# Chapter one

Hydronephrosis is a condition where urine overfills, or backs up, into the kidney, which causes the kidney to stretch (dilate), much like a balloon when it is filled with water.

## 1-1 Hydronephrosis

Hydronephrosis is very common. It affects all ages. Infants with hydronephrosis may be diagnosed prenatally (before birth) or after birth during evaluation for other issues or after a urinary tract infection. It may be caused by something blocking the urine flow somewhere along the urinary drainage tubes or due to urine back-flowing from the urinary bladder into the ureter (the tube that drains the kidney) and kidney, There are three grades of hydronephrosis:

### 1-1-1 Grade I: (mild):

There is a minimal dilatation of the collecting system. The calyces are blunted but some pyramids indentation remains.

On ultrasound (u/s) this appears as a single ellipsoidal fluid collection spreading the central echo complex. Slight dilatation of renal pelvis and calyces will be seen.

### 1-1-2 Grade II: (moderate):

Shows the bear claw effect, with fluid extending into the major and minor calyceal system, the calyces are clubbed and there is no pyramidal indentation into the calyces. On u/s there is lobulated fluid collection with a few septate between the distended calyces. The parenchymal thickness is preserved.

### 1-1-3 Grade III (severe):

Represent massive dilatation of the renal pelvis with loss of renal parenchyma. On u/s there is multiple rounded fluid containing structure which are the distended calyces. These distended calyces displace the central echo complex and totally replace the normal parenchyma.

Hydronephrosis may be present in one kidney (unilateral) or both kidneys (bilateral). It refers to dilatation of the renal collecting system most frequently caused by incomplete or complete obstruction.

There are many causes of Hydronephrosis which include congenital blockage (present at birth, scarring of tissue from injuries or previous surgery), tumors or cancer, vesical mass, urinary tract

infection (UTI) and benign prostatic hypertension (BPH) and pregnancy. Calculi are the most common cause in adults followed by tumors of the kidney, ureter and bladder.

Less common causes are inflammatory ureteral strictures, neurogenic bladder and bladder outlet obstruction.

The causes of hydronephrosis are categorized based upon the location of

the hydronephrosis and whether the cause is intrinsic (located within the urinary collecting system), extrinsic (outside of the collecting system) or if it is due to an alteration in function. Causes of the hydronephrosis may be detected, such as bladder or ureteral calculi, benign prostatic hypertrophy, pelvic abscesses or tumors.

Post-voiding examination may demonstrate disappearance of urinary tract dilatation or massive urine retention if the cause of hydronephrosis is at the bladder outlet. The increased pressure caused by hydronephrosis potentially can compromise kidney function if it is not relieved in a reasonable period of time. Patients with hydronephrosis always complain from pain,

gross or microscopic hematuria, UTI, acute and chronic renal failure.

The etiology and presentation of hydronephrosis in adults differ from that in neonates and children. Anatomic abnormalities (including urethral valves or stricture, and stenosis at the ureterovesical or ureteropelvic junction) account for the majority of cases in children. In comparison, calculi are most common in young adults, while prostatic hypertrophy or carcinoma, retroperitoneal or pelvic neoplasms, and calculi are the primary causes in older patients. Hydronephrosis or hydroureter is a normal finding in pregnant women. The renal pelvises and calyceal systems may be dilated as a result of progesterone effects and mechanical compression of the ureters at the pelvic brim.

## 1-2 Problem of the study:

Not all PCS (pelvi-calyceal system) is dilatation, i.e. hydronephrosis is pathological, or indeed obstructive, that is, there can be dilatation without physiological obstruction. Conversely, not all obstructive uropathy necessarily results in PCS

dilatation. Also many conditions may mimic hydronephrosis such as extra renal pelvis, para pelvis cysts, reflux, transient diuresis, congenital mega calyces, papillary necrosis, and renal artery aneurysm. Therefore evaluation of the renal function using ultrasound and renal scintigraphy can give a complete image about renal function and the cause of the dilatation.

## 1-3 Objectives:

The general objective of this study is to evaluate renal hydronephrosis using ultrasound and renal scintigraphy in order to detect the presence or the absent of hydronephrosis, to explore the cause and hence facilitate a good medical attention, also to determine which study is more accurate in detecting it.

***Specific objectives*:**

- To measure the renal size, cortex, medulla and renal pelvis.
- To find the renal function using renal scintigraphy, maximum uptake (time & counts)
- To correlate between the renal scintigraphy results and ultrasound outcomes as well as body characteristics

- To predict the renal scintigraphy using kidney size as measured by ultrasound

## 1-4 Significance of the study

This study is an attempt to evaluate renal hydronephrosis using ultrasound to explore the morphologic characteristics and renal scintigraphy to relate the function impairment to the pathological condition, as well as to predict the function problem using ultrasound measurement.

## 1-5 Overview of the study

This study consisted of five chapters. Chapter one will deals with the introduction, problem of the study, objectives, Significant of the study and thesis over view. Chapter two highlighted the literature review related to urinary system and hydronephrosis of the study. Chapter three discussed the method and material used in this study. Chapter four deals with the results and finally chapter five included the discussion, conclusion, recommendation, references and appendices.

# Chapter two
## Literature review

### 2-1 Anatomy of the kidney:

The kidneys are developing from a common mesodermal ridge intermediate mesoderm. Three slightly overlapping kidney systems are formed in cranial to caudal sequence during intrauterine life; the pronephrosis which is rudimentary and nonfunctional, nesonephros may function for short time during the early fetal period, and metanephrosis which is from the permanent kidney.

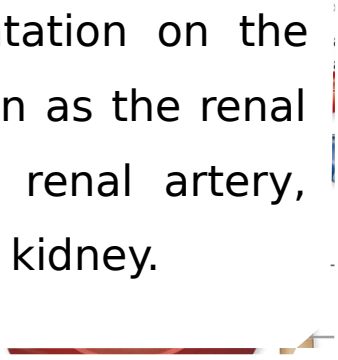
### 2-1-1 Location:

The kidneys are a pair of organs found along the posterior muscular wall of the abdominal cavity. The left kidney is located slightly more superior than the right kidney due to the larger size of the liver on the right side of the body. Unlike the other abdominal organs, the kidneys lie behind the peritoneum that lines the abdominal cavity and are

thus considered to be retroperitoneal organs. The ribs and muscles of the back protect the kidneys from external damage. Adipose tissue known as peri renal fat surrounds the kidneys and acts as protective padding.

**Structure:**

The kidneys are bean-shaped with the convex side of each organ located laterally and the concave side medial. The indentation on the concave side of the kidney, known as the renal hilus, provides a space for the renal artery, renal vein, and ureter to enter the kidney.



A thin layer of fibrous connective tissue forms the renal capsule surrounding each kidney. The renal capsule provides a stiff outer shell to maintain the shape of the soft inner tissues.

Deep to the renal capsule is the soft, dense, vascular renal cortex. Seven cone-shaped renal pyramids form the renal medulla deep to the renal cortex. The renal pyramids are aligned with their

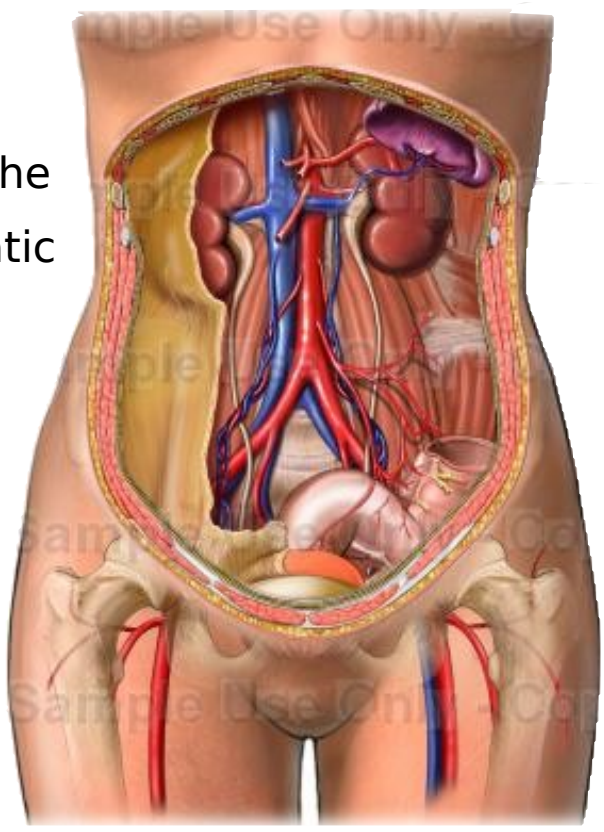
bases facing outward toward the renal cortex and their apexes point inward toward the center of the kidney.

Each apex connects to a minor calyx, a small hollow tube that collects urine. The minor calyces merge to form 3 larger major calyces, which further merge to form the hollow renal pelvis at the center of the kidney. The renal pelvis exits the kidney at the renal hilus, where urine drains into the ureter.

## 2-1-2 Relationships:

*Right kidneys:*

Anteriorly: the suprarenal gland, the right lobe of the liver, the second part of the duodenum and the right hepatic flexure of the colon. Posteriorly: the diaphragm, the costodiaphragmatic recess of the pleura, the twelfth rib, the psoas major muscle, quadratus lumborum and transversus abdominis muscles.



Left kidney:

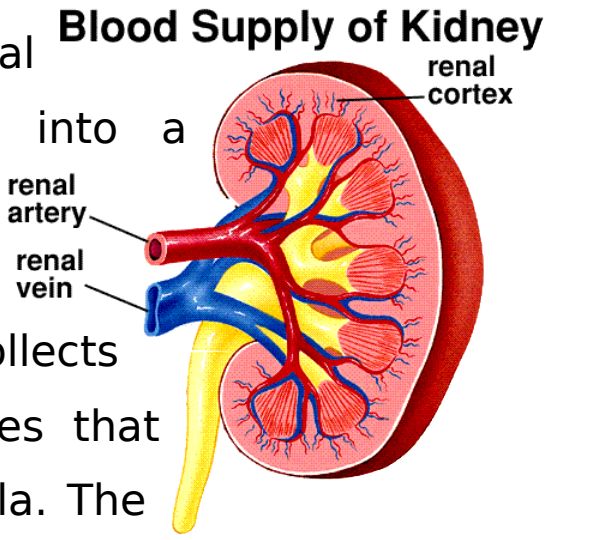
Anteriorly: the suprarenal gland, the spleen, the stomach, the

pancreas, the left coil of the jejunum, quadratus labarum, and the transversus abdominis muscle. Posteriorly: the diaphragm, the costodiaphragmatic recess of the pleura, the eleventh (the left kidney is higher than the right) and the twelfth ribs and the psoas major muscle.

## 2-1-3 Blood Supply

1. The renal arteries branch directly from the abdominal aorta and enter the kidneys through the renal hilus.
Inside our kidneys, the renal arteries diverge into the smaller afferent arterioles of the kidneys.






Each afferent arteriole carries blood into the renal cortex, where it separates into a bundle of capillaries known as a glomerulus. From the glomerulus, the blood recollects into smaller efferent arterioles that descend into the renal medulla. The efferent arterioles separate into the peri tubular capillaries that surround the renal tubules. Next, the peri tubular capillaries merge to form veins that merge again to form the large renal vein.

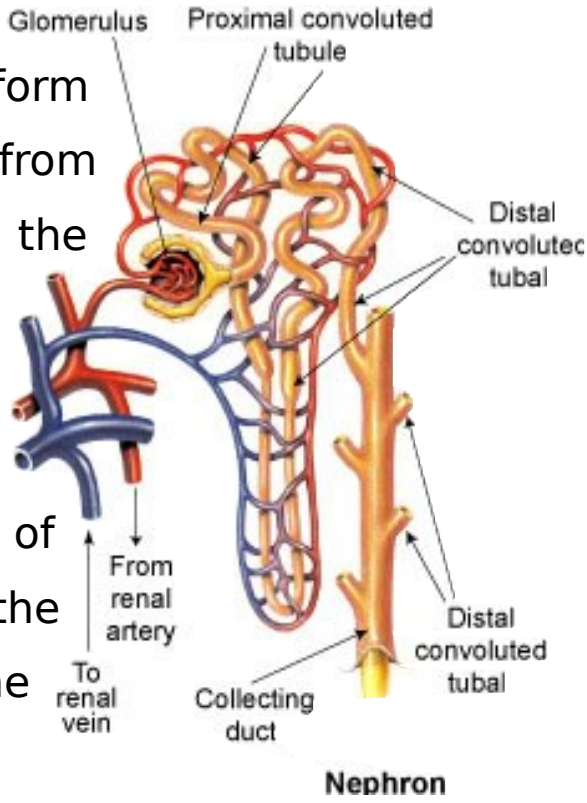
Finally, the renal vein exits the kidney and joins with the inferior vena cava, which carries blood back to the heart.

### 2-1-4 the Nephron

Each kidney contains around 1 million individual nephrons, the kidneys' microscopic functional units that filter blood to produce urine. The nephron is made of 2 main parts: the renal corpuscle and the renal tubule.

Responsible for filtering the blood, our renal corpuscle is formed by the capillaries of the glomerulus and the glomerular capsule (also known as Bowman's capsule). The glomerulus is a bundled network of capillaries that increases the surface area of blood in contact the blood vessel walls. Surrounding the glomerulus is the glomerular capsule, a cup-shaped double layer of simple squamous epithelium with a hollow space between the layers. Special epithelial cells known as podocytes form the layer of the glomerular capsule

surrounding the capillaries of the glomerulus. Podocytes work with the endothelium of the capillaries to form a thin filter to separate urine from blood passing through the glomerulus. The outer layer of the glomerular capsule holds the urine separated from the blood within the capsule. At the far end of the glomerular capsule, opposite the glomerulus, is the mouth of the renal tubule.




A series of tubes called the renal tubule concentrate urine and recover non-waste solutes from the urine. The renal tubule carries urine from the glomerular capsule to the renal pelvis.

The curvy first section of the renal tubule is known as the proximal convoluted tubule. The tubule cells that line the proximal convoluted tubule reabsorb much of the water and nutrients initially filtered into the urine.

Urine next passes through the loop of Henle, a long straight tubule that carries urine into the renal medulla before making a hairpin turn and returning to the renal cortex.

Following the loop of Henle is the distal convoluted tubule.

Finally, urine from the distal convoluted tubules of several nephrons enters the collecting duct, which carries the concentrated urine through the renal medulla and into the renal pelvis.

From the renal pelvis urine from many collecting ducts combines and flows out of the kidneys and into the ureters.

### 2-1-5 Lymph drainage:

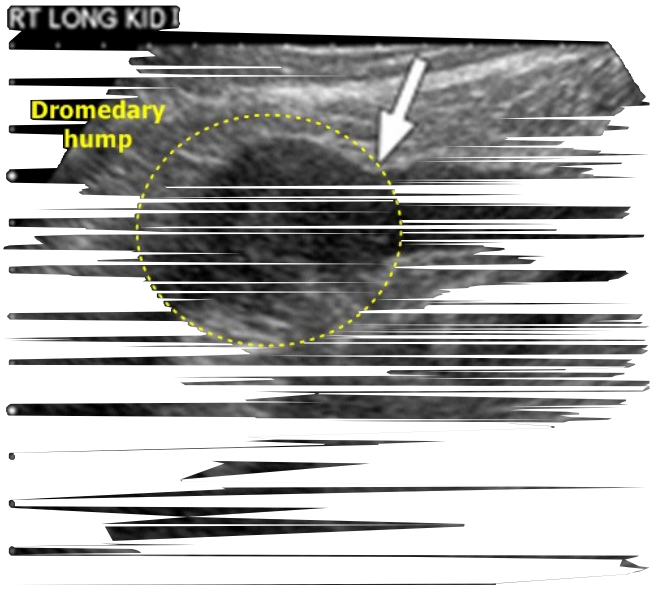
Lateral aortic lymph node around the origin of the renal artery.

**Nerve supply:** Renal sympathetic plexus

## 2-2 Normal variants:

- ***Dromedary hump:***

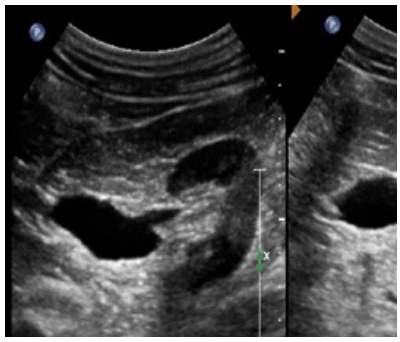
Either kidney, but more commonly the left, can demonstrate a lateral bulge at its mid portion. If the internal architecture is normal, the variant is not clinically significant.



Sonographically, Dromedary humps appear the same as normal renal cortex.

- ***Renal column hypertrophy:***

It is a common anatomic variant and is a double layer of renal cortex that is folded toward the center of the kidney, displacing a portion of the renal sinus. The echo texture is exactly the same as the adjacent renal cortex.



- ***Double collecting system:***

  It is very common cause of unilateral renal enlargement. The ultrasound scan demonstrates a large cortical area between two renal sinuses and an enlarge kidney.

- ***In complete duplications:***

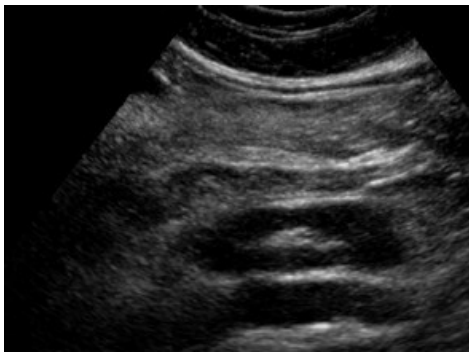
  Is most common and involves two complete renal pelvis with fusion of ureters so only one ureters into the bladder. The bladder insertion site is normal. Since non dilated ureters are seldom seen on u/s.

- ***Complete duplication: -***

Consists of two renal pelvis and two ureters will have and ectopic insertion to the bladder.

- ***Horse shoe kidney:***

  This is the most common renal fusion anomaly. The lower poles of the kidneys fuse, and this fused area is called the isthmus. The blood supply is abnormal and often is from regional vessels. Their abnormal position after impairs drainage resulting in higher incidence of infection, obstruction and stone formation. Sonographically Horse shoe kidney appears as normal renal cortex.



- ***Renal ectopia:***

  An ectopic kidney is a kidney located outside the renal bed. Most ectopic kidneys are located in the pelvis and are called pelvic kidneys. An abnormal kidney position causes the ureter to be bent to some degree. This also impairs the flow of urine and is associated with infection and calculus. Ectopic kidneys often exhibit uretero pelvic junction obstruction and calculi. Ectopic kidney doesn’t receive their blood

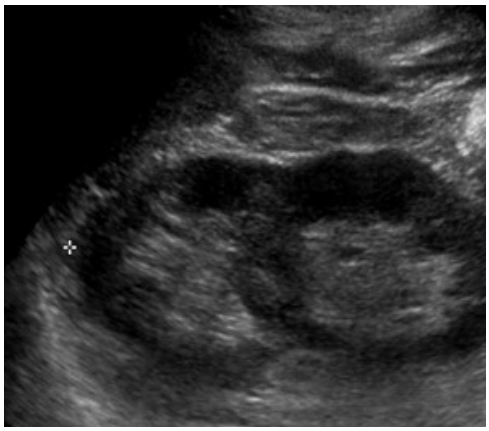
supply from usual source but from regional vessels which are common or internal iliac arteries.

- ***Congenital ectopic kidney:***

  Is due to failure of the kidney to ascend from its fetal pelvic location where as ptosis of the kidney is due to trauma which has torn the supporting attachments of the kidney and permitted the kidney to fall. Ptosis is associated with a redundant whereas ectopia is associated with ureter of normal length for its location in the body. A redundant ureter is a ureter that is too long for the position of the kidney relative to the urinary bladder.

- ***Crossed fused Ectopia:***

In this case both kidneys are found on the same side. In 85% to 90% of cases, the ectopic kidney will be fused to other kidney .Usually the lower pole of the ectopic kidney. The pelvic of ectopic kidney is directed interiorly. The ectopic ureter crossed mid line and inserted on the connect side of the bladder.



Sonographically: -

The fused kidneys have a normal transverse diameter but are unusually long. There is often notch defect at the fusion point. There are two separate renal sinuses and pelvis and the uretero pelvic junction are normally located. The opposite kidneys are absent.

## 2-3 Physiology of the Kidneys

### 2-3-1 Excretion of Wastes:

The primary function of the kidneys is the excretion of waste products resulting from protein metabolism and muscle contraction. The liver metabolizes dietary proteins to produce energy and produces toxic ammonia as a waste product.

The liver is able to convert most of this ammonia into uric acid and urea, which are less toxic to the body. Meanwhile, the muscles of our body use creatine as an energy source and, in the process, produce the waste product creatinine. Ammonia, uric acid, urea, and creatinine all accumulate in the body over time and need to be removed from circulation to maintain homeostasis.

The glomerulus in the kidneys filters all four of these waste products out of the bloodstream, allowing us to excrete them out of our bodies in urine. Around 50% of the urea found in the blood is reabsorbed by the tubule cells of the nephron and returned to the blood supply. Urea in the blood helps to concentrate other more toxic waste products in urine by maintaining the osmotic balance between urine and blood in the renal medulla.

**2-3-2Filtration, Reabsorption, and Secretion:**

The kidneys filter blood as it passes through the capillaries that form the glomerulus.

Blood pressure forces most of the blood plasma through the lining of the capillaries and into the glomerular capsule. Blood cells are too large to pass through the capillary lining and so remain

within the capillaries along with some residual plasma. The filtered plasma, now known as tubular fluid, begins to flow out of the glomerular capsule and into the proximal convoluted tubule.

At the same time, the concentrated blood that remains inside the capillaries of the glomerulus moves into the efferent arterioles and on to the peri tubular capillaries surrounding the proximal convoluted tubule. Epithelial cells lining the tubule actively reabsorb valuable molecules of glucose, amino acids, and ions from the filtrate and deposit them back into the blood. These cells also absorb any waste products remaining in the blood (such as ammonia and creatinine) and secrete these chemicals into the filtrate. While these solutes are being exchanged, osmotic pressure pushes water from the dilute, hypotonic filtrate back into the concentrated, hypertonic blood.

From the proximal convoluted tubule, the tubular fluid next enters the loop of Henle, where water and ions are reabsorbed. The descending limb of the loop of Henle is permeable to water and carries the filtrate deep into the medulla of the kidney. Tissues in the medulla surrounding the tubule contain a high concentration of ions and very little

water compared to the filtrate. Osmotic pressure between the hypotonic filtrate and hypertonic medullary cells pushes water out of the filtrate and into the cells. The cells of the medulla return this water to the blood flowing through nearby capillaries.

Filtrate next passes through the ascending limb of the loop of Henle as it exits the medulla. The tissues surrounding the ascending limb are not permeable to water but are permeable to ions. The filtrate is very concentrated after passing through the descending limb, so ions easily diffuse out of the filtrate and into the cells lining the ascending limb. These ions are returned to the blood flowing through nearby capillaries.

Tubular fluid exiting the loop of Henle next passes through the distal convoluted tubule and the collecting duct of the nephron. These tubules continue to reabsorb small amounts of water and ions that are still left in the filtrate. The tissues surrounding the collecting duct actively absorb excess potassium and hydrogen ions from the nearby capillaries and secrete these excess ions as waste into the filtrate.

When filtrate reaches the end of the collecting duct, almost all of the valuable nutrients, ions, and water have been returned to the blood supply while waste products and a small amount of water are left to form urine. The urine exits the collecting duct and joins with urine from other collecting ducts in the renal pelvis.

**2-3-3 Water Homeostasis:**

The kidneys are able to control the volume of water in the body by changing the reabsorption of water by the tubules of the nephron. Under normal conditions, the tubule cells of the nephron tubules reabsorb (via osmosis) nearly all of the water that is filtered into urine by the glomerulus.

Water reabsorption leads to very concentrated urine and the conservation of water in the body. The hormones antidiuretic hormone (ADH) and aldosterone both increase the reabsorption of water until almost 100% of the water filtered by the nephron is returned to the blood. ADH stimulates the formation of water channel proteins in the collecting ducts of the nephrons that permit water to pass from urine into the tubule cells and on to the blood. Aldosterone functions by increasing the reabsorption of Na+ and Cl- ions,

causing more water to move into the blood via osmosis.

In situations where there is too much water present in the blood, our heart secretes the hormone atrial natriuretic peptide (ANP) in order to increase the excretion of Na+ and Cl- ions. Increased concentration of Na+ and Cl- in urine draws water into the urine via osmosis, increasing the volume of urine produced.

**2-3-4 Acid/Base Homeostasis:**

The kidneys regulate the pH level of the blood by controlling the excretion of hydrogen ions (H+) and bicarbonate ions (HCO3-). Hydrogen ions accumulate when proteins are metabolized in the liver and when carbon dioxide in the blood reacts with water to form carbonic acid (H2CO3). Carbonic acid is a weak acid that partially dissociates in water to form hydrogen ions and bicarbonate ions. Both ions are filtered out of the blood in the glomerulus of the kidney, but the tubule cells lining the nephron selectively reabsorb bicarbonate ions while leaving hydrogen ions as a waste product in urine. The tubule cells may also actively secrete additional hydrogen ions into the urine when the blood becomes extremely acidic.

The reabsorbed bicarbonate ions enter the bloodstream where they can neutralize hydrogen ions by forming new molecules of carbonic acid. Carbonic acid passing through the capillaries of the lungs dissociates into carbon dioxide and water, allowing us to exhale the carbon dioxide.

**2-3-5 Electrolyte Homeostasis:**

The kidneys maintain the homeostasis of important electrolytes by controlling their excretion into urine.

Sodium (Na+): Sodium is a vital electrolyte for muscle function, neuron function, blood pressure regulation, and blood volume regulation. Over 99% of the sodium ions passing through the kidneys are reabsorbed into the blood from tubular filtrate. Most of the reabsorption of sodium takes place in the proximal convoluted tubule and ascending loop of Henle.

Potassium (K+): Just like sodium, potassium is a vital electrolyte for muscle function, neuron function, and blood volume regulation. Unlike sodium, however, only about 60 to 80% of the potassium ions passing through the kidneys are reabsorbed. Most of the reabsorption of potassium

occurs in the proximal convoluted tubule and ascending loop of Henle.

Chloride (Cl-): Chloride is the most important anion (negatively charged ion) in the body. Chloride is vital to the regulation of factors such as pH and cellular fluid balance and helps to establish the electrical potential of neurons and muscle cells. The proximal convoluted tubule and ascending loop of Henle reabsorb about 90% of the chloride ions filtered by the kidneys.

Calcium (Ca2+): Calcium is not only one of the most important minerals in the body that composes the bones and teeth, but is also a vital electrolyte. Functioning as an electrolyte, calcium is essential for the contraction of muscle tissue, the release of neurotransmitters by neurons, and the stimulation of cardiac muscle tissue in the heart. The proximal convoluted tubule and the ascending loop of Henle reabsorb most of the calcium in tubular filtrate into the blood. Parathyroid hormone increases the reabsorption of calcium in the kidneys when blood calcium levels become too low.

Magnesium (Mg2+): Magnesium ion is an essential electrolyte for the proper function of enzymes that work with phosphate compounds like ATP, DNA,

and RNA. The proximal convoluted tubule and loop of Henle reabsorb most of the magnesium that passes through the kidney.

**2-3-6 Blood Pressure Homeostasis:**

The kidneys help to control blood pressure in the body by regulating the excretion of sodium ions and water and by producing the enzyme renin. Because blood is mostly made of water, an increased volume of water in the body results in an increase in the volume of blood in the blood vessels. Increased blood volume means that the heart has to pump harder than usual to push blood into vessels that are crowded with excess blood. Thus, increased blood volume leads to increased blood pressure. On the other hand, when the body is dehydrated, the volume of blood and blood pressure decrease.

The kidneys are able to control blood pressure by either reabsorbing water to maintain blood pressure or by allowing more water than usual to be excreted into urine and thus reduce blood volume and pressure. Sodium ions in the body help to manage the body’s osmotic pressure by drawing water towards areas of high sodium concentration. To lower blood pressure, the kidneys can excrete

extra sodium ions that draw water out of the body with them. Conversely, the kidneys may reabsorb additional sodium ions to help retain water in the body.

Finally, the kidneys produce the enzyme renin to prevent the body’s blood pressure from becoming too low. The kidneys rely on a certain amount of blood pressure to force blood plasma through the capillaries in the glomerulus. If blood pressure becomes too low, cells of the kidneys release renin into the blood. Renin starts a complex process that results in the release of the hormone aldosterone by the adrenal glands. Aldosterone stimulates the cells of the kidney to increase their reabsorption of sodium and water to maintain blood volume and pressure.

**2-3-7 Hormones:**

The kidneys maintain a small but important endocrine function by producing the hormones calcitriol and erythropoietin.

Calcitriol is the active form of vitamin D in the body. Tubule cells of the proximal convoluted tubule produce calcitriol from inactive vitamin D molecules. At that point, calcitriol travels from the kidneys through the bloodstream to the intestines,

where it increases the absorption of calcium from food in the intestinal lumen.

Erythropoietin (EPO) is a hormone produced by cells of the peritubular capillaries in response to hypoxia (a low level of oxygen in the blood). EPO stimulates the cells of red bone marrow to increase their output of red blood cells. Oxygen levels in the blood increase as more red blood cells mature and enter the bloodstream. Once oxygen levels return to normal, the cells of the peritubular capillaries stop producing EPO.

Several hormones produced elsewhere in the body help to control the function of the kidneys.

Antidiuretic hormone (ADH), also known as vasopressin, is a hormone produced by neurosecretory cells in the brain's hypothalamus. These cells extend into the posterior pituitary, which stores and releases ADH. ADH production is stimulated by a decrease in blood volume and increased blood osmolarity. ADH helps the body retain water by increasing the number of water channels in the cells of the collecting ducts of the kidneys. These water channels allow water remaining in urine to be reabsorbed into the blood, resulting in extremely concentrated urine.

Angiotensin II is a hormone made in the liver and activated by the enzymes renin and angiotensin-converting enzyme. Once activated, angiotensin II increases the reabsorption of sodium and chloride ions in the proximal convoluted tubule, leading to an increased reabsorption of water as well.

Aldosterone is a hormone produced in the adrenal cortex in response to Angiotensin II. Aldosterone binds to target cells in the walls of the nephron's collecting ducts. These cells reabsorb additional sodium and chloride ions that would have been excreted as urine. The target cells also remove potassium ions from the blood and excrete it into urine.

Atrial natriuretic peptide (ANP) is a hormone produced by cardiac muscle cells in the atria of the heart. These cells produce ANP in response to high levels of sodium in the blood or increased blood pressure. In the kidneys, ANP increases the glomerular filtration rate so that more blood plasma is forced into the glomerular capsule and into the renal tubules. ANP also removes some solutes from the cells of the renal medulla, making the loop of Henle less efficient in reabsorbing water and ions from the filtrate. The net result of ANP is

that more sodium and water end up being excreted into urine, blood volume decreases, and blood pressure decreases as well.

## 2-4 Histology of the kidney

Renal histology studies the structure of the kidney as viewed under a microscope. Various distinct cell types occur in the kidney, including:

- Kidney glomerulus parietal cell
- Kidney glomerulus podocyte
- Kidney proximal tubule brush border cell
- Loop of Henle thin segment cell
- Thick ascending limb cell
- Kidney distal tubule cell
- Kidney collecting duct cell
- Interstitial kidney cell. (15)

## 2-5 Pathology of the kidney:

There are various kidney diseases, ranging from relatively common to rare disorders and from benign disorders to those with a high morbidity and mortality. Presentation may also vary - eg, renal mass, loin pain, failure to thrive, short stature, hypertension or renal dysfunction.

Congenital and developmental renal anomalies:

Congenital (existing at birth) and developmental kidney diseases are a group of diseases in which

the kidney may be abnormal in appearance, or may be abnormal in its ability to function normally, or both. These diseases result from inherited or genetic problems or disease processes that affect the development and growth of the kidney before or shortly after birth.

### 2-5-1 Renal agenesis

Renal agenesis refers to a congenital absence of one or both kidneys. If bilateral (traditionally known as the classic Potter syndrome) the condition is fatal, whereas if unilateral, patients can have a normal life -expectancy.

### 2-5-2Renal dysgenesis:

It is a very broad term which can include any form underdevelopment of the kidneys. The spectrum includes:

- **Renal agenesis**: complete lack of formation
- **Renal hypoplasia**: partial lack of formation

Some authors also classify any form of renal mal development affecting size, shape of function under this group

### 2-5-3Congenital megacalyectasis

It is an incidental finding which mimics hydronephrosis. It is a result of underdevelopment of the renal medullary pyramids with resultant enlargement of the calyces. It is more frequently seen in males.

The enlarged, floppy calyces predispose to stasis, infection and calculus formation.

### 2-5-4 Congenital cystic renal disease

It can be in included in three of the four types classified according the system by Osathanondh and Potter:

i. **Autosomal recessive polycystic kidney disease (ARPKD): Potter type I**

   It is one of the commonest inheritable infantile cystic renal diseases, but is far less common than autosomal dominant polycystic disease (ADPKD) which affects adults.

ii. **Multicystic dysplastic kidney (MCDK): Potter type II:**

   It is a type of non-heritable paediatric cystic renal disease. It results in multiple minute cysts being formed in utero in the affected kidney.

iii. **Autosomal dominant polycystic kidney disease (ADPKD): Potter type III:**

It is as the name would suggest a hereditary form of adult cystic renal disease.

iv. O**bstructive cystic renal dysplasia: Potter type IV:**

It is a potential complication that can occur from prolonged obstruction of the bladder outlet or urethra during gestation.

### 2.5.5 Obstructive renal disease (congenital PUJ obstruction):

Also known as ureteropelvic junction (UPJ) obstruction can be one of the causes of an obstructive uropathy. It can be congenital or acquired with a congenital PUJ obstruction being one of the commonest causes of antenatal hydronephrosis.

### 2-5-6 Pre tumorous conditions (nephroblastomatosis):

It refers to diffuse or multifocal involvement of the kidneys with nephrogenic rests (persistent

metanephric blastoma). Nephrogenic rests are foci of metanephric blastoma that persist beyond 36 weeks of gestation and have the potential for malignant transformation into Wilms tumour.

## 2-5-7 Renal morphological anomalies:

a. **Horseshoe kidney:**

   Are the most common type of renal fusion anomaly. They render the kidneys susceptible to trauma and are an independent risk factor for the development of renal calculi and transitional cell carcinoma of the renal pelvis.

b. **Cross fused renal ectopia:**

   Essentially refers to an anomaly where the kidneys are fused and located on the same side of the midline.

## 2-5-8 Congenital renal positional anomalies

a. **Pelvic kidney:**

   (Sometimes known as sacral kidney) is a kidney that is seen fixed in the bony pelvis or across the spine 1.

b. **Fused pelvic kidney:**

   Pancake kidney (also known as discoid kidney, disc kidney, lump kidney, fused pelvic kidney or cake kidney) is a rare renal

fusion anomaly of the kidneys of the crossed fused variety.

### 2-5-9 Tumors presenting in antenatal: childhood period:

a. **Mesoblastic nephroma:**

   (Also sometimes known as a congenital mesoblastic nephroma (CMN) or fetal renal hematoma) is in general a benign renal tumour. It typically occurs in utero or in infancy. It is the commonest neonatal renal tumour. Diagnosis is usually in the antenatal period or immediately after birth.

b. **Nephroblastoma:**

   Also known as Wilms tumour is a malignant paediatric renal tumour. Wilms tumours are the most common paediatric renal mass, accounting for over 85% of cases and accounts for 6% of all childhood cancers. It typically occurs in early childhood (1-11 years) with peak incidence between 3 and 4 years of age. Approximately 80% of these tumours are found before the age of 5 years.

c. **Multilocular cystic nephroma**

It is one of many paediatric cystic renal lesions. MLCN is a rare, non-familial tumour which has a bimodal age and sex distribution. In the paediatric population it has a 75% male predilection, whereas in later life females are more predominantly affected, typically in the 5th - 6th decades.

## 2-6 Previous study

Malave et al. (1980) studied hydronephrosis using radionuclide and sonography scanning for 56 patients (35 men and 21 female) evaluated for suspected hydnonephrosis their age ranged from 29 to 77 years old. Patients were generally studied to determine the cause of flank pain or deteriorating renal function as manifested by rising blood ureanitrogen and creatinine on decreasing creatinine clearance. Patients were grouped into two categories: In the first group 30 patients, results of renal radioisotope scan and renal sonographic examination were confirmed by an excretory urogram. A second group consisted of 26 patients; these patients did not have radiographic contrast examinations because of known allergy to iodinated contrast material or fear of further compromising poorly functioning kidneys with iodinated contrast material. The sonography and radionuclide scanning were compared with the clinical diagnosis by an experienced nephrologist. The result showed that;

sonography and radioisotope scanning techniques have been shown to be useful in the diagnosis of obstructive uropathy. The accuracy of both methods was compared and sonography was found to provide the more accurate result; sensitivity, 90%; specificity, 98%; accuracy, 97%. Sonography provides excellent anatomic information and enables one to grade the degree of dilatation. Renal radionuclide studies were less sensitive in detecting obstruction, particularly in the presence of chronic renal disease, but offered additional information regarding relative renal blood flow, total effective renal plasma flow, and interval change in renal parenchymal function.

Nitzsche et al. (1993) correlated between ultrasound and renal scintigraphy in children with unilateral hydronephrosis in primary workup to examine the relationship between ultrasound morphological findings and relative renal function, quantified with dynamic99mtechnetium mereaptotriacetylglycine imaging. The data of their study collected from 142 child with unilateral hydronephrosis (284 kidneys), newborn to adolescent (56 female, 86 males). Ultrasound performed with real time linear array, and, 3.5 MHz probe. All neonatal with known hydronephrosis (discovered during fetal development) underwent

renal ultrasound imaging 3 to 7 days after birth. Dynamic renal scintigraphy was performed as follows. New born infant and infants younger than 3 months were fed 1 hour prior to the study. Children, aged 3 months to 3 years received an oral sedative combined with 150-200 ml water 1 hour prior to the study. Older children were prepared by drinking 300ml water 1 hour prior to the study and were instructed to empty their bladder immediately prior to the renal scintigram. The result of their study showed that of the 284 kidneys, 142 kidneys were normal and 142 either anatomically or both anatomically and functionally abnormal. Hydronephrosis was most commonly related to proximal or distal ureteral junction narrowing (n = 102, 72%). Eighty-one kidneys (57%) were hydronephrotic secondary to uretopelvic junction narrowing. Twenty-four kidney-uretal units (17%) were reflexive and 16 kidneys (11%) appeared hydronephrotic secondary to various pathologies, including multicystic renal dysplasia, simple ureterocele, and ectopic insertion of a ureter. The most common cause of hydronephrosis in this series was unilateral ureteropelvic junction narrowing (81 kidneys, 57%).

The ultrasound grade of hydronephrosis and relative renal function ipsilateral to the hydronephrosis were inversely related, indicating that with more severe hydronephrosis ultrasound fails to estimate the potential reduction of relative kidney function. Because renal function is not necessarily affected by hydronephrosis, renal scintigraphy is indicated to assess the functional status of hydronephrotic kidneys. In conclusion ultrasound accurately detects hydronephrosis in infants and children, while nuclear medicine techniques quantify relative renal function in addition to characterizing the urodynamic relevance of hydronephrosis..

# Chapter three
# Method and Material

## 3-1 Design of the study

The data of this study collected from a cross-sectional study of a descriptive type prospectively

## 3-2 Population of the study

The patients included in this study were suffering from hydronephrosis whom undergo renal

ultrasound and renal scan their age varies from neonatal to children and adult hospitalized in Mafraq Hospital- Abu Dhabi - UAE (different nationalities) in the period from 2/2015 to 9/205

## 3-3 Sample size and type

The data of this study collected from a sample consisted of 50 patients from both gender selected conveniently.

## 3-4 Method of data collection (technique)

### *Ultrasonography of the kidney:*

Evaluation of the kidney with u/s is a noninvasive approach. It delineates retroperitoneal masses or fluid collection such as haematomas or abscesses, it also rules out the hydronephrosis and fluid filled structure like cysts. It determines the renal anatomy, size and parenchymal details. It detects also upper ureter and renal congenital abnormalities.

Patient will drink plenty of liquids (of your choice) for two hours before your exam, until your bladder is very full.

When the patient is over hydrated, the internal collecting system will become distended but if the patient is dehydrated renal pelvic will be collapsed. The examination begins with the patient in the supine position or decubitus position scans are performed in the sagittal and transverse planes from the anterior

approach using the liver and spleen as acoustic windows for the right and left kidneys respectively.

Scanning is also done in deep suspended aspiration. Start with longitudinal scan over the right upper abdomen and then follow with transverses scan. Next, rotate the patient to the left lateral decubitus position to visualize the right kidney in the coronal view. To visualize the left kidney, scan the left upper abdomen in a similar sequence, if the left kidney cannot be seen usually due to excess bowel gas; try the right lateral decubitus position. If the kidney cannot be imaged adequately, scan through the lower inter costal spaces. Turn the patient prone and apply enough gel to the left and right renal areas and perform longitudinal and transverses scan. Both kidneys can be also examined with the patient setting or standing erect, when examining any part of renal, compare both kidneys in different projection. Variations in size counter and internal echogenicity may indicate abnormality.

For adults use 3.5 MHZ transducer, children and thin adults use a 5.0 MHZ start by placing the transducer over the right upper abdomen, then angle the beam as necessary and adjust the time gain compensation ( TGC) with adequate sensitivity setting to allow uniform acoustic pattern, thus obtaining the best image of renal parenchyma. Gain is amplification of the reflective ultrasound waves by the unit. The near gain control amplifies echoes returning from tissue above the focal point of the beam. While the far gain control amplifies echoes returning from

beyond the focal point of the beam, e.g. echoes coming from deeper tissues need more amplification. These controls can be adjusted to allow the proper comparison of echogenicity at different level.

Renal detail may be obscured if there is significant amount at peri renal fat, hepatocellular diseases, gall bladder stones, rib interface or other abdominal masses, or collection of fluid between the liver and kidney. When scanning the kidney it is better to identify the renal capsule, the cortex, the medulla sinus, upper ureter, renal arties and vein.

### ***Renal scintigraphy of the kidney:***

It is performed in the nuclear department. A Nuclear Medicine Renal Scan can be performed with 2 different substances - DTPA or MAG3.

It is important, prior to having the scan, that the patient is well hydrated.

The height and weight is measured….give reason

For the Scan, the patient will be lying down on the scanning bed, with the gamma camera under the bed. It is important to keep still during the test as any movement of the body will blur the images and give poor scan results. The imaging itself does not hurt.

A small injection in a vein will be given, usually in the arm. A cannula (thin plastic tube) will be inserted into the vein and will stay in the vein for the duration of the test.

Through this cannula the radiopharmaceutical is injected. This can be detected by the gamma camera and will provide clear images of the kidneys. After about 15 minutes of scanning, you may be given a second injection through the same cannula of a diuretic called frusemide (Lasix). This causes the kidneys to make more urine by decreasing the amount of water that the kidneys resorb as part of the filtering process. There is also an increased flow of urine through the ureters which makes any obstruction of the ureters easier to see. The test itself will take approximately 30 to 60 minutes

## 3-5 Variables of the study

The data of the study will be collected using the following variables: age, BMI, kidney size (width and length), kidney pelvic size, cortical thickness, max uptake and uptake time

## 3-6 Method of data analysis

The data will be analyzed using Excel and SPSS software under windows, where the mean and standard deviation for the measured values will be calculated, as well as the relationship between the ultrasound results (kidney dimensions) and renal scintigraphy (max uptake and uptake time) using scatter plot with a trend line.

# Chapter four
## Results

The results of this study presented in table and graphs. The table shows the mean ± the standard deviation as well as minimum and maximum of the measured variables. The graphs shows the frequency distribution of gender and the site of the affected kidney as well as scatter plots, which relates the kidney size, pelvis and cortical thickness of the kidney to body characteristics and radiopharmaceutical update

Table 4-1 the mean, standard deviation, minimum and maximum values of the measured variables

| Variables | Mean ± SD | Min | Max |
|---|---|---|---|
| Age (years) | 5.5±13.3 | 0.01 | 71 |
| BMI ($kg/m^2$) | 16.7±3.5 | 10 | 32 |
| Kidney size ($cm^2$) | 27.5±17.4 | 9.1 | 76.7 |
| Cortical thickness (cm) | 0.5±0.2 | 0.2 | 1.2 |
| Kidney pelvic size (cm) | 6.7±5.5 | 0.3 | 23.3 |
| Maximum uptake (counts) | 620.7±378 | 200 | 1700 |
| Uptake time (min) | 13.8±9.4 | 3 | 30 |

(A)

(B)

Figure 4-1 a pie graph shows (A) gender distributions and (B) affected kidney site

Figure 4-2 scatter plot shows direct linear relationship between uptake time and max uptake.

Figure 4-3 scatter plot shows direct linear relationship between kidney size and max uptake.

Figure 4-4 scatter plot shows direct linear relationship between kidney pelvic size and max uptake.

Figure 4-5 scatter plot shows direct linear relationship between cortical thickness and max uptake.

Figure 4-6 scatter plot shows direct linear relationship between BMI and kidney size.

Figure 4-7 scatter plot shows direct linear relationship between BMI and kidney pelvic size.

Figure 4-8 scatter plot shows direct linear relationship between BMI and cortical thickness.

Figure 4-9 scatter plot shows direct linear relationship between BMI and max uptake.

Figure 4-10 scatter plot shows direct linear relationship between age and max uptake.

# Chapter five

## Discussion, Conclusion and Recommendation

The general objective of this study was to evaluate renal hydronephrosis in pediatric using ultrasound and renal scintigraphy in patients investigated by the two methods of investigations

## 5-1 Discussion

This study included 50 patients affected by hydronephrosis, investigated using ultrasound and nuclear medicine, their mean Age, BMI, kidney size, cortical thickness and Kidney pelvic size was 5.5±13.3, 16.7±3.5, 27.5±17.4, 0.5±0.2 and 6.7±5.5 respectively. Also The results of this study showed that 66% of the patients were male and the rest were females; which means that male are more susceptible to renal hydronephrosis than female, this result agree with Malave et al. (1980). The most affected site of the kidney was Lt kidney 68% (Figure 4-1).

The function of the kidney using nuclear medicine investigation showed that the average of maximum uptake was 620.7±378 with a mean time scanning 13.8±9.4 min. The normal concentration that detected by the maximum uptake occurs in 3 to 5 minutes; as long as the patients in this study suffering from hydronephrosis problem, which might be arise due to blockage in the urinary system, which alter the function of the kidney, usually this results in the low absorption

rate due to the difficulty in secretion function (Figure 4-2). If the kidneys were normal usually after 5 min the maximum counts will start to decrease as a result of secretion process. But in the case of hydronephrosis the maximum counts increase by 11 counts/min and start to rise till 30 min.

Normally as child grows up kidney dimension will increase but also in case of the presence of hydronephrosis these dimensions also increased. Therefore in this study as the kidney size, kidney pelvic size and cortical thickness increased the max uptake increased and hence the uptake time as follows: 10.3 count/$cm^2$, 17.7 count/$cm^2$ and 671 count/cm respectively (Figure 4-3 to 4-5).

Also the results of this study showed that the kidney dimensions (kidney size, kidney pelvic size and cortical thickness) increased linearly as the BMI increased, by 2.8cm/kg/$m^2$, 0.5cm/kg/$m^2$ and 0.01cm/kg/$m^2$ respectively with the presence of hydronephrosis condition (Figure 4-6 to 6-8). Also the body characteristics showed the same pattern

i.e. the max uptake increased as the result of BMI and age increases by 28 counts/kg/$m^2$ and 6.5 count/year respectively and this is considered as confounding factors but the increased of the max uptake as a result of dilatation in respect to the increases in uptake as the kidney dimensions collectively and consequently the increases in time uptake (Figure 5-9 and 5-10).

## 5-2 Conclusion

This study portrayed the relationship of the kidney dimensions (measured by ultrasound) in the presences of hydronephrosis condition and the kidney function represented by max uptake and uptake time (assessed by nuclear medicine). All the relations showed a direct linear relationship where the max uptake increases as a result of the increased time of uptake which is a characteristic of delayed absorption and secretion mostly those associated with hydronephrosis.

The function of the kidney can be estimated using the kidney dimensions as measured by ultrasound

and hence the max uptake and consequently the associated uptake time using the following linear equations:

$$Max\ uptake\ (Counts) = (10.263 \times kidney\ size) + 338.67$$

$$Uptake\ time\ (min) = (0.097 \times kidney\ size) + 11.155$$

## 5-3 Recommendation

- Ultrasound scan must be done first in all cases of hydronephrosis for evaluation followed by nuclear medicine in case of moderate condition for function evaluation.
- Similar study could be carried out incorporating the ultrasound grades for hydronephrosis in order to correlate the uptake time to the grade.
- Another study could be done using GFR instead of max uptake including Creatinen clearance.

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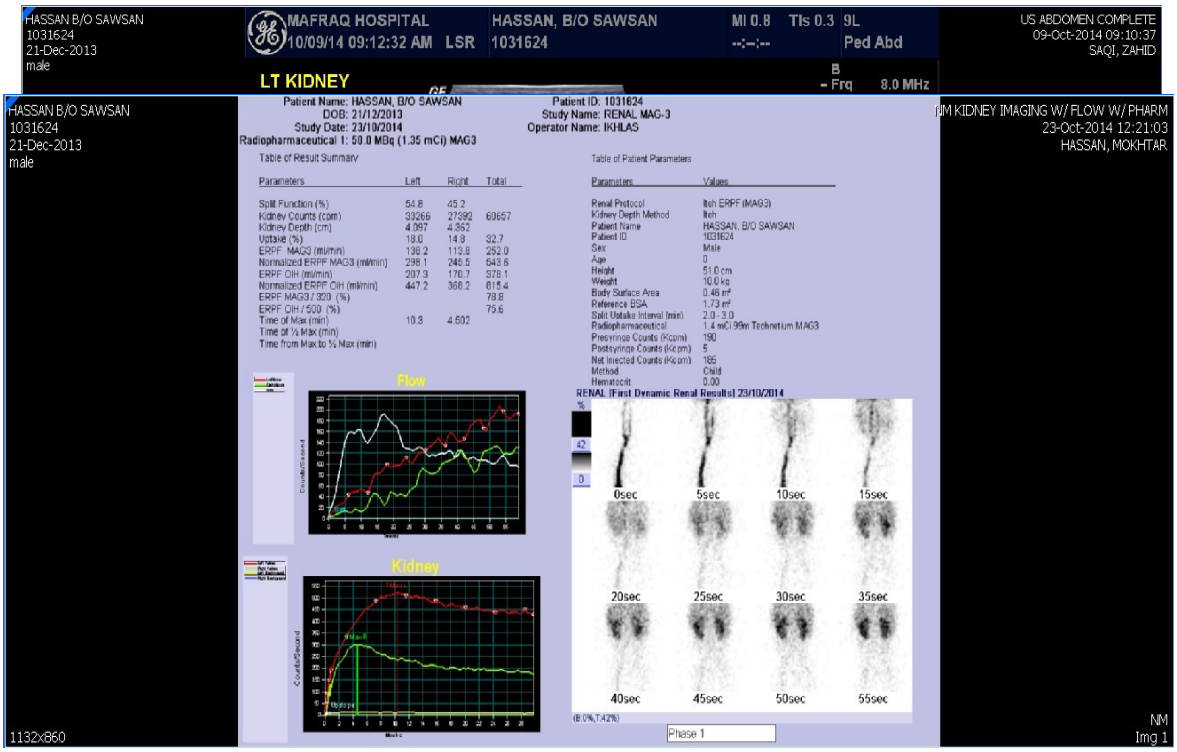
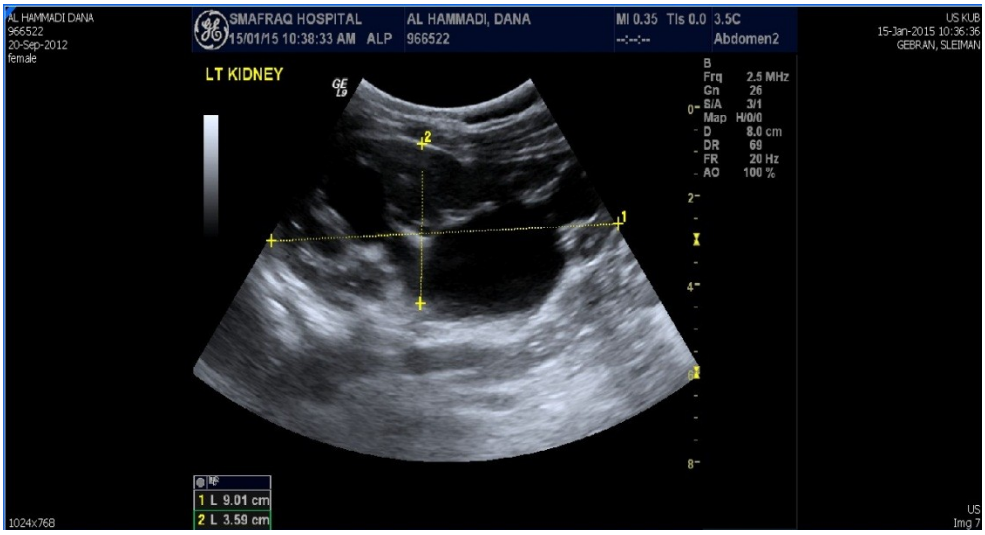
# Appendix

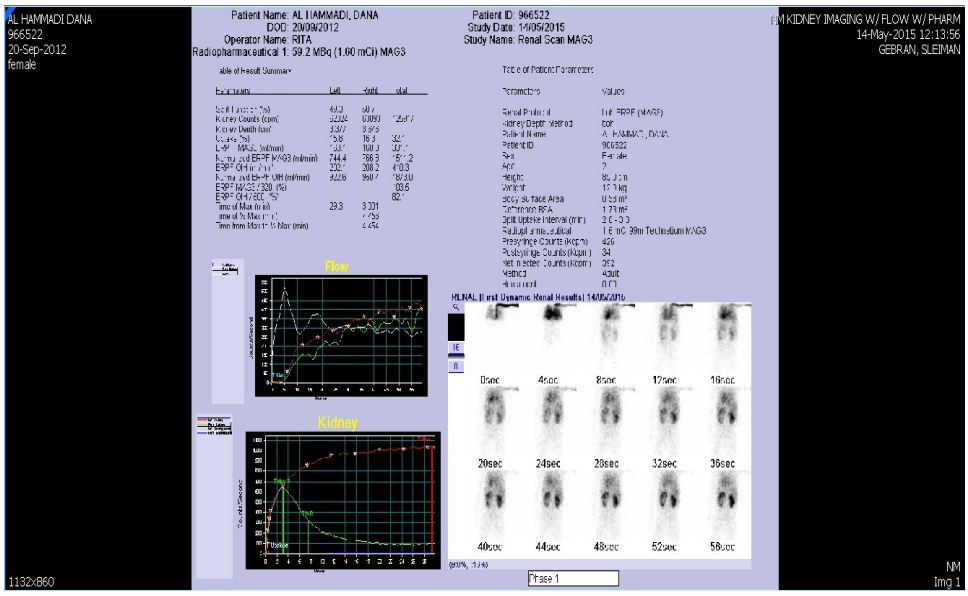
## Ultrasound and renal scintigraphy Images:

**Patient No. 1:** 10 month old male with moderate Hydronephrosis

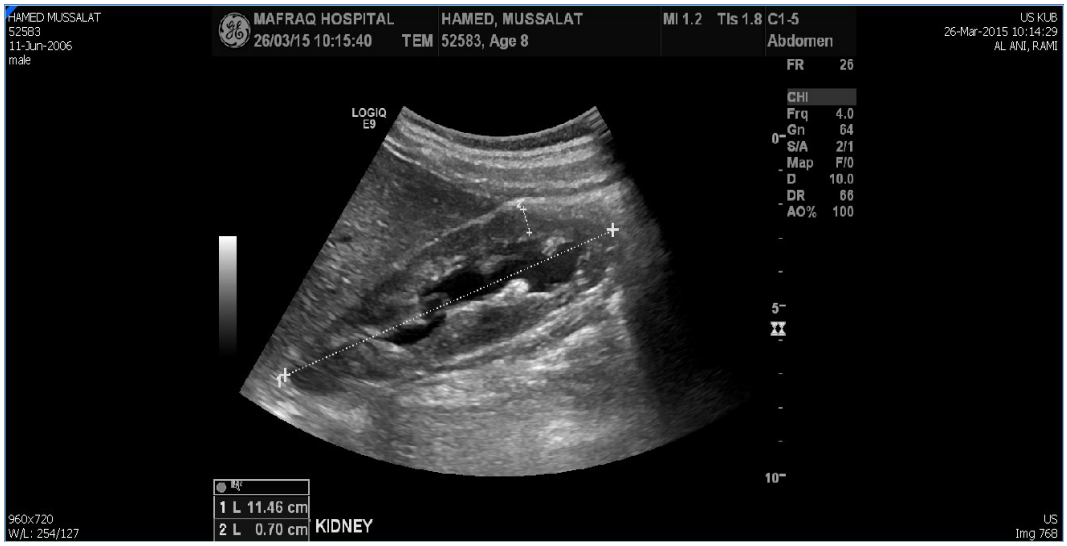


**Patient No. 2:** 2 years old female with sever Lt Hydronephrosis



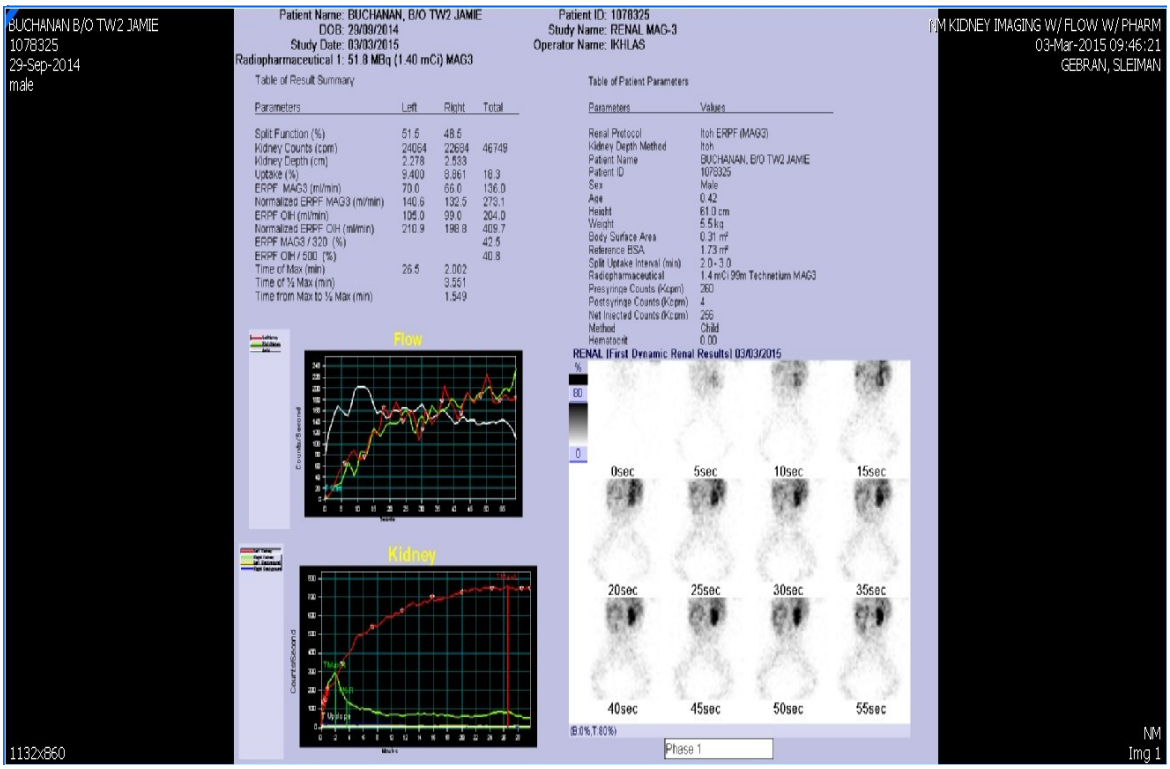




**Patient No.3**: 8 years old male with severe LT kidney Hydronephrosis

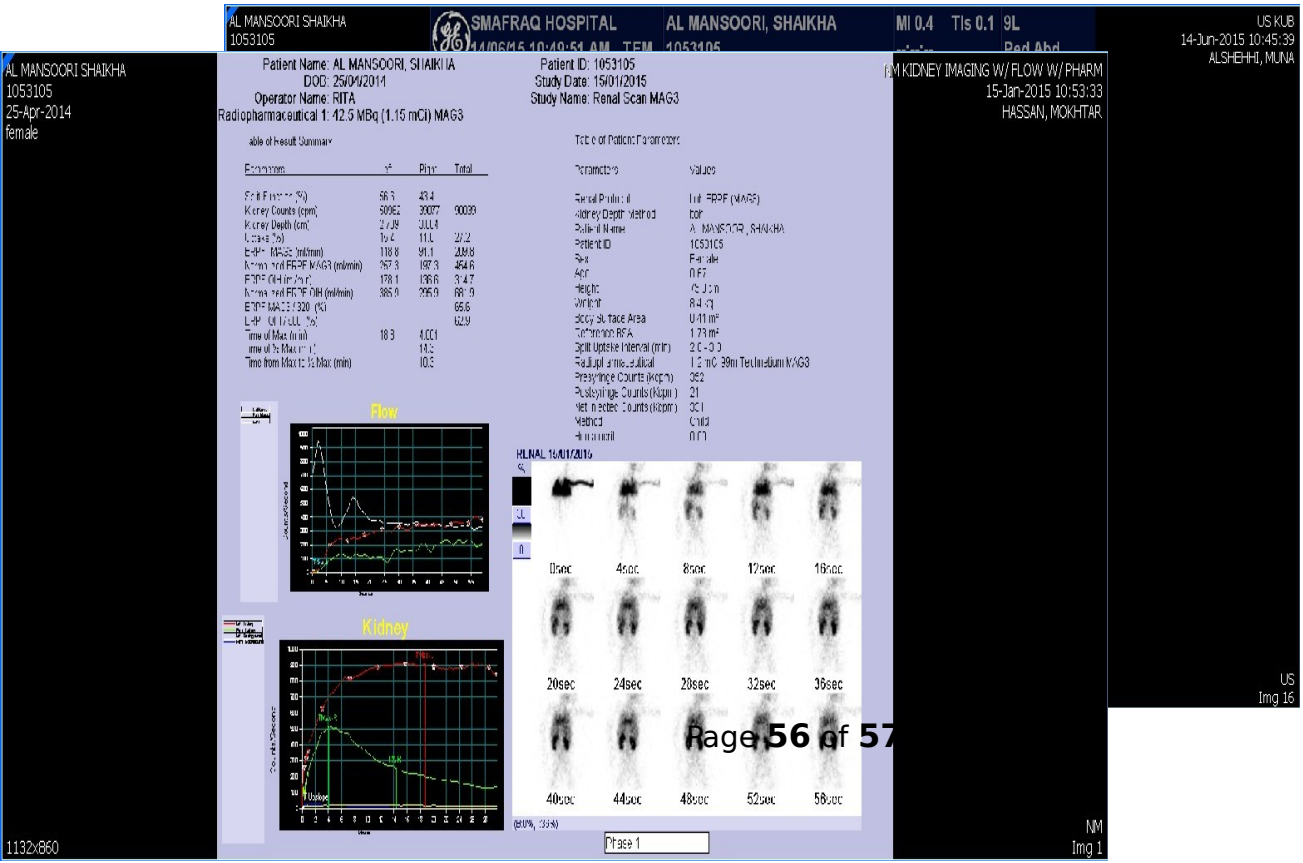

HAMED MUSSALAT
52583
11-Jun-2006
male
MAFRAQ HOSPITAL
26/03/15 10:15:40
HAMED, MUSSALAT
TEM 52583, Age 8
MI 1.2 TIs 1.8 C1-5
Abdomen
US KUB
26-Mar-2015 10:14:29
AL ANI, RAMI
LOGIQ
E9
FR 26
CHI
Frq 4.0
Gn 64
S/A 2/1
Map F/0
D 10.0
DR 66
AO% 100
1 L 11.46 cm
2 L 0.70 cm
KIDNEY
960x720
W/L: 254/127
US
Img 768


HAMED MUSSALAT
52583
11-Jun-2006
male
Patient Name: HAMED, MUSSALAT
DOB: 11/08/2006
Operator Name: IKHLAS
Radiopharmaceutical 1: 114.7 MBq (3.10 mCi) MAG3
Patient ID: 52583
Study Date: 26/03/2015
Study Name: Renal Scan MAG3
NM KIDNEY IMAGING W/ FLOW W/ PHARM
26-Mar-2015 12:24:22
AL ANI, RAMI
Table of Result Summary
Table of Patient Parameters
Flow
Kidney
RENAL [First Dynamic Renal Results] 26/03/2015
0sec
4sec
8sec
12sec
16sec
20sec
24sec
28sec
32sec
36sec
52sec
56sec
Phase 1
1132x860
NM
Img 1

**Patient No: 4:** 5 month old male with severe LT kidney Hydronephrosis




**Patient No 5:** 14 month old female with severe LT Hydronephrosis



**Patient No 6:** 2 month old male with moderate RT kidney Hydronephrosis