nephritis to an abscess. An abscess can be transmitted through the parenchyma into the blood. Most renal infections stay in the kidney and are resolved with antibiotics. A perirenal abscess may occur from direct extension. (Sandara L. Hagen, 2012)

2-5-4-1 Pyonephrosis:

Pyonephrosis occurs when pus is found within the collecting renal system. It is often associated with severe urosepsis and represents a true urologic emergency that requires urgent intravenous (IV) antibiotherapy and/or percutaneous drainage. It usually occurs secondary to long-standing ureteral obstruction resulting from calculus disease, stricture, or a congenital anomaly. Sonographic findings include the presence of low-level echoes with a fluid-debris level (Figures 2-15). The sonographer should be aware that an anechoic dilated system may be found. (Sandara L. Hagen, 2012)

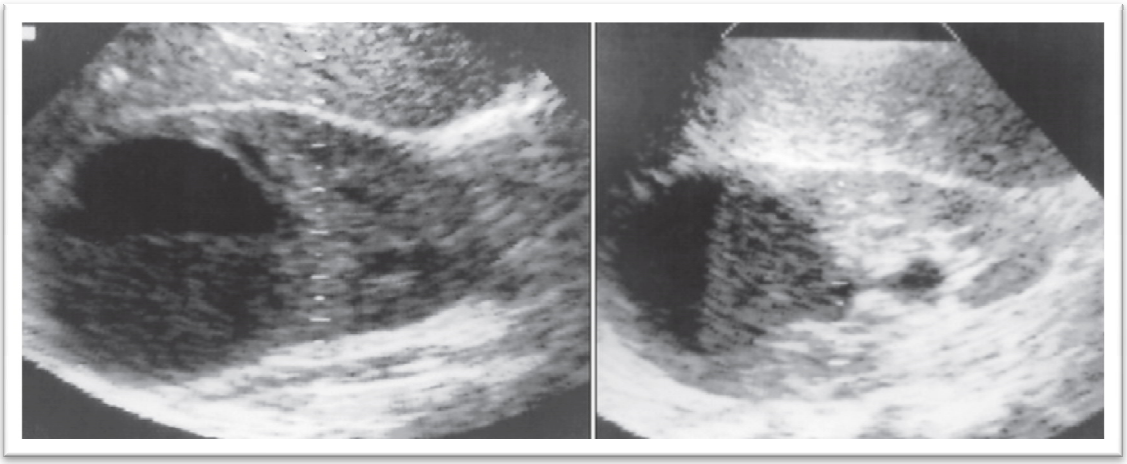


Fig (2-15): findings in a patient with pyonephrosis include a fluid and/or debris level within a well-defined mass lesion. (Sandara L. Hagen, 2012)

2-5-4-2 Emphysematous Pyelonephritis:

Emphysematous pyelonephritis occurs when air is present in the parenchyma (diffuse gas-forming parenchymal infection). It may be caused by Escherichia coli bacteria. When this occurs in diabetic patients, they become very sick. It generally is found unilaterally and may be cause for an emergency nephrectomy. On a sonogram, the enlarged kidneys appear hypoechoic and inflamed. (Sandara L. Hagen, 2012)

2-5-4-3 Xanthogranulomatous Pyelonephritis:

Xanthogranulomatous pyelonephritis is an uncommon renal disease associated with chronic obstruction and infection. It involves destruction of renal parenchyma and infiltration of lipid-laden histiocytes. Clinically, the patient presents with a large nonfunctioning kidney, staghorn calculus, and multiple infections (Figure 2-16). The disease is more common in females and is poorly understood. It is thought to represent an impaired host response to infection in a chronically obstructed and infected kidney.

The sonographic appearance may show bright echogenicity from the staghorn calculus. (Peripelvic fibrosis can prevent the staghorn from shadowing.) The renal parenchyma is replaced by cystic spaces. Overall renal size is increased. The disease process may be diffuse or segmental. (Sandara L. Hagen, 2012)

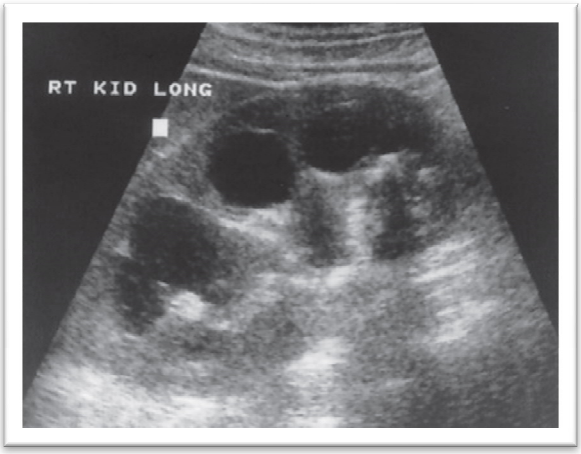


Fig (2-16): Patient with xanthogranulomatous pyelonephritis shows a large, nonfunctioning right kidney secondary to a stone. Multiple areas of shadowing are seen within the renal parenchyma from the renal stones. (Sandara L. Hagen, 2012)

2-5-5 Renal Infarction

A renal infarction occurs when part of the tissue undergoes necrosis after cessation of the blood supply, usually as a result of artery occlusion. Renal function is usually normal. This may result from a thrombus, a tumor infiltration, or

obstruction or it may be iatrogenic. Infarcts within the renal parenchyma appear as irregular areas, somewhat triangular in shape, along the periphery of the renal border. The renal contour may be somewhat “lumpy-bumpy.” Remember that lobulations in the pediatric patient may be normal, except for the dromedary hump variant. In the adult patient, the renal contour should be smooth. In a patient with a renal infarct, the irregular area may be slightly more echogenic than the renal parenchyma. (Sandara L. Hagen, 2012).

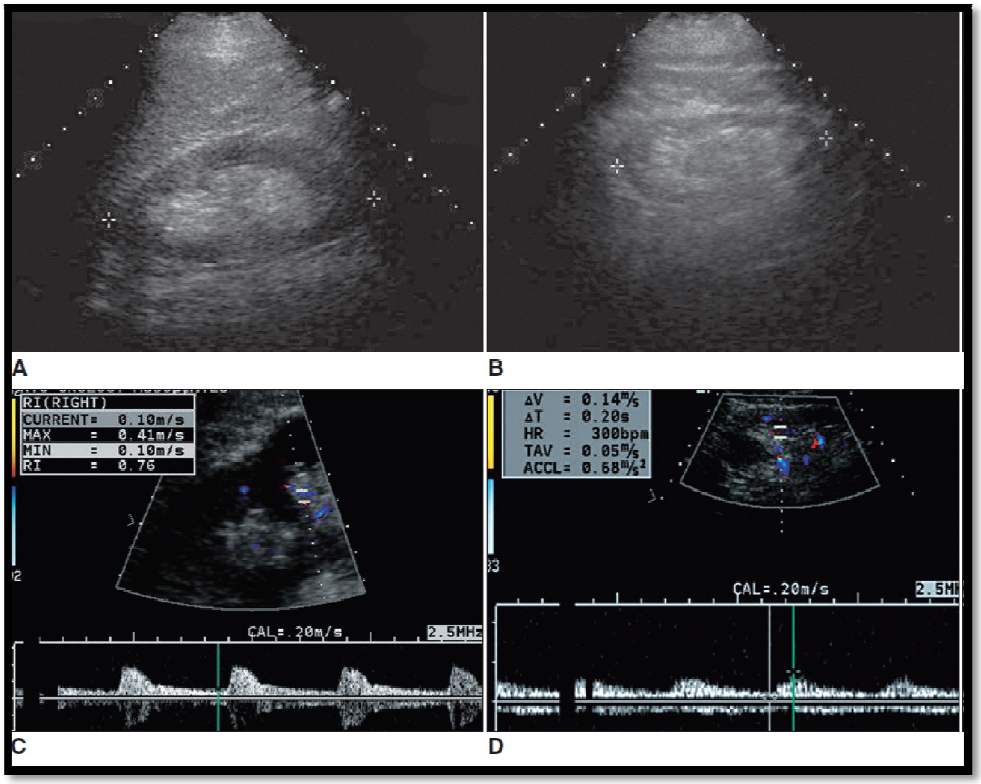


Fig (2-17): A, Longitudinal scan of normal size of right kidney. B, Longitudinal scan of small (shrunken) left kidney with cortical atrophy. C, Normal spectral waveform right kidney. D, Parvus-tardus (delayed SRT) left kidney consistent with renal artery stenosis. (Sandara L. Hagen, 2012)

2-5-6 Renal Vein Thrombosis

Renal vein thrombosis is most likely to occur in the dehydrated or septic infant and is more prevalent in infants of diabetic mothers. One or both kidneys may be involved. There is renal enlargement, hematuria, proteinuria, and a low platelet

count. Thrombosis occurs initially in the small intrarenal venous branches, and at this stage the enlarged kidney has a nonspecific disordered heterogeneous internal echogenicity corresponding to the extent and severity of the process (Figure 2-18). If the thrombus reaches the renal vein or inferior vena cava, it may be directly visualized within these vascular structures. There may be coexistent adrenal hemorrhage, particularly on the left side where the adrenal vein drains directly into the renal vein. Calcification within the involved veins may eventually result. The use of color Doppler helps the sonographer to identify whether the flow is present, reversed, or obstructed. (Sandara L. Hagen, 2012).

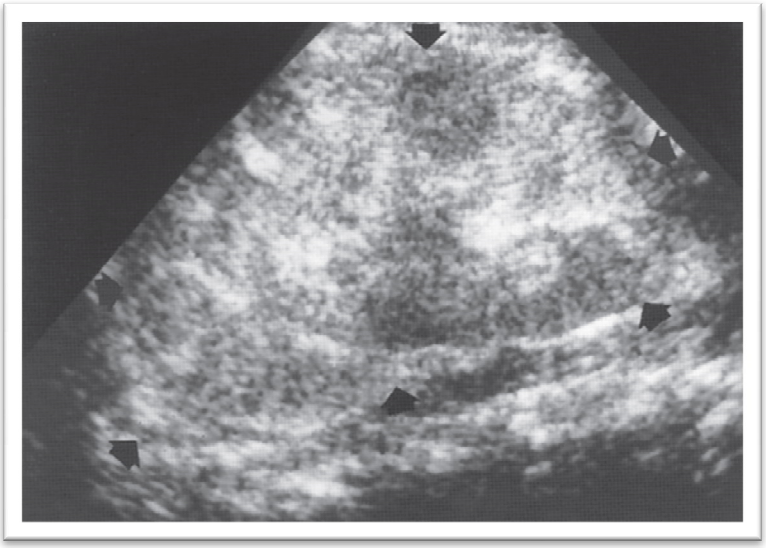


Fig (2-18): Renal vein thrombosis in a 5-day-old term newborn with hematuria. Coronal sonogram of the left flank demonstrates an enlarged kidney *(arrows)* with patchy areas of increased echogenicity. (Sandara L. Hagen, 2012).

2-5-7 Hydronephrosis

Hydronephrosis describes the dilation of the urinary collecting system and is a common finding in the younger patient. There are many causes of dilation of the collecting system, the most common being obstruction, reflux, or abnormal muscle development. Sonography is sensitive in detecting small amounts of fluid in the renal pelvis. The sonographer is able to determine the severity of the

hydronephrosis, whether the condition is unilateral or bilateral, if the ureters and bladder are dilated, and the status of the renal parenchyma. Sonographic features found in hydronephrosis include visible renal parenchyma surrounding a central cystic component, small peripheral cysts (dilated calyces) budding off a large central cyst (renal pelvis), and visualization of a dilated ureter. This must be distinguished from the non communicating cysts of multicystic dysplastic kidneys.

2-5-7-1 Ureteropelvic Junction Obstruction:

The most common type of obstruction of the upper urinary tract is called ureteropelvic junction obstruction. It most often results from intrinsic narrowing or extrinsic vascular compression at the level of the ureteropelvic junction. Bilateral involvement may occur along with a contralateral multicystic dysplastic kidney or vesicoureteral reflux. The obstruction produces proximal dilation of the collecting system; however, the ureter is normal in caliber. There is an increased incidence of abnormalities of the contralateral kidney. Sonographically, there is pelvocalyceal dilation without ureteral dilation (Figure 2-19, A). When the obstruction is pronounced, the dilated renal pelvis extends inferiorly and medially (Figure 2-19, B). If vesicoureteral reflux or primary megaureter is present, the ureter may be dilated. The best way to demonstrate the dilated ureters at the ureteropelvic junction is with a coronal scan plane. (Sandara L. Hagen, 2012).

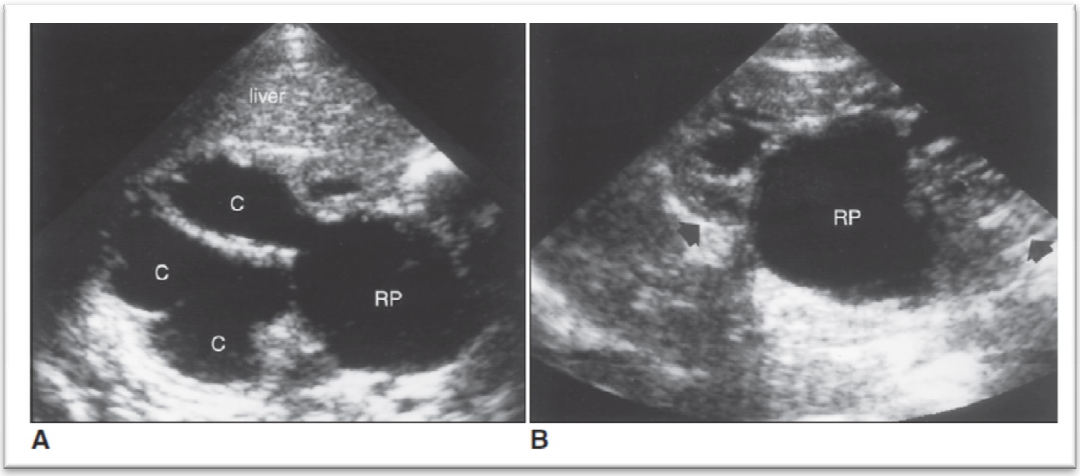


Fig (2-19): **A,** Ureteropelvic junction obstruction in a 2-week-old female infant with an abnormal prenatal ultrasound. Marked dilation of the renal pelvis *(RP)* and calyces *(C)* is present. Parenchymal loss is also noted. The distal ureter was not identified. Radionuclide imaging confirmed the diagnosis. **B,** Uteropelvic junction obstruction in a 1-day-old infant. Coronal image of the kidney *(arrows)* identifies marked dilation of the renal pelvis *(RP)*. (Sandara L. Hagen, 2012).

2-5-7-2 Ureteral Obstruction:

The ureter may be obstructed anywhere along its course or at the ureterovesical junction. An abscess or lymphoma may cause obstruction to the ureter, or the presence of a primary megaureter, atresia, or an ectopic ureter may be the cause of obstruction. With a primary megaureter, sonography shows hydronephrosis and hydroureter with a narrow segment of the distal ureter behind the bladder. The increased peristalsis in the ureter distal to the obstruction may be seen with sonography as the probe is held over the dilated ureter and the sonographer watches for the peristaltic movement. A diminished ureteral jet may be seen at the lower margin of the bladder with color Doppler on the side of the obstruction.

2-5-7-3 Bladder Outlet Obstruction:

Bilateral hydronephrosis is frequently caused by obstruction at the level of the bladder or bladder outlet. The bladder may be obstructed by a neurogenic bladder, a pelvic mass, or a congenital anomaly, such as posterior urethral valves. (Sandara L. Hagen, 2012).

2-5-7-4 Posterior urethral:

Valves are the most common cause of bladder outlet obstruction in the male neonate. A pelvic mass or tumor may be the cause of the bladder obstruction, causing the bladder to be distended with a thickened wall. Vesicoureteral reflux may also be the cause of the dilated renal pelvis. The wall of the urinary bladder appears thickened and trabeculated (Figure 2-20, A). Midline sagittal imaging with caudal angulation through the bladder may allow visualization of the distended posterior urethra. Alternatively the posterior urethra can be imaged directly from a

perineal approach. The resultant hydronephrosis and hydroureter are usually bilateral. Urinary ascites or a perirenal urinoma can result from high-pressure vesicoureteral reflux, rupturing a calyceal fornix or tearing the renal parenchyma (Figure 2-20, B). (Sandara L. Hagen, 2012).

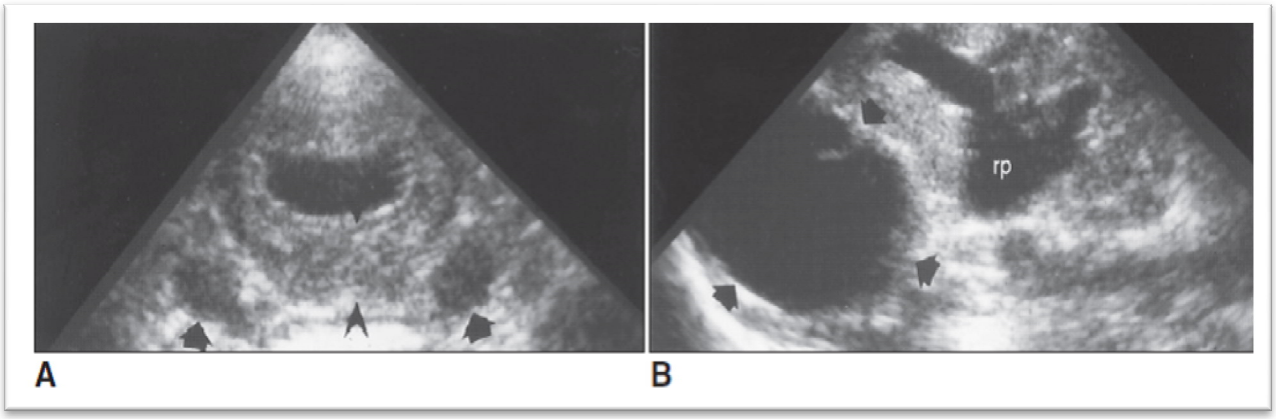


Fig (2-20): **A,** Posterior urethral valves in a male infant. Transverse view of the urinary bladder shows the thickened bladder wall *(arrowheads)*. Dilated distal ureters *(arrows)* are identified posterior to the bladder. **B,** Coronal view of the left kidney shows moderate pelvocaliectasis *(rp)*. A urinoma *(arrows)* is seen superior to the kidney. (Sandara L. Hagen, 2012).

2-5-8 Renal Calculi

Renal stones are uncommon in childhood and when they occur predisposing causes must be sought, for example:

- urinary tract infection
- structural abnormalities of the urinary tract
- metabolic abnormalities.

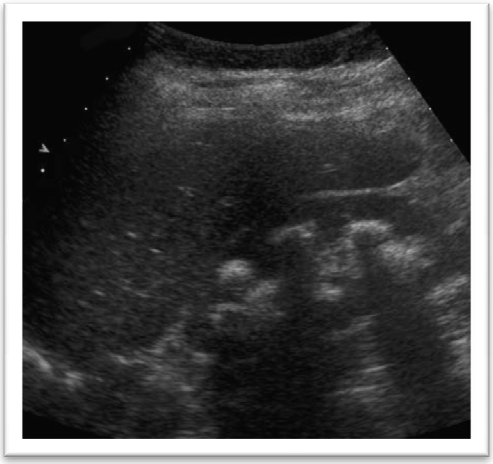
The stones most commonly associated with infection are phosphate stones, and these are particularly associated with Proteus infections. The infective stones tend to occur in infants and young children. Calcium-containing stones occur in idiopathic hypercalciuria, the most common metabolic abnormality, and with increased urinary and oxalate excretion. Cysteine and xanthine stones are rare.

Renal calculi in children have a wide geographic variation, being more common in hotter climates such as the Far and Middle East.

A few specific types of calculi that the sonographer should be aware of are mentioned below.

2-5-8-1 Hyperoxaluria

Primary hyperoxaluria is a rare autosomal recessive inherited disease (Fig. 2-21). Infants may present with highly echogenic kidneys and it may be fatal. (Rose de Bruyn,2005).

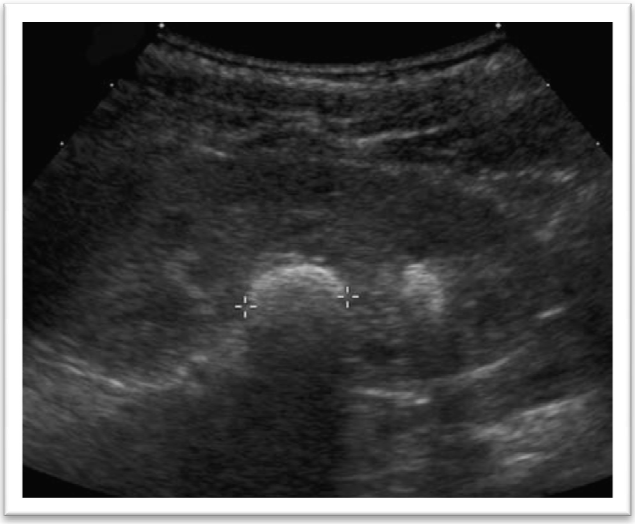


(Fig: 2-21): Longitudinal sonogram of the right kidney in a child with hyperoxaluria. The stones are very dense and echogenic, casting acoustic shadows typical of this condition. (Rose de Bruyn, 2005).

Secondary (enteric hyperoxaluria) is a complication in patients with diseases involving fat malabsorption, for example, cystic fibrosis and inflammatory bowel disease. Normally oxalate is bound to calcium, which is not absorbed. In patients with enteric hyperoxaluria, calcium instead binds to fatty acids, so the water soluble oxalate is absorbed. It has been reported that nearly 15% of patients with cystic fibrosis develop renal calculi. Oxalate stones are extremely dense on plain abdominal radiography. (Rose de Bruyn, 2005).

2-5-8-2 Cysteine stones

These may develop as small stones or also assume a staghorn configuration. They are less opaque than calcium stones and are sometimes difficult to see on plain abdominal radiography (Fig. 2-22). (Rose de Bruyn, 2005).



(Fig: 2-22): Staghorn calculus. (A) Longitudinal sonogram of the left kidney which shows dense acoustic shadowing in the central collecting system (between calipers). A staghorn calculus should be suspected when this coalition of echoes is seen within the renal pelvis. (Rose de Bruyn, 2005).

2-5-8-3 Uric acid stones

These stones are rarely found in children. Most commonly they occur after treatment of myeloproliferative disorders has caused tumor lysis and release and deposition of the tumor tissue products into the urinary tract. They may also be seen in the Lesch–Nyhan syndrome, a metabolic disorder affecting the uric acid pathway. (Rose de Bruyn, 2005).

2-5-8-4 Infectious stones

Infectious stones are mainly composed of struvite. Urease-producing bacteria are responsible for the formation of these calculi. They are mainly seen in boys under the age of 5 years, and there is commonly an associated anomaly in the urinary

tract such as a megaureter. Patients with a neurogenic bladder and extrophy are particularly prone. (Rose de Bruyn, 2005).

The perirenal urinoma is usually anechoic, but septations may be noted. Other potential causes of perirenal urine extravasation include ureteropelvic junction obstruction, ureterovesical junction obstruction, and pelvic masses that obstruct the bladder or ureter (Figure 2-23). (Rose de Bruyn, 2005).

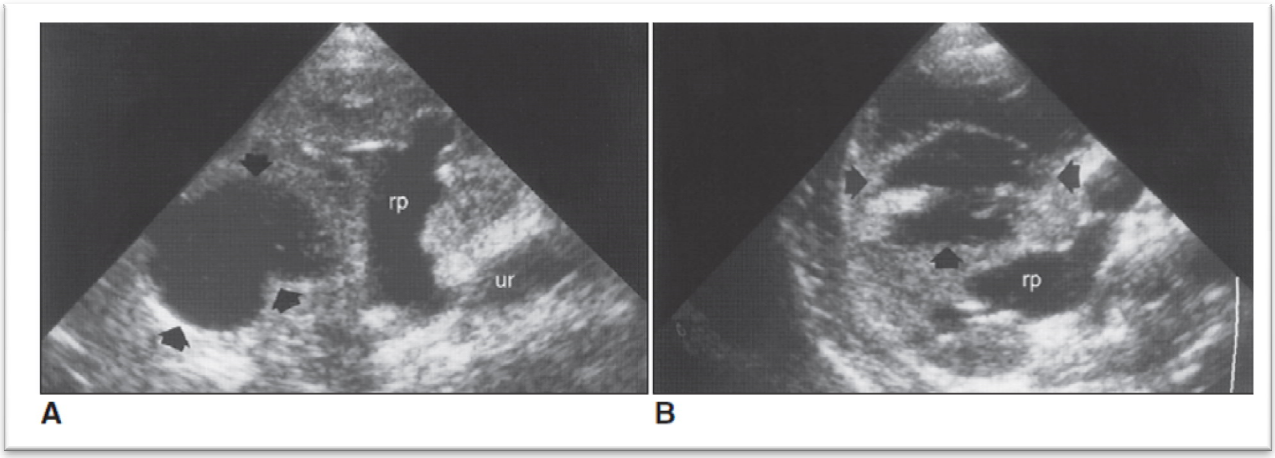
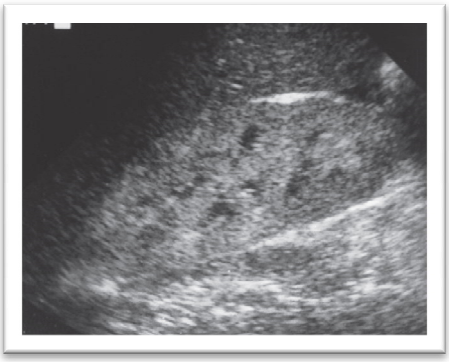


Fig (2-23): **A,** Sonogram of urinoma *(arrows)* in a 5-week-old with bilateral ureterovesical obstruction. Moderate pelvocaliectasis *(rp)* and dilation of the ureter *(ur)* are seen. **B,** Transverse image in the same patient identifies septations within the urinoma *(arrows)*. (Sandara L. Hagen, 2012).

2-5-9 Medical renal disease

2-5-9-1 Acute Glomerulonephritis:

In acute glomerulonephritis, necrosis or proliferation of cellular elements (or both) occurs in the glomeruli. The vascular elements, tubules, and interstitium become secondarily affected; the end result is enlarged, poorly functioning kidneys. Different forms of glomerulonephritis, including membranous, idiopathic, membranoproliferative, rapidly progressive, and poststreptococcal, can be associated with abnormal echo patterns from the renal parenchyma on a sonogram (Fig 2-24). Increased cortical echoes probably result from changes within the glomerular, interstitial, tubular, and vascular structures. Patients have many symptoms, including nephrotic syndrome, hypertension, anemia, and peripheral edema. (Sandara L. Hagen, 2012).



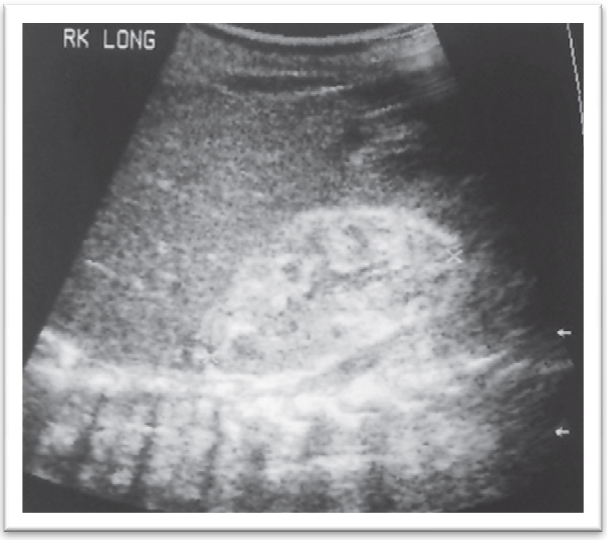
(Fig: 2-24). Acute glomerulonephritis may be suspected when the echogenicity of the renal parenchyma exceeds that of the liver. (Sandara L. Hagen, 2012).

2-5-9-2 Acute Interstitial Nephritis.

Acute interstitial nephritis has been associated with the infectious processes of scarlet fever and diphtheria. It may be a manifestation of an allergic reaction to certain drugs. Patient signs and symptoms include uremia, proteinuria, hematuria, rash, fever, and eosinophilia. The kidneys are enlarged and mottled. On a sonogram, renal cortical echogenicity is increased. The increase in echogenicity is greatest in cases of diffuse active disease. This increase is less apparent in diffuse scarring.

2-5-9-3 Lupus Nephritis.

Systemic lupus erythematosus is a connective tissue disorder believed to result from an abnormal immune system. Females are affected more often than males, and incidence peaks between 20 and 40 years of age. The kidneys are involved in more than 50% of patients. Renal manifestations include hematuria, proteinuria, hypertension, renal vein thrombosis, and renal insufficiency. Sonography shows increased cortical echogenicity and renal atrophy (Fig 2-25). (Sandara L. Hagen, 2012).



(Fig: 2-25) Patients with lupus nephritis demonstrate a highly echogenic renal parenchymal pattern compared with the liver. Renal atrophy is usually present (Sandara L. Hagen, 2012).

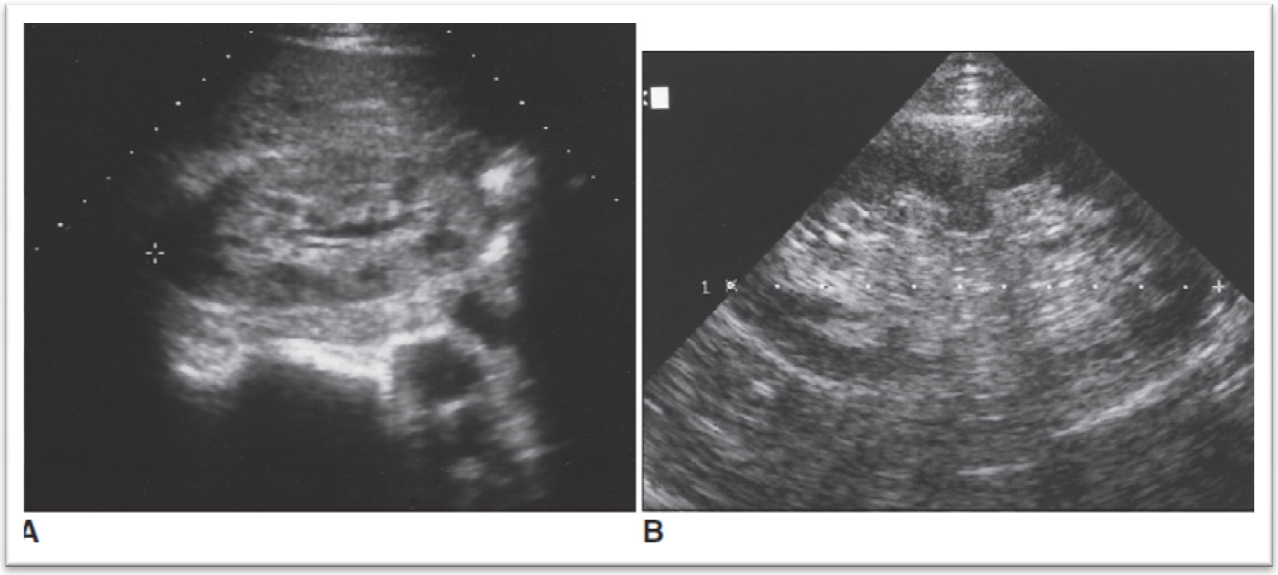
2-5-9-4 Sickle Cell Nephropathy.

Renal involvement is common in patients with sickle cell disease. Abnormalities include glomerulonephritis, renal vein thrombosis, and papillary necrosis. Hematuria is common. The sonographic appearance depends on the type of disorder. In acute renal vein thrombosis, the kidneys are enlarged with decreased echogenicity secondary to edema. In patients with subacute cases, renal enlargement is present with increased cortical echoes.

2-5-9-5 Renal Atrophy.

Renal atrophy results from numerous disease processes. Intrarenal anatomy is preserved with uniform loss of renal tissue. Renal sinus lipomatosis occurs secondary to renal atrophy. More severe lipomatosis results from atremendous increase in renal sinus fat content in cases of marked renal atrophy caused by hydronephrosis and chronic calculus disease. The kidneys appear enlarged with a highly echogenic, enlarged renal sinus and a thin cortical rim. Renal sinus fat is

easily seen on a sonogram as highly echogenic reflections (Fig 2-26). (Sandara L. Hagen, 2012).

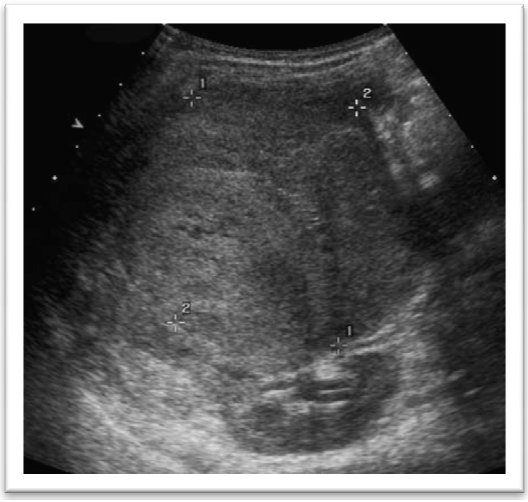


(Fig: 2-26) **A,** A 73-year-old man with chronic renal disease. Small echogenic kidney with inability to distinguish the medulla from the cortex region of the kidney. **B,** Renal sinus lipomatosis appears as enlarged kidneys with an echogenic, enlarged renal sinus and a thin cortical rim. Renal sinus fat is easily seen on ultrasound as highly echogenic reflections. (Sandara L. Hagen, 2012).

2-5-10 Wilms tumor

These children usually present with an abdominal mass. There may be associated hematuria, fever and hypertension. Wilms tumors usually present in the under 5 age group and are unilateral in 95%. These tumors are extremely rapidly growing, and the clinical presentation may be related to tumor hemorrhage or rupture. Rarely are they found during screening. Ultrasound is the first examination on any child presenting with an abdominal mass. The appearances are very much dependent on the stage and size of the renal tumor at presentation. The tumor is usually well defined with no definite normal renal parenchyma seen. Sometimes a sliver of compressed kidney may be visible on the edge of the tumor mass. Very occasionally the Wilms tumor may be completely exophytic, i.e. arising from the kidney but completely extrarenal (Fig. 2-27). The mass is predominantly solid, but

hypoechoic areas or venous lakes are a common feature. The contralateral kidney must be carefully examined both for nephroblastomatosis and a distinct renal tumor. A small number of Wilms tumors calcify (as opposed to a neuroblastoma) and the calcification is generally coarse and linear. Lymphadenopathy is not usually a feature of Wilms tumors but rather that of neuroblastoma. The role of ultrasound is to make the diagnosis and thus direct further imaging. It is important for the sonographer not to misdiagnose solid renal lesions and in particular xanthogranulomatous pyelonephritis, which will show dense calculi with or without extrarenal rupture.Occasionally the intrarenal mass, may be cystic throughout. The liver must be carefully examined for hypoechoic metastases. Occasionally the children present with trauma, and the use of Doppler will help differentiate between a hematoma and tumor. (Rose de Bruyn,2005).



(Fig: 2-27): Exophytic Wilms tumor. (A) Transverse sonogram in a child presenting with an abdominal mass (between calipers). The normal kidney is squashed posteriorly by the large extrarenal mass. This was a Wilms tumor which was predominantly extrarenal. This can sometimes confuse the unsuspecting sonographer.
(Rose de Bruyn,2005).

2-6 Previous study:

A previous study titled pattern of renal diseases among hospitalized children in Khartoum state conducted by A/Rahman, Amel Hussein found that renal parenchymal disease was25,7%,urinary tract infections25,2% ,renal stonewas13,7% , chronic renal faliure13,3% acute renal failure was5,3%, congenital anomalies was12,5% ,renal tumors2,2% and other

Another previous study conducted by Mohammed, Sumaiya Ali 2011, titled ultrasound evaluation of chronic kidney disease in children, the study showed that CKD in children is common in boys than girls ,and the age of presentation was to be at any age from birth onwards, congenital cause tend to appear earlier in life ,the peak age of presentation in the study was found to be between 11_12 years of age.

A third previous study conducted by Khans Z, Fahim F, Mansoor K was titled Obstructive Uropathy causes and outcome in pediatric patients, obstructive uropathy was caused by posterior urethral valve as the commonest cause, second most common cause was renal stones, the study found that both causes were detected by ultrasounic screening in early asymptomatic stages, which allow for prevention of CRF caused by obstructive uropathy.

A fourth study conducted by Shareef, Thekrayat Mohammed Ibraheem, titled A Study of Urinary Tract Problems Using Ultrasound Imaging ,The results conclude that the common ultrasound findings regarding urinary tract problems are hydronephrosis, urinary stones, cysts, pyonephrosis, cystitis, benign prostatic hyperplasia (BPH) and others (Ectopic kidney, uterine fibroids and absent kidney).

Ultrasound findings are very important to detect the complications and signs of urinary tract problems and helpful in follow up to manage these critical complications.

Another previous study conducted by Dr. Peter Brown was titled ―Ultrasound in Diffuse renal disease. The conducted study reached to the following results:

- Ultrasound is an essential initial investigation in a patient presenting with renal failure.
- Ultrasound gives immediate information on the presence, size and appearance of both kidneys and importantly assesses dilatation of the pelvicalyceal system, which may be due to obstruction.
- Renal ultrasound, distinguishes patients with obstructive renal failure allowing appropriate treatment and intervention.
- Ultrasound has an observable role in the assessment of patients with pre renal, and intrinsic renal failure.
- Ultrasound can identify patients with intrinsic renal disease, and distinguish different diseases. Ultrasound can identify end stage kidneys and give prognostic information. (Date of download: 23/7/2017).

METHODOLOGY

3-1 Type of the study

Descriptive analytical study

3-2Population of the study

Sudanese children (1 month - 18) years in Soba University Hospital and Jafar Ibn Auf paediatric Hospital in Khartoum State from (March to June 2017).

3-3 Study sample

Eighty Sudanese children suffering from urinary tract symptoms, (46) males and (34) females.

3-4 Inclusion criteria

Children who are suffer from renal disease or have signs and symptoms of renal disease.

3-5 Exclusion criteria

- Healthy children.
- Patients who are more than 18 years old.

3-6 Material of study

The sonographic examination performed with high resolution real time scanner (Digiprince-Dp9900 plus), with (2.5 5.0 MHz), convex transducer in Gaafr Ibnaof Hospital.

3-7 Technique

Measurement of the kidneys size (cm), echogenicity, CMD and urinary bladder wall thickness (mm) were taken for eighty Sudanese children. US examination of the urinary tract was performed using Trans abdominal (TA) convex probe 3.5MHZ, and also linear probe 12 Mega hertz was used in many cases, subject was scanned abdomen with fullness bladder. Ages and gender of subjects was recorded.

For purpose of this study the supine position was selected and also prone position, imaging in two planes (sagittal, transverse). After visualization the maximal outline of urinary tract, the measurements will be taken for both kidneys diameter with longitudinal plane, bladder wall thickness with transverse plane with slight caudal angle

3-8 Duration of the study

This study was done from March to august 2017.

3-9 Data collection

The data was collected by master data sheets using the following variables:

- Ag
- Gender: male or female
- kidney size: Normal renal length from(5cm to10,7cm.) using the following guide:

Over one year - renal length in cm. = 6.79 + (0.22 x age in years)

Less than one year - renal length in cm. = 4.98 + (0.155 x age in months)

- kidney echogenicity: Normal renal cortex is typically less echogenic than adjacent liver and spleen, increased echogenicity if more than liver, decreased echogenicity if less echogenic than normal
- CMD: differentiated when cortex more echogenic than medulla, un differentiated if the echogenicity of the cortex was similar to medulla, and cannot be separately identified.
- Ureter: if appear that mean it was dilated
- Bladder wall thickness. It considered thick if it was more than 3mm

Chapter Four

Results

Table (4.1): Distribution of sample according to age.

Age	Frequency	Percent
<1-4	13	16.3%
5-9	16	20.0%
10-13	32	40.0%
14-18	19	23.8%
Mean±SD	10.12±4.59	
Total	**80**	**100.0%**

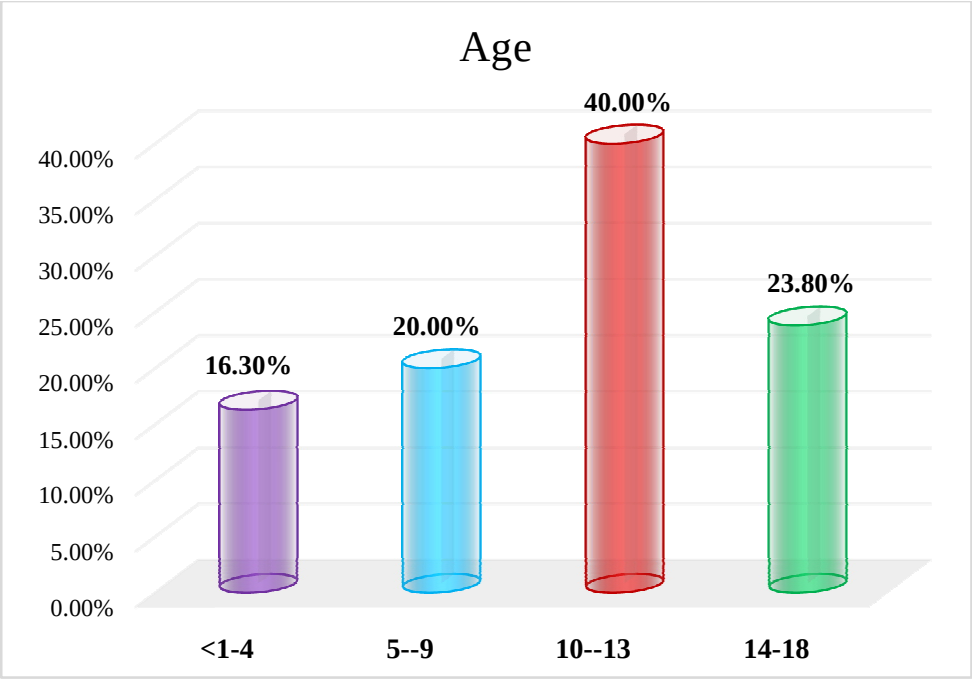


Table (4.2): Distribution of sample according to gender

Gender	Frequency	Percent
Male	46	57.5%
Female	34	42.5%
Total	**80**	**100.0%**

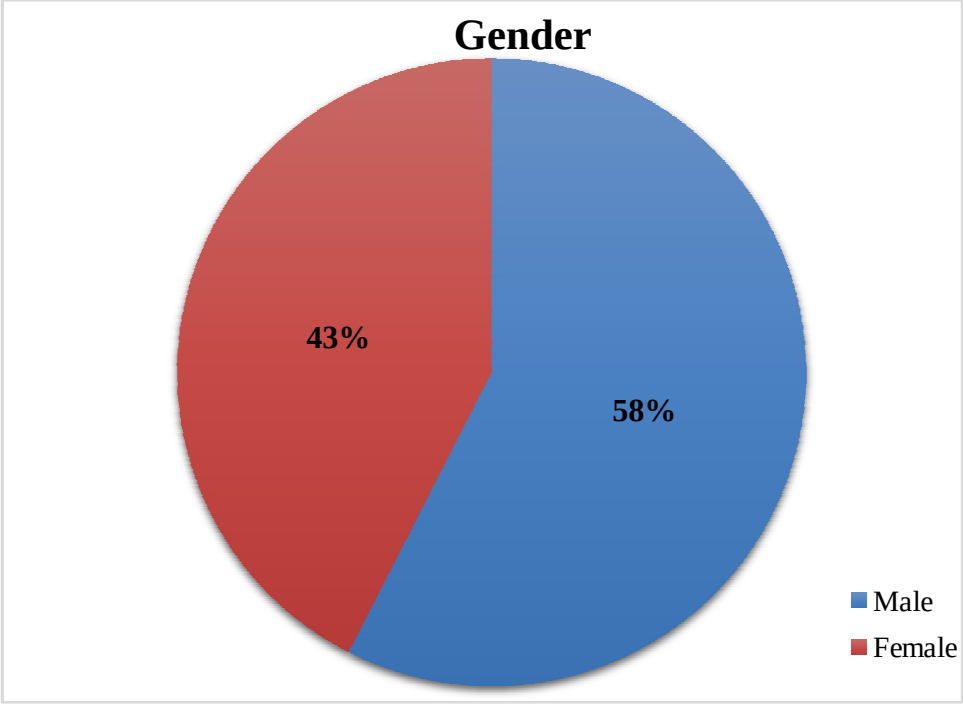


Table (4.3): Distribution of sample according to the kidney size.

Size	Right Kidney		Left Kidney		Significant Test
	Frequency	Percent	Frequency	Percent	
Normal	23	28.8%	26	32.5%	X^2=111.753 P0.000*
Enlarge	34	42.5%	35	43.8%	
Small	19	23.8%	19	23.8%	
Absent	4	5.0%	00	00.0%	
Total	**80**	**100.0%**	**80**	**100.0%**	

*= Statistical Significant were P<0.05 (there is statistical significant between Rt and Lt kidney size).

Table (4.4): Distribution of sample according to causes of kidney absence.

Causes	AbsentKidney	
	Frequency	Percent
Congenital (Right renal agenesis)	3	75%
Surgery	1	25%
Total	**4**	**100.0%**

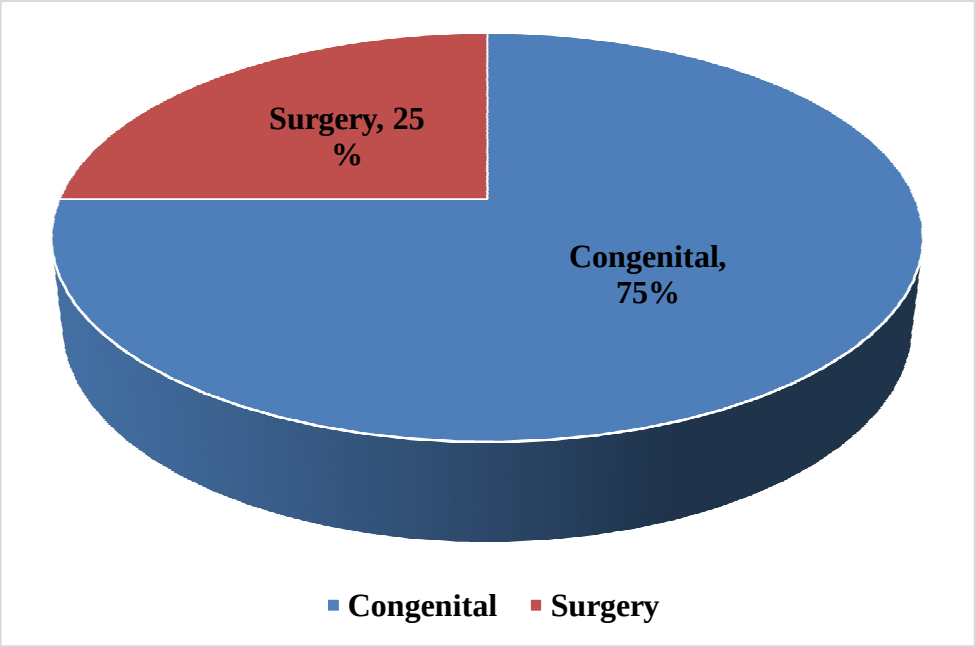


Table (4.5): Relationship between right and left kidney echogenicity.

Echogenicity	Right Kidney		Left Kidney		Significant Test
	Frequency	Percent	Frequency	Percent	
Normal	18	22.5%	23	28.8%	X^2=113.508 P0.000*
Increase	49	61.3%	50	62.5%	
Decrease	8	10.0%	7	8.8%	
Heterogeneous	1	1.3%	00	00.0%	
Absent	4	5.0%	00	00.0%	
Total	**80**	**100.0%**	**80**	**100.0%**	

Table (4.6): Relationship between right and left kidney pyramids.

Pyramids	Right Kidney		Left Kidney		Significant Test
	Frequency	Percent	Frequency	Percent	
Normal	25	31.3%	29	36.3%	X^2=263.246 P0.000*
Prominent	15	18.8%	15	18.8%	
Dilated	16	20.0%	18	22.5%	
Distorted	19	23.8%	17	21.3%	
Hyperechoic	1	1.3%	1	1.3%	
Absent	4	5.0%	00	00.0%	
Total	**80**	**100.0%**	**80**	**100.0%**	

Table (4.7): Relationship between right and left kidney corticomedullary differentiation.

CMD	Right Kidney		Left Kidney		Significant Test
	Frequency	Percent	Frequency	Percent	
Differentiated	45	56.3%	48	60.0%	X^2=47.174 P0.000*
Undifferentiated	31	38.8%	32	40.0%	
Absent	4	5.0%	00	00.0%	
Total	**80**	**100.0%**	**80**	**100.0%**	

Table (4.8): Relationship between right and left ureter.

Finding	Right Ureter		Left Ureter		Significant Test
	Frequency	Percent	Frequency	Percent	
Normal	64	84.2%	68	85.0%	
Dilated	12	15.8%	12	15.0%	X^2=76.00
Absent	4	5.0%	00	00.0%	P0.000*
Total	**80**	**100.0%**	**80**	**100.0%**	

Table (4.9): Distribution of sample according to their urinary bladder wall thickness.

Wall Thickness	Urinary Bladder	
	Frequency	Percent
Normal	68	85.0%
Thick wall	12	15.0%
Total	**80**	**100.0%**

Table (4.10): Distribution of sample according to their final diagnosis.

Final Diagnosis	Frequency	Percent
Renal parenchymal disease	25	31.3%
Obstructive uropathy	14	17.5%
Acute renal failure	5	6.3%
Chronic renal failure	18	22.5%
Lupus Nephritis	5	6.3%
Sickle cell nephropathy	3	3.8%
Unilateral Wilms tumor	2	2.5%
Right kidney atrophy	1	1.3%
Urinary bladder leishmaniasis	1	1.3%
Posterior urethral valve anomaly	5	6.3%
Right renal agenesis	1	1.3%
Total	**80**	**100.0%**

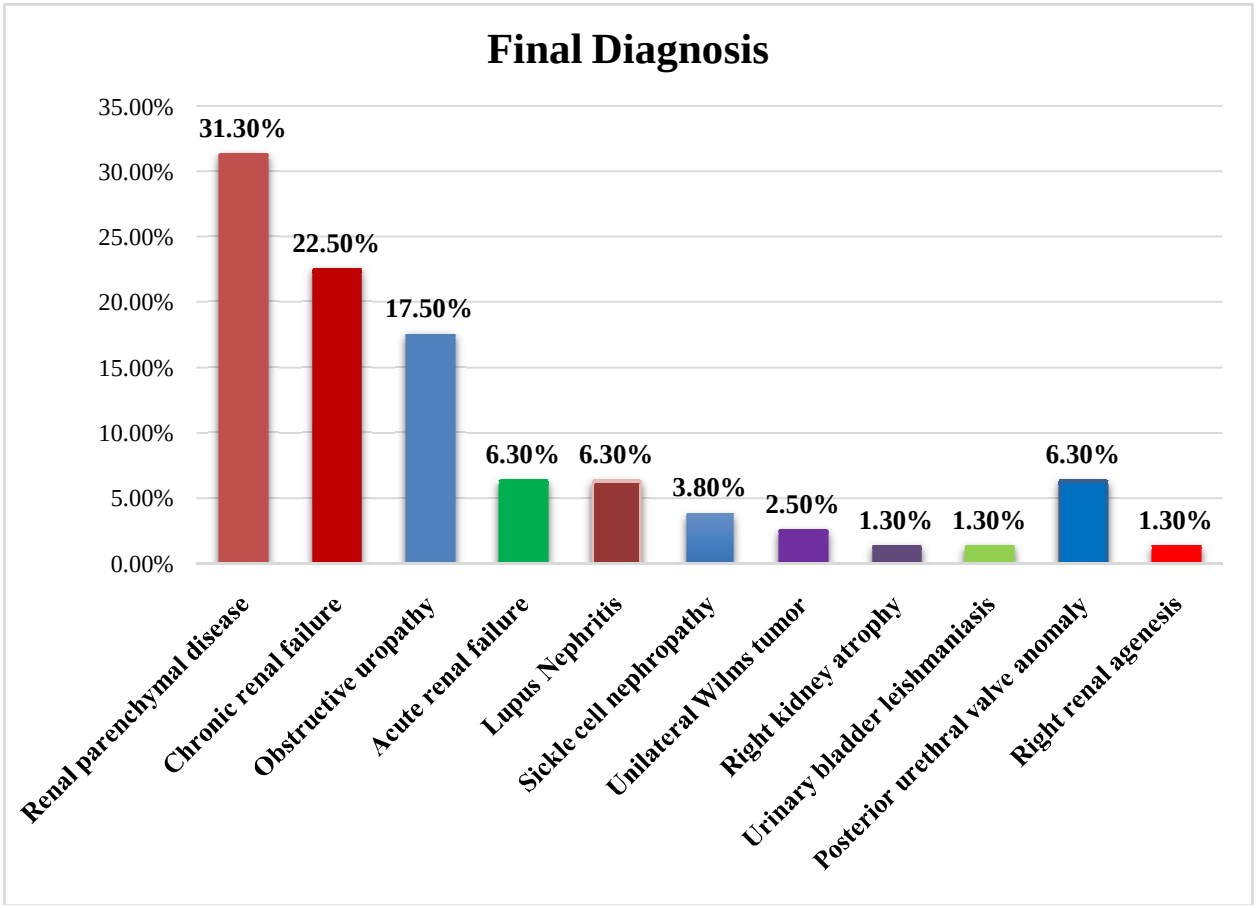


Table (4.11): Distribution of sample according to other findings.

Other Finding	Frequency	Percent
Hydronephrosis	19	23.8%
Hydroureter	13	16.3%
Stone	10	12.5%
Neurogenic Bladder	2	2.5%
Congenital PUJ Obstruction	1	1.3%
Bladder outlet Obstruction	1	1.3%
Cystitis	6	7.5%

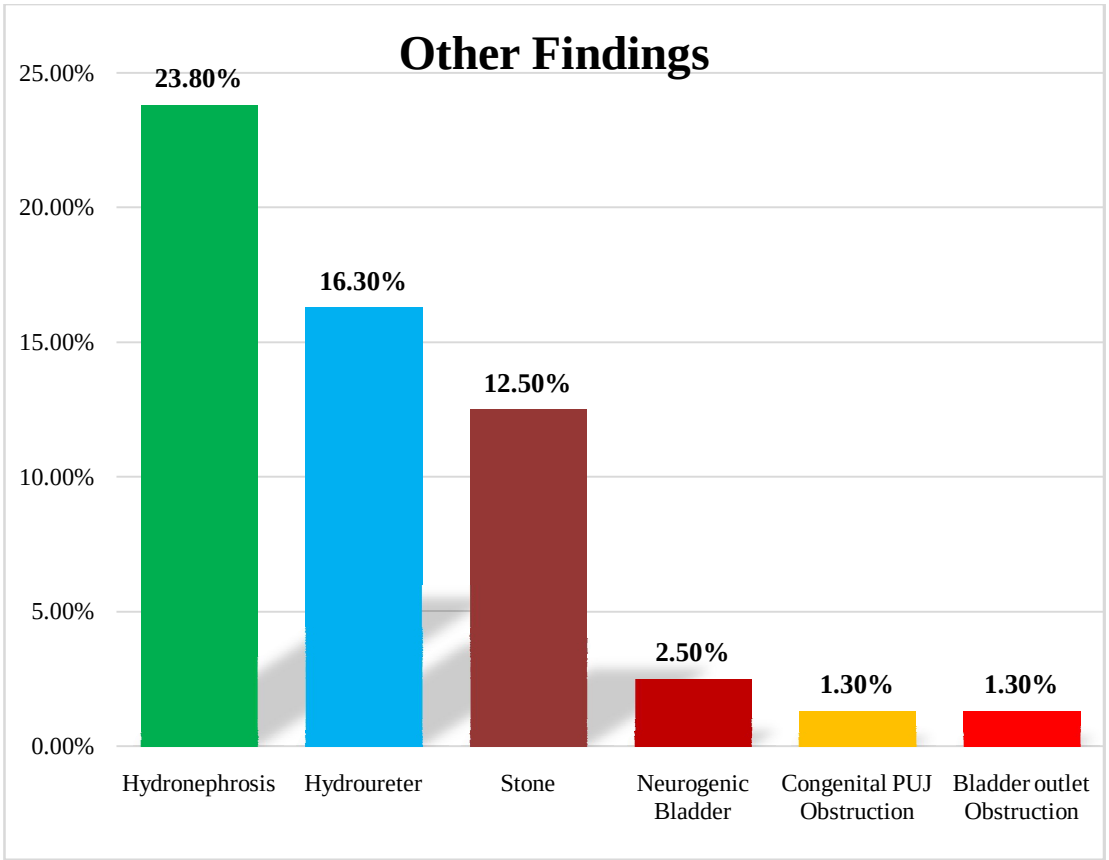


Table (4.12): Distribution of sample according to obstructive uropathy causes.

Causes	Obstructive Uropathy	
	Frequency	**Percent**
Stone	10	53.0%
PUV	5	26.3 %
Neurogenic Bladder	2	10.3%
Congenital PUJ Obstruction	1	5.2%
Bladder outlet Obstruction	1	5.2%
Total	**19**	**100%**

Table (4.13): Correlation between the final diagnosis and age group.

Final Diagnosis		Age Group				Total
		<1-4	5-9	10-13	14-18	
Renal parenchymal disease	n	3	6	9	7	25
	%	12.0%	24.0%	36.0%	28.0%	100.0%
Obstructive uropathy	n	4	2	5	3	14
	%	28.6%	14.3%	35.7%	21.4%	100.0%
Acute renal failure	n	0	1	4	0	5
	%	0.0%	20.0%	80.0%	0.0%	100.0%
Chronic renal failure	n	1	1	11	5	18
	%	5.6%	5.6%	61.1%	27.8%	100.0%
Lupus Nephritis	n	0	1	1	3	5
	%	0.0%	20.0%	20.0%	60.0%	100.0%
Sickle cell nephropathy	n	1	1	0	1	3
	%	33.3%	33.3%	0.0%	33.3%	100.0%
Unilateral Wilms tumor	n	1	1	0	0	2
	%	50.0%	50.0%	0.0%	0.0%	100.0%
Right kidney atrophy	n	0	0	1	0	1
	%	0.0%	0.0%	100.0%	0.0%	100.0%
Urinary bladder leishmaniasis	n	0	0	1	0	1
	%	0.0%	0.0%	100.0%	0.0%	100.0%
Posterior urethral valve anomaly	n	3	2	0	0	5
	%	60.0%	40.0%	0.0%	0.0%	100.0%
Right renal agenesis	n	0	1	0	0	1
	%	0.0%	100.0%	0.0%	0.0%	100.0%
Total	**n**	**13**	**16**	**32**	**19**	**80**
	%	**16.3%**	**20.0%**	**40.0%**	**23.8%**	**100.0%**
Significant Test		**X^2=38.528**			**P0.137**	

Table (4.14): Correlation between final diagnosis and gender.

Final Diagnosis		Gender		
		Male	**Female**	**Total**
Renal parenchymal disease	n	18	7	25
	%	72.0%	28.0%	100.0%
Obstructive uropathy	n	8	6	14
	%	57.1%	42.9%	100.0%
Acute renal failure	n	4	1	5
	%	80.0%	20.0%	100.0%
Chronic renal failure	n	9	9	18
	%	50.0%	50.0%	100.0%
Lupus Nephritis	n	0	5	5
	%	0.0%	100.0%	100.0%
Sickle cell nephropathy	n	2	1	3
	%	66.7%	33.3%	100.0%
Unilateral Wilms tumor	n	0	2	2
	%	0.0%	100.0%	100.0%
Right kidney atrophy	n	0	1	1
	%	0.0%	100.0%	100.0%
Urinary bladder leishmaniasis	n	0	1	1
	%	0.0%	100.0%	100.0%
Posterior urethral valve anomaly	n	5	0	5
	%	100.0%	0.0%	100.0%
Right renal agenesis	n	0	1	1
	%	0.0%	100.0%	100.0%
Total	**n**	**46**	**34**	**80**
	%	**57.5%**	**42.5%**	**100.0%**
Significant Test			**X^2=20.930**	**P0.022***

Chapter five
Discussion, conclusion and recommendations

5.1-Discussion:

This research has been carried out to study the common ultrasound finding in urinary tract in Sudanese children in Khartoum state ,80 patient was included in this study,46male and 34 female ,all of them with in age group (3month-18years old).

It has been carried out in Soba University Hospital and Jafar Ibn Auf Pediatric Hospital from March 2017to August2017.

The result of the study showed that common renal disease which is detected sonographically were: Renal parenchymal disease(31.3%),chronic renal failure(2.5%),obstructive uropathy(17.5%),acute renal failure, lupus nephritis and posterior urethral valve had a same percentage of(6.3%).renal tumors' (2.2%),renal agenesis ,renal atrophy and urinary bladder lishmaneasis were(1.3%).This result is approximately similar to previous study conducted by A/Rahman.Amel,2005.

Posterior urethral valve was a common congenital anomaly which was reported in this study and this result was match previous study conducted by A/Rahman.Amel,2005.

Obstructive uropathy had a percentage of(17.5%),and most common cause of it was renal stones(53%) followed by posterior urethral valve(26.3%)and this un like previous study from Khan Z.etal,2012, this difference may be explained by hotter climate and poorer dietary. other causes of obstructive uropathy were neurogenic bladder(10.3%),congenital pelvic ureteric junction obstruction and bladder out let obstruction with same percentage(5.2%).

Renal tumor had a percentage of (2.5%),which is approximately similar to previous study conducted by A/Rahman.Amel,2005 , Wilms tumor is unilateral (100%) in our study, where literature state that is(95%),this difference due to small sample of the study

Most patients 32(40%) were children between10-13years old, because of chronicity of disease which is worsen as child gets older and this was matched with previous study from Mohammed.Sumaiya,2011. there was no significant correlation between final diagnosis and age group

In this study renal disease was found to be more common in males 46 (57. 5%) than females 34(42. 5%), which is similar to previous study conducted by A/Rahman.Amel,2005. because majority of structural abnormalities were more common in males. Strong correlation was found between the final diagnosis and gender .

5.2- Conclusion: -

This study has been carried out in Khartoum state. The goal of the study is to document the common renal pathology among Sudanese children by using ultra sound as diagnostic imaging modality.

The results conclude that the common renal pathology among Sudanese children detected by ultra sound were renal parenchymal disease ,chronic renal failure, obstructive uropathy, acute renal failure, lupus nephritis, posterior urethral valve, and others (sickle cell nephropathy, renal tumors , agenesis ,urinary bladder leshmaniasis).

Ultrasound findings are very important to detect the urinary tract disease, and complications, and helpful in follow up to prevent and manage these critical complications.

5.3- Recommendations: -

After the enumeration of the results that related to the following thesis, there are some recommendations which could help further in the field of research and better to be recommended as follow: -•

- Renal diseases among children in our country should be take seriously and dealt with through programmed health services and this will be a major step towards improvement of the health status and well-being in the community.
- Would be better to do the U/S scan as a routine study in the urinary tract diseases to detect the lesions as a cause of urinary tract pathology.
- It would be better to do the U/S scan to sought the cause of obstructive uropathy.
- Further studies should be done on renal stones to explore the possible association of factors such as climate, dietary habits, familial and socio-economic status, which could shed some light on the problem.
- U/S scanning could be used as a routine checkup, follow up to help treatment and control of the disease.
- It would be better to do more studies in U/S findings in patients with urinary tract problems by large samples and further modalities.
- It would be better to use Doppler ultrasound to investigate renal vessels in case of congenital hydronephrosis and other renal vascular problems.