Chapter One

Introduction

1.1. Background

The organs of the urinary system are the kidneys, ureters, urinary bladder, and urethra. This system functions to remove waste products from the blood-stream. These waste products are excreted from the body in the form of urine. Nephrons are microscopic structures within the kidneys that filter blood, remove waste products, and form urine. The kidneys are responsible for removing metabolic waste products from the blood. (McGraw, et al., 2009).

These metabolic wastes are combined with water and ions to form urine, which is excreted from the body. The kidneys also secrete the hormone erythropoietin, which stimulates the red bone marrow to produce red blood cells, and hormone renin, which helps to regulate blood pressure. All three of these functions are important in maintaining the body's internal environment or homeostasis, which is a balanced, stable state within the body. (McGraw, et al., 2009).

The retroperitoneal kidneys are nestled within the paravertebral gutters in the upper quadrant. Each kidney lies anterior to the costvertebral angle near the midline of the back; its superior pole extends above the posterior body segment of the twelfth rib. The right kidney lies slightly lower than its left counterpart (Williamset al., 1990).

The two kidneys are situated behind the peritoneum upper on the posterior abdominal wall on each side of the vertebral column: they are largely under cover of the costal margin. (Snell, 2007).

Each kidney has a dark brown outer cortex and a light brown inner medulla. The medulla is composed of about a dozen renal pyramids, each having its base oriented toward the cortex and its apex, the renal papilla, projecting medially. (Snell, 2007)

The cortex extends into the medulla between adjacent pyramids as the renal columns. Extending from the bases of renal pyramids into the cortex are striations known as medullary rays. Renal ultrasonography and excretory urography (or IV pyelography) traditionally have been the primary means of investigating the kidney, but CT has rapidly gained ground and conventional IV pyelography is now rarely performed.(Snell, 2005)

The kidneys are located in the lumber fossa and are usually well demonstrated in CT studies. The medulla and cortex are not well differentiated in plain CT scan, through the fat in the medullary sinus is well delineated. Density values in normal renal tissue average 35HU.Following bolus injection of a contrast agent these is significant contrast enhancement and clear demarcation of the peripheral renal cortex during the Arterial phase (10-20), with maximum density values as high as 140HU.

(Springer et al., 1985).

After a slow decrease in enhancement in the cortex, density values increase in the medulla, and there is homogenous enhancement in the tubular phase (60 -120s) followed by demonstration of contrast material in the renal pelvis. Demonstration of the renal vessel is usually incomplete in a single slice. (Springer et al., 1985).

The IVC is seen on the right of the aorta. It is a transverse oval in cross-section but its shape varies from slit-like on inspiration to circular on expiration. The right adrenal gland is seen to be partly posterior to the IVC. Some liver tissue may also be found posterior to it in its upper course. The aortic branches that pass behind the IVC are usually visible.(Elsevier, et al., 2004).

The kidneys are covered by a tight fibrous capsule which produces a sharp margin defined by perirenal fat on CT. subscapular collections of fluid or blood will compress and distort the renal parenchyma without affecting the perirenal fat. The perirenal fat extends into the renal sinus, outlining blood vessels and the renal collecting system. (Saunders et al., 1991).

Recent technological advances have produced a bewildering array of complex imaging techniques and procedures. The basic principle of imaging, however, remains the anatomical demonstration of a particular region and related abnormalities, the principle of imaging modalities being:

Diabetes is a group of diseases characterized by elevated blood glucose concentration. It may be a consequence of either the body does not produce enough insulin or because cells do not respond to the insulin that is produced, it can be classified into three major classes: Type1, Type 2 and Gestational diabetes mellitus) (Jameson, 2006).

Type1diabetes known as insulin-dependent diabetes(Astorri, 1997), childhood diabetes or also known as juvenile diabetes, is characterized by loss of the insulin producing beta cells of the islets of Langerhans of the pancreas leading to a severe deficiency of insulin.(Gardner and Greenspan, 2007)

(Type 2 diabetes mellitus known as adult-onset diabetes or non-insulin dependent diabetes mellitus (NIDDM) is characterized by insulin resistance which may be combined with relatively reduced insulin secretion .The defective responsiveness of body tissues to insulin is believed to involve the insulin receptor (Benedict C., 2004).

Gestational diabetes mellitus resembles type 2 diabetes in several aspects, involving a combination of inadequate insulin secretion and responsiveness. It occurs in about 2% to 5% of all pregnancies and may improve or disappear after delivery (Lawrence, 2008).

The radiographic term tomography is derived from the Greek words tomos,meaning “slice,” and graphein,meaning “to write.” CT uses a complex computer and mechanical imaging system to provide sectional anatomic images in the axial, sagittal, and coronal planes. CT is used to produce cross-sectional images of body parts when slight differences in soft tissue densities must be demonstrated. (Mosby, et al., 2014).

A CT unit uses an x-ray tube and a detector array to gather anatomic data from a patient. These data are reconstructed into an image. X-ray tube movement in early CT scanners was restricted by high-tension cables. The x ray tube first would rotate 360° in one directionto obtain one slice, the CT table would advance a set distance,and the x-ray tube would rotate 360° in the opposite direction andwould obtain the next slice. (Mosby, et al., 2014).

The development of slip-ring technologyin the early 1990s allowed CT technology to move beyondsingle-slice acquisition.Slip rings replaced the high-tension cables and allowed forcontinuous rotation of the x-ray tube,

Which when combinedwith patient movement through the gantry acquired data in a helicalor spiral fashion. The general term used to describethis acquisition of a volume of data is volume scanning. The termshelical and spiral scanning sometimes are used to refer to thisscanning technique, but these are vendor-specific terms. VolumeCT scanners are also capable of single-slice acquisition. (Mosby, et al., 2014).

Advantages Volume scanning offers several advantages over Single-slice scanning, as follows: Multiplanar reconstruction (MPR): Volumetric data allow more Accurate reconstruction of patient data into alternative planes (Coronal, sagittal, oblique, and three-dimensional [3D])—hencethe term multiplanar reconstruction. Shorter scan times: Scan times are short because the patient Moves continuously through the gantry.Artifacts reduced: Artifacts caused by patient motion arereduce. (Mosby, et al., 2014).

MultisliceCT scanners developed before 1992 were single-slice scanners that were capable of imaging only one slice at a time. By late 1998, CT manufacturers announced that new multislice technology scanners were available that were capable of imaging four slices simultaneously per x-ray tube rotation. (Mosby, et al., 2014).

Multislice CT has continued to progress rapidly, largely because of advances in computer technology. At the present time, multislice scanners are available that can image 320 slices per x-ray tube rotation.

Advantages Multislice CT offers several advantages over single slice or volume CT, as follows:

Shorter acquisition time: A 64-slice system can acquire 160 images per second versus a 1 slice per second scanner. This faster imaging is

advantageous for procedures that require asingle breath hold or in cases in which patient motion is a problem. It also makes possible procedures that require shorter exposure times (e.g., cardiac CT).

Decreased amount of contrast medium: A decreased amount of intravenous contrast medium can be used because of the increased acquisition speed of multislice scanners. Improved spatial resolution: Submillimeter slice thickness is possible as a result of multislice technology. This is especially advantageous for examinations of the inner ear and other complex structures. Also, a decreased amount of contrast medium is required because of the increased speed of image acquisition.Improved image quality: Image quality for CT angiography and3D MPR is improved as a result of the acquisition of thinner slices. (Mosby, et al., 2014).

In routine abdominal scanning patients are given oral contrast to opacify the bowel and allow differentiation from adjacent pathological lesions. In most instances patients are given 800 ml of positive oral contrast, either a dilute barium suspension contrast which may be flavoured with fruit squash. The contrast is given 30–40 minutes before the scan to opacify the small bowel and a further 200 ml of the same contrast is given immediately before the scan to opacify the stomach and proximal small bowel.(Green, et al., 1999).

The use of contrast is at the discretionof the radiologist. Intravenous contrast may be used toopacify the vessels and aid their differentiation fromretroperitoneal nodes. It is also frequently used to characterize liver lesions, renal masses and pancreaticdisease and in the assessment of the aorta.

The amount and timing of the contrast injection is vital. Many centres use non-ionic contrast at a concentration of 300 mg/ml. In vascular imaging the

length of the bolus should equal the scan duration to maximise contrast levels, using an injection rate of between 3 and 6 ml/sec. The volume to be injected is calculated by multiplying the injection rate by the scan duration. The timing of the delay between the onset of the injection and commencing
The scan is very important, to ensure optimal contrast in the vessel of interest. For non-vascular imaging the volume and timing of contrast administration varies depending on the organ of interest. (Green, et al., 1999).
In this study, 300 kidneys (right and left) of 150 patients were examined. The study population was selected from the age groups (younger, adults, and old) starting from 10 up to 70 years old

1-2The problem of the study

The kidneys sizes vary in patients according to the body characteristics as well as the pathology, similarly the structure of the kidneys. Diabetes affects the morphology, internal structures and function of the kidney. Therefore evaluation of these effects in respect to normal variation will give a clear picture of diabetes effects on kidneys and hence facilitate accurate medical management.

1-3Objectives

1-3-1 general Objectives

The general objective of this study is to characterize the effects of diabetes in the patient kidneys in order to differentiate these changes from normal one and hence and therefore help in providing better health care

1-3-2Specific objectives

- To measure the length and width of the kidneys
- To measure the cortex, medulla and renal pelvis.
- To correlate between patient age, gender, body mass index, duration and types of diabetes and the kidneys measurement
- To find the CT number of the cortex, medulla.
- To correlate between the CT number and duration of diabetes and patient age.
- To classify the kidneys of the diabetic patient using CT number in respect to effects represented by diabetes duration.

1.4 Significant of the Study

This study will have a significant importance in the diabetic's patients because, complication rate of developing end-stage renal disease is 10 to 15 times greater in patients with diabetes compared to patients without diabetes, so the functions of the kidneys are important in maintaining the body's internal environment or homeostasis, which is a balanced, and stable state within the body.

1-5over view of study

This study will fall into five chapters with chapter one is an introduction, problem of the study, objectives and overview. Chapter two include literature review while chapter three include material used and the method of data collection and analysis. Chapter four presents the result of the study in a

line graphs and table and finally chapter five which include the discussion, conclusion and recommendations

Chapter Two

Background and Literature Review

2.1 Anatomy of urinary system

The urinary system is one of the excretory systems of the body. It consists of the fowling structures: 2 kidneys, which secrete urine, 2 ureters, which convey the urine from the kidneys tothe urinary bladder, 1 urinary bladder where urine collects and temporarily stored, 1 urethra through which the urine is discharged from the urinary bladder to the exterior.(Elsevier, et al., 2004).

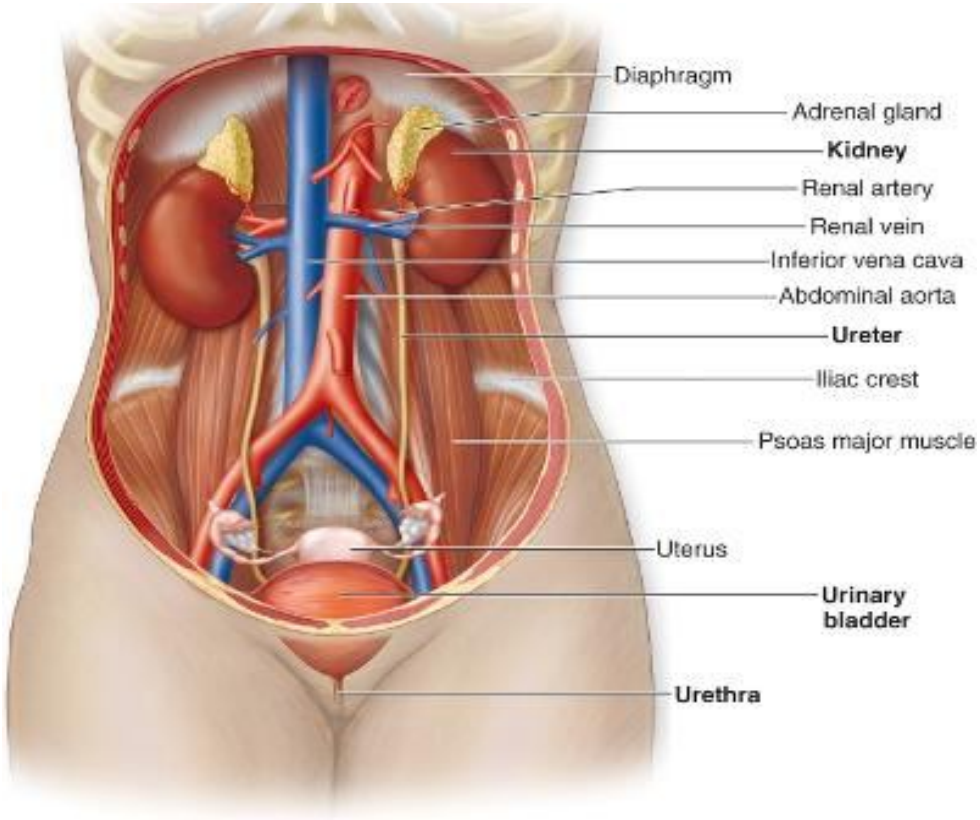


Figure. (2-1) Gross Anatomy of the Kidney

As the kidneys lie on either side of the vertebral column each is associated with a different group of structuresright kidneysuperiorly-the right adrenal glandanteriorly -the right lobe of the liver, the duodenum and the hepatic flexure of the colonposteriorly-the diaphragm, and muscles of the posterior abdominal wall. Left kidney superiorly - the left adrenal gland anteriorly - the spleen, stomach, pancreas, jejunum and splenic flexure of the colon posteriorly -the diaphragm and muscles of the posterior abdominal wall.(Elsevier, et al., 2004).

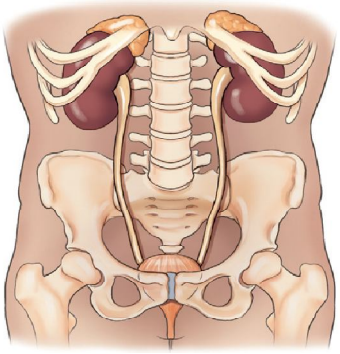
2.1.2 Urinary System

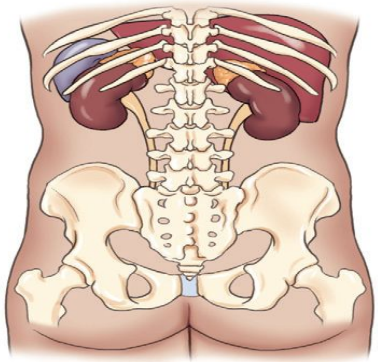
The two kidneys and the ureters are organs that lie in the retroperitoneal Space. These two bean-shaped organs lie on either side of the vertebral column in the most posterior part of the abdominal cavity. The right kidney is generally slightly lower or more inferior to the left because of the presence of the liver. Superior and medial to each kidney is a suprarenal (Adrenal) gland. (Mosby, et al., 2014).

These important glands of the endocrine system are located in the fatty capsule that surrounds each kidney. Each kidney is connected to the single urinary bladder by its own ureter. Waste material, in the form of urine, travels from the kidneys to the bladder via these two narrow tubes, termed ureters. (Mosby, et al., 2014).

The saclike urinary bladder serves as a reservoir that stores urineuntil it can be eliminated from the body via the urethra.The Latin designation for kidney is Ren,and renal is an adjectivethat is commonly used to refer to the kidney. (Mosby,et al., 2014).

Urinary system, anterior view. Urinary system, posterior view





(Mosby, et al., 2014).

Fig. (2.2)Fig. (2.3)

The posteriorly placed kidneys lie in the upper posterior abdomen on either side of the vertebral column. The right kidney is positioned posterior to the lower portion of the liver. The left kidney is positioned posterior to the inferior border of the spleen. The lower rib cage thus forms a protective enclosure for the kidneys. (Mosby, et al., 2014).

The average adult kidney is fairly small, weighing about 150g. Themeasurements are 10 to 12 cm (4 to 5 inches) long, 5 to 7.5 cm(2 to 3 inches) wide, and 2.5 cm (1 inch) thick. The left kidney isa little longer but narrower than the right. Despite its small size, atleast one functional kidney is absolutely essential for normal health.Failure of both kidneys, unless corrected, means inevitable death. (Mosby, et al., 2014).

The kidneys lie retroperitoneal in the paravertebral gutters of the posterior abdominal wall. The kidneys measure 10 -15cm in length, the left being commonly 1.5cm longer than the Right. Their size is approximately that of

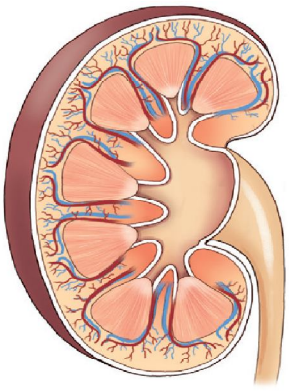
three-and-a-half lumbar vertebrae and their associated discson a radiograph.Each kidney has an outer cortex and an innermedulla. (Elsevier et al., 2004).

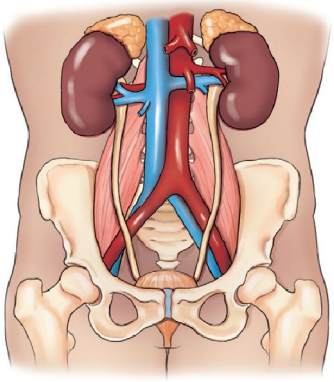
Extension of the cortex centrally as columns separate the medulla into pyramidswhose apices,jutting into the calyces, are called the papillae. Here are usually seven pairs of minor calyces, each pair having an anterior and a posterior calyx, although there is wide variation. Minor calyx pairs combine to form two or three major calyces, which in turn drain via their infundibula pelvis.(Elsevier et al., 2004).

Renal structureKidney orientation, frontal view.

Fig.(2.4)

Fig.(2.5)





(Mosby, et.,2014)

This management is quite variable, but when there are two infundibula these usually drain four usually from the upper pole and three from the lower.When there are three infundibula there are usually three upper pole calyces, and two set of two calyces draining the midpolar region and lower pole. The pelvis may be internal or partially or entirely external. The gap between the renal substance and the pelvis is called the renal sinus and is

filled with fat. A simple calyx has one papilla indenting it; a Compound calyx has more than one. (Elsevier et al., 2004).

Compound calyx are said to be less efficient preventing intrarenal reflux of urine from the calyx and are more common in the upper pole. The hilum of the kidney lies medially, that of the left at L1 vertebral level and that of the right slightly lower at L1-L2 level, owing to the bulk of the liver above.At the hilum, the pelvis lies posteriorly and the renal vein anteriorly with the artery in between. The artery may branch early and a posterior arterial branch may enter the hilum posterior to the pelvis. Lymph vessels and nerves also enter at the hilum. (Elsevier et al., 2004).

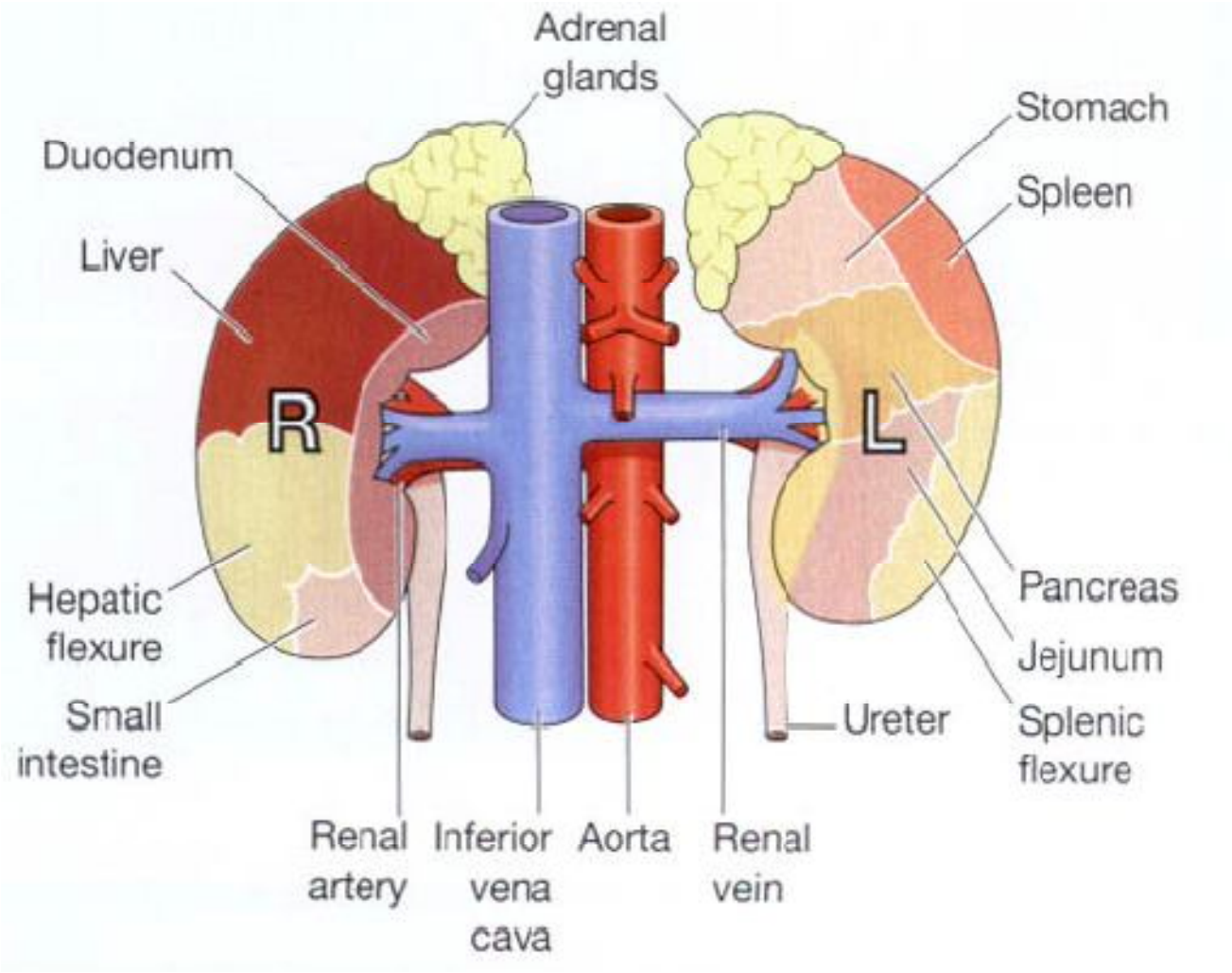


Fig 2.6 anterior views of the kidneys showing the areas ofcontact with associated structures. (Elsevier, et al., 2004).

Because the kidneys are only loosely attached within their fatty capsule, they tend to move up and down with movements of the diaphragm and position changes. When one inhales deeply, the kidneys normally drop about 2.5 cm (1 inch). When one stands upright, the kidneys normally drop about one lumbar vertebra, or 5 cm (2 inches). If the kidneys drop farther than this, a condition termed nephroptosis (nef″-rop-to′-sis) is said to exist. With some very thin and older patients in particular, the kidneys may drop dramatically and end up within the pelvis, which may create problems caused by "kinking" or twisting of the ureters.

2.2 Physiology

2.2.1Urinary Function

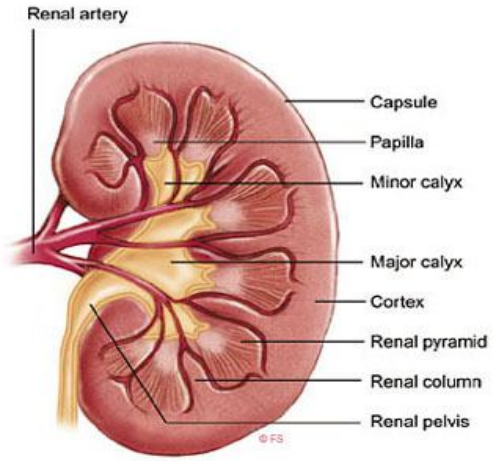


Fig.2.7

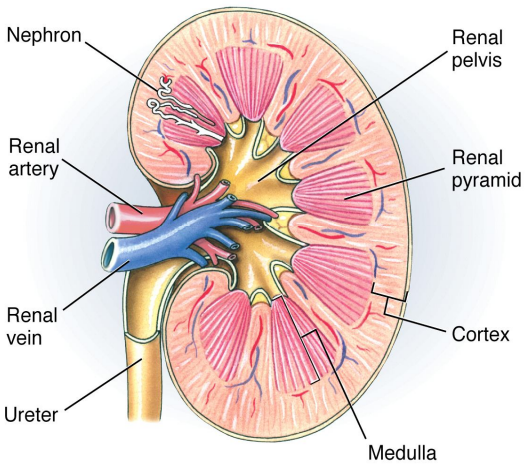


Fig.2.8

Anatomy/Function of the Kidney

The urinary system functions in the removal of waste products from blood. The kidney also functions in fluids balance, salt balance, and acid-base balance. The kidney functions as an endocrine gland; it produces and release rennin, which leads to an increase in extracellular fluid volume, erythropoietin, which stimulates erythropoiesis, and prostaglandins, which act as vasodepressors.(Kaplan et al., 2014).

A sagittal section through the center of a kidney shows a capsule (connective tissue) surrounding and protecting the organ, a wide band of cortex showing radial striations and the presence of glomeruli, and a medulla in the shape of an inverted pyramid. The medulla in turn shows an outer and inner zone. The blurred tip of the pyramid, called the papilla, borders a space that is surrounded by calices of the ureter. (Kaplan et al., 2014).

The collecting ducts are invaginations of the papilla's epithelium and the urine drains from their open ends into the calices. (Kaplan et al., 2014).

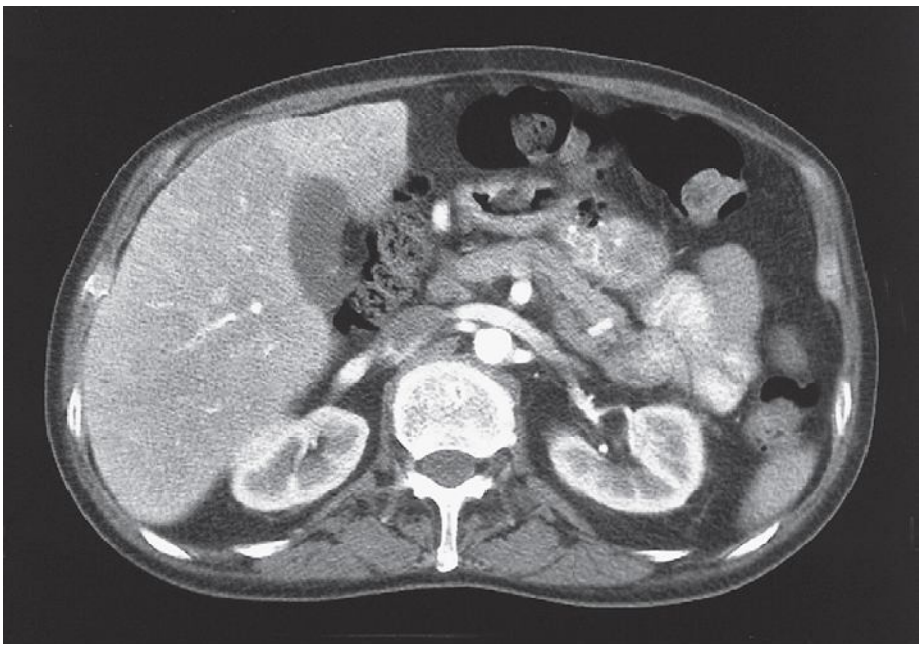


Fig.(2.9)Normal CT renal anatomy

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

All other structures, including the first section of the collecting ducts, are in the cortex. In the cortex, the proximal and distal tubules, as well as the initial segment of the collecting duct, are surrounded by a capillary network, and the interstitiumis close to an isotonic environment (300mOsm).(Kaplan et al., 2014).

The modularly region instead has capillary loops organized similar to the loops of Henle. The slow flow through these capillary loops preserves the osmolar gradient of the interstitium. (Kaplan et al., 2014).

However, this slow CV flow also keeps the PO2 of the medulla lower than that in the cortex. Even through the metabolic rate of the medulla is lower than in the cortex, it is more susceptible to ischemic damage. (Kaplan et al., 2014).

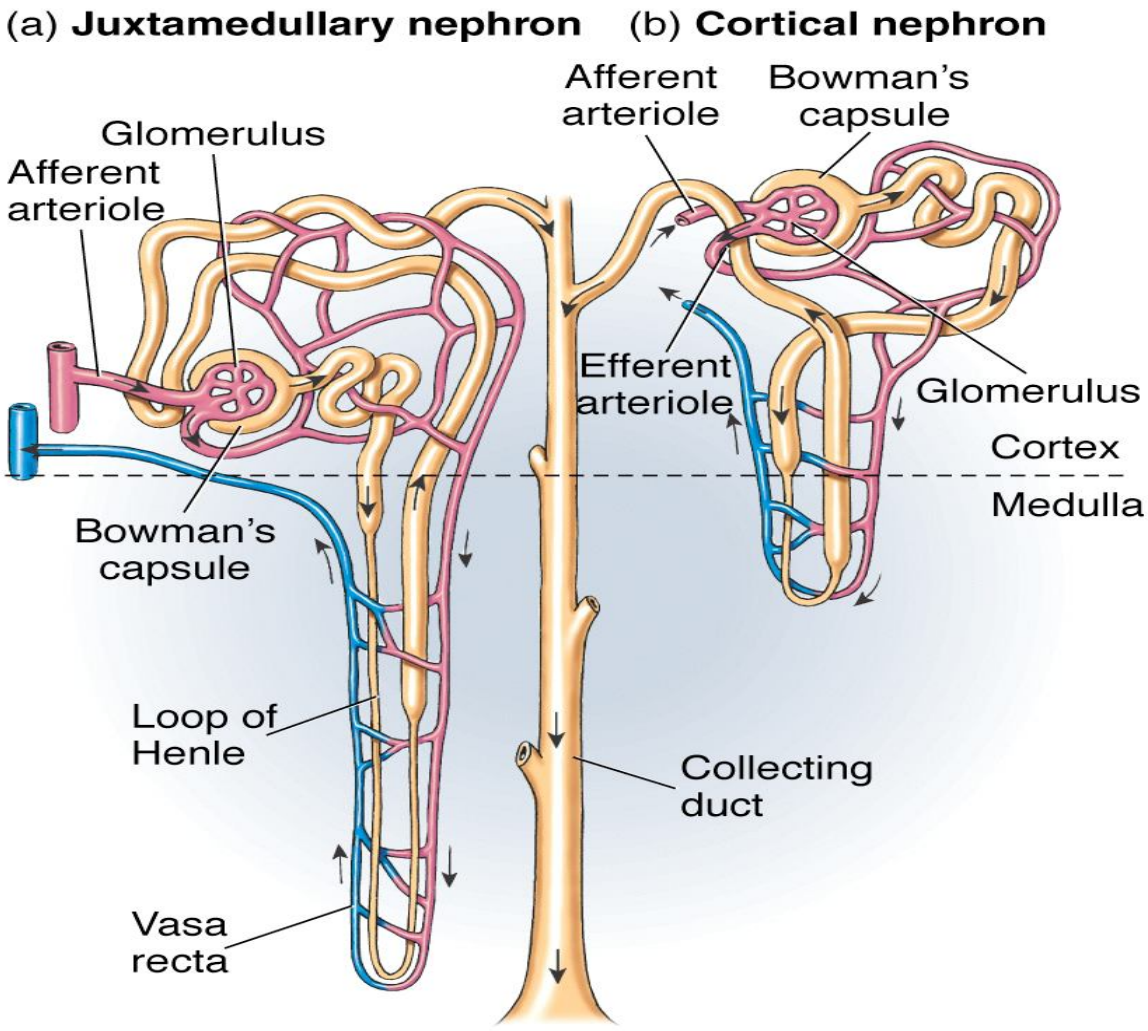


Figure 2.10 Renal Circulation

2.2.2Blood Supply:

The kidneys are supplied with arterial blood by renal arteries, which are direct branches of the abdominal aorta. Normally there is one renal artery to each kidney, but sometimes there are two on one or both sides. The blood from the kidneys is drained by the left and right renal veins into the inferior vena cava. If the kidney is divided into an anterior and posterior half is it seen to consist of an outer layer, the cortex, and the inner layer, the medulla.(Blackwell et al., 1987).

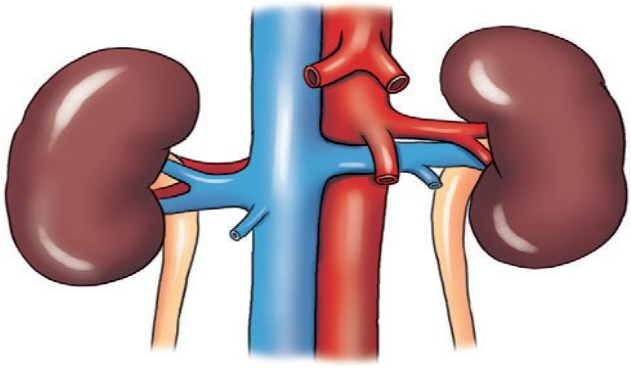


Fig. 2.11 renal blood vessels

The medulla consist of conical masses, the apices of which point towards the hilum and project into the minor calyx as a renal papilla. The cortex of thekidney contains approximately 1000 000 units' called nephrons, which are the functional units of the kidney. Each nephron commences as a blind expanded end, called Bowmen's capsule, and this is indented by a cluster of capillaries, the glomerulus. Bowmen's capsule and the glamerulus together form a unit called aMalpighian corpuscle. Immediately by the Malpighian corpuscle the nephron consists of a coiled tube, called the proximal convoluted tubule. The next part of the nephron is like a U-tube. (Blackwell et al., 1987).

The first limb runs towards the hilum of the kidney into the medulla for a variable distance then turns and the second limb runs parallel to it back into the cortex. This loop is called the loop of Henle.Thenephron then again lies in a coil, called the distal convoluted tubule, and finally straightens out to join a collecting duct near the medulla several collecting ducts unite to form larger ducts which finally empty into a minor calyx on the surface of renal papilla. (Blackwell et al., 1987).

The blood is brought to the glomerulus by a branch of the renal artery. After passing through the glomerular capillaries the blood enters a venous capillary network surrounding the tubules, and is finally drained into a tributary of the renal vein.(Blackwell et al., 1987).

2.2.3The nephron

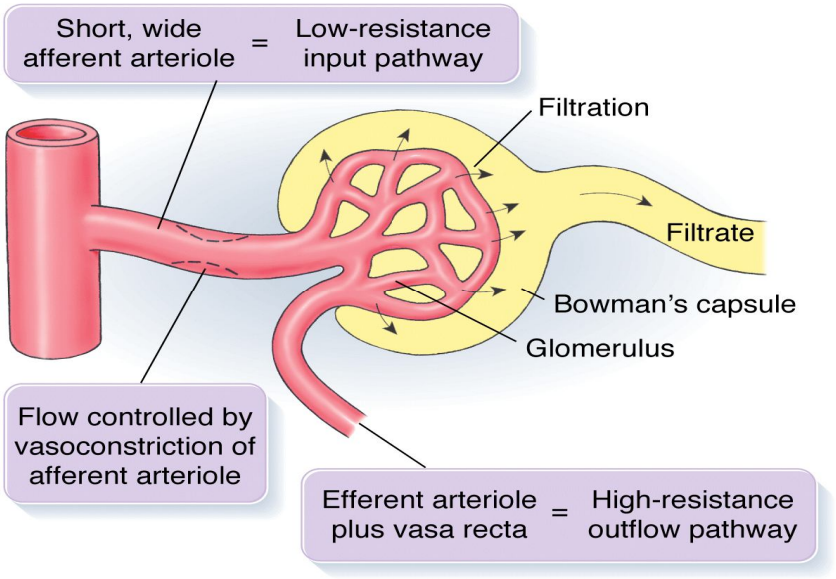


Figure 2.12 Nephron Structure

2.2.4Glomerular filtration

Several distal convoluted tubules lead to a collecting duct. Many of these then joint and empty into the renal calyx. The Glomerular capillaries filter the blood .the large volume of fluid thus produced in Bowman's capsule is called glomerular filtrate.it contains no solid elements and very few plasma proteins. The blood constituents of less than 68,000mw can pass into tubule, but anything larger is retained in the blood. (Olof et al., 1991).

The nephron consists of a tubule closed at one end, the other end opening into a collecting tubule. The closed or blind end is indented to form the cup-shaped glomerular capsule (Bowman's capsule) which almost completely encloses a network of arterial capillaries, the glomerulus. (Elsevier, et al., 2004).

Continuing from the glomerular capsule the remainder of the nephron is about 3 cm long and is described in three parts: the proximal convoluted tubule, the medullary loop (loop of Henle), the distal convoluted tubule, leading into a collecting duct. (Elsevier, et al., 2004).

Nephrons with glomeruli in the outer cortex have short loops of Henle. (Cortical nephrons). Those with glomeruli in the inner cortex have long loops of Henle, which penetrate the medullary region (juxtamedullary nephrons). 7/8 of all nephrons are cortical. Nephrons. 1/8 of all nephrons are juxtamedullary nephrons.Nephron structures in the medulla consist of the long loops of Henle and the terminal regions of the collecting ducts.(Kaplan et al., 2014).

The individual nephrons that make up both kidneys are connected in parallel. However, the flow through a single nephron represents 2 arterioles and 2 capillary beds connected in series.The following represents some of the basic consequences of a serieshemodynamic system. Flow must be equal at all points in any series system. If flow changes, it changes equally at all points in the system. (Kaplan et al., 2014).

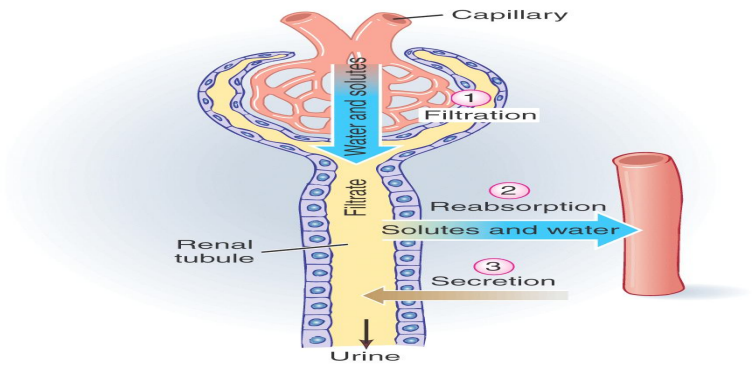


Fig.2.13 Functional Overview of the Nephron

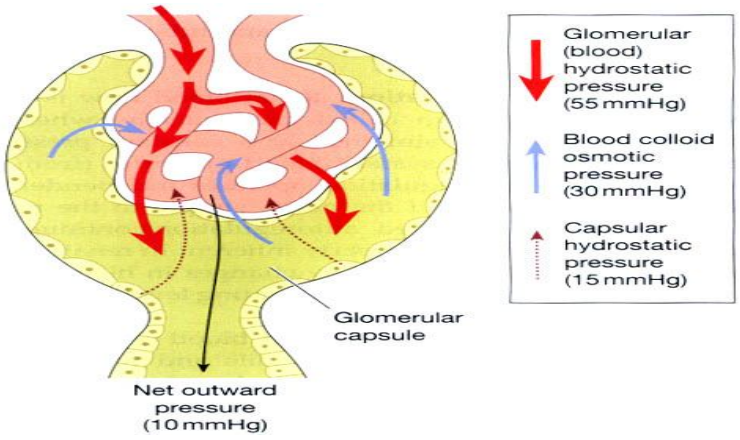


Fig. 2.14 Functional of the Nephron.

Total body water (TBW) is approximately 60% of body weight. The percentage of TBW is highest in newborns and adult males and lowest in adults' females and in adults' with a rage amount of adipose tissue. (Linda S Costanzo).

The two kidneys function to excrete most of the waste products of metabolism. They play major role in controlling the water and electrolyte balance within the body and in maintaining the acid-base balance of the blood. The waste products leave the kidneys as urine, which passes down the ureter to the urinary bladder, located within the pelvis. The urine leaves the body in the urethra. (Tortora, 2012).

The kidney regulates body fluids and excretes waste products. It is a rapid process because $1/5^{th}$ of the blood volume goes through the two kidneys each minute. (Olof et al., 1991).

2.3 The pathology of kidneys

Disease of the genitourinary system currently affect between eight and nine million Americans. These diseases vary from inconsequential to severe and life threatening. (Saunders et al., 1989)

2.3.1 Congenital Disorders

Unilateral renal congenital agenesis (solitary kidney) is a rare anomaly that may be associated with a variety of other congenital malformations. Before the diagnosis can be made, it is essential to exclude a nonfunctioning, diseased kidney or a prior nephrectomy. Ultrasound or CT can demonstrate the absence of renal tissue. A solitary kidney tends to be larger than expected, reflecting compensating hypertrophy.(Mosby et al., 1995).

A supernumerary kidney is also a rare anomaly. The third kidney is usually small and rudimentary and possesses a separate pelvis, ureter, and blood supply. A small, hypoplastic kidney often appears as a miniature replica of a normal kidney, with good function and normal relation between the amount of parenchyma and the size of the collecting system. (Mosby et al., 1995).

Renal hyperplasia must be differentiated from an acquired atrophic kidney, which is small and contracted because of vascular or inflammatory disease that has the volume of renal parenchyma. (Mosby et al., 1995).

2.3.1.1 Anomalies of rotation, position, and fusion

Marotation of one or both kidneys may produce a bizarre appearance of the renal parenchyma, calyces, and pelvis that is suggestive of a pathologic condition when in reality the kidney is otherwise entirely normal.

Abnormally positioned kidneys (ectopic kidney) maybe found in various locations, from the true pelvis (pelvic kidney) to above the diaphragm (intrathoaracickidney. Mosby et al., 1995).

Horseshoe kidney is most common type of fusion anomaly. In this condition, both kidneys are malrotated and their lower poles are joined by a band of normal renal parenchyma (isthmus) or connective tissue. The ureters arise from the kidneys anteriorly instead of medially and the lower pole calyces point medially rather than lateralally.Thepelves are often large and flabby may simulate obstruction. (Mosby et al., 1995).

Duplication (duplex kidney) is a common anomaly that may vary from a simple bifid pelvis to a completely double pelvis, ureter, and ureterovesical orifice. Complete duplication can be complicated by obstruction or by vesicoureteral reflux with infection. (Mosby et al., 1995).

2.3.2Inflammatory disorder

2.3.2.1Glomerulonephritis

Glomerulonephritis is a kidney disorder that may develop in response to several different stimuli such as chemical agents, anoxia, ionizing radiation, and bacteria. (Saunders et al., 1989).

Diseases of the glomeruli are usually separated into primary diseases and those that are secondary to systemic diseases. It is thought that the major cause of inflammation is immunological factors. In this regard, it is accepted that Glomerulonephritis is a disorder that occurs are secondary to inflammation. Many of these inflammatory responses are due to an allergic reaction or antigen-antibodyresponse. (Saunders et al., 1989).

2.3.3Pyelonephritis

Pyelonephritis is a suppurateinflammation of the kidney and renal pelvis caused by pyogenic (pusforming) bacteria. Unlike glomerulonephritis, which primarily involves the parenchyma (glomeruli and tubules) of the kidney, the inflammatory process of pyelonephritis affects the interstitial tissue between the tubules. (Mosby et al., 1995).

2.3.4Tuberculosis

The hematogenous spread oftuberculosis may lead to the development of small granulomas scattered in the cortical portion of the kidneys.Spread of infection to the renal pyramid causes an ulcerative, destructive process in the tips of the papillae with irregularity and enlargement of the calyces. Fibrosis and structure formation lead to cortical scarring and parenchymal atrophy. (Mosby et al., 1995).

2.3.5Papillary necrosis

Papillary necrosis refers to a destructive process involving a varying amount of the medullary papillae and renal pyramids. It is most often seen in patients with diabetes, pyelonephritis, urinary tract infection or obstruction, sickle, cell disease, or phenacetin abuse. (Mosby et al., 1995).

2.3.6Cystitis

Inflammation of the urinary bladder is most common in women because of their shorter urethra. The major cause is the inadvertent spread of bacteria present in fecal material, which reaches the urinary opening and travels upward to the bladder.(Mosby et al., 1995).

Instrumentation or catheterization of the bladder is another important cause of cystitis, which is the most common infection in hospitalized patients (nosocomial infection).Cystitis also can develop from sexual intercourse with the spread of infecting organisms from around the vaginal opening. (Mosby et al., 1995).

2.3.7Kidney Stone

Urinary calculi most commonly form in the kidney. They are asymptomatic until they lodge in the ureter and cause partial obstruction, resulting in extreme pain that radiates from the area of the kidney to the groin. The cause of kidney stones is varied and often reflects an underlying metabolic abnormality, such as hypercalcemia, resulting from hyper parathyroidism or any cause of increased calcium excretion in the urine. (Mosby et al., 1995).

Urinary stasis and infection are also important factors in promoting stone formation. More than 80% of symptomatic renal stones contain enough calcium to be radiopaque and detectable on plain abdominal radiographs completely radiolucent calculi content no. Calcium and are composed of a variety of substances that are in excessive concentration in the urine. Excretory urography is used to detect these otherwise invisible nonopaque stone, which appear as filling defects in the contrast-filled collecting system. (Mosby et al., 1995).

2.3.8Urinary Tract Obstruction

Urinary tract obstruction produces anatomic and functional changes that vary with the rapidity of onset, the degree of occlusion, and the distance between the kidney and the obstructing lesion. (Mosby et al., 1995).

In adults, urinary calculi, pelvis tumors, urethral strictures, and enlargement of the prostate gland are the major causes. In children, congenital malformations (ureteropelvic junction narrowing, ureterocele, retrocaval ureter, posterior urethral valve) are usually responsible for mechanical obstruction. Normal points of narrowing, such as the ureteropelvic and ureterovesical junctions, the bladder neck, and the urethral meatus, are common sites of obstruction. (Mosby et al., 1995).

Blockage above the level of the bladder causes unilateral dilatation of the ureter (hydroureter) and renal pelvocalycealsystem (hydronephrosis); if the lesion is at or below the level of the bladder, as in prostatic hypertrophy or tumor, bilateral involvement is the rule. (Mosby et al., 1995).

2.3.9Disease involving blood vessels

Nearly all diseases of the kidney involve the renal blood vessels secondarily. Systemic vascular diseases, such as various forms of vasculitis, also involve renal blood vessels, and often the effects on the kidney are clinically important. The kidney is intimately involved in the pathogenesis of both essential and secondary hypertension. (Saunders et al., 2013).

2.3.10Urinary tract tumor

Benign disease is relatively uncommon in the urinary tract. Renal cell carcinoma/hypernephroma/adenocarcinoma is an important malignant kidney tumor affecting adults. Wilms" tumor is the most important malignant kidney lesion in children. The kidney is also the recipient of metastatic lesionfrom many primary tumor sites in the body. Bladder carcinoma is the most frequently occurring malignancy of the urinary tract

and accounts for 2.5% of all cancer death in the United States. (Saunders et al., 1989).

Many diagnostic procedures adequately demonstrate the urinary tract or identify abnormal conditions. The urinalysis is considered the most important laboratory test when evaluating the urinary tract. The excretory urogram or intravenous pyelography (IVP) is valuable for demonstrating a space –occupying lesion or a filling defect anywhere in the urinary tract. Nephrotomography and ultrasonography are able to differentiate solid and cystic masses. (Saunders et al., 1989).

Needle aspiration provides a means of obtaining information on the cellular contents of a renal cyst. CT provides information regarding renal size, density, and extent of a lesion. Selective renal angiography is excellent for demonstrating the hypervascularity and extent of hypernephroma and for identifying the preoperative blood supply. (Saunders et al., 1989).

2.3.10.1Wilms' tumor (nephroblastoma)

Wilms' tumor is the most common abdominal neoplasm of infancy and childhood. The lesion arises from embryonic renal tissue, may be bilateral, and tend to become very large and appear as palpable mass. (Mosby et al., 1995).

2.3.10.2Renal cyst

Cystic disease of the kidney are a heterogeneous group comprising hereditary, developmental, and acquired disorders. These diseases are important for several reasons: they are reasonably common and often present diagnostic problems for clinicians radiologists, and pathologists. Some

forms, such as adult polycystic disease, constitute major causes of chronic renal failure. (Saunders et al., 2013).

Simple cysts can occasionally be confused with malignant tumors. Simple cysts are generally innocuous lesions that occur as multiple or single cystic spaces of variable size. Commonly, they are 1to5 cm in diameter. Simple cysts constitute a common postmortem finding that has no clinical significance. (Saunders et al., 2013).

The main importance of cysts lies in their differentiation from kidney tumors, when they discovered either incidentally or during evaluation of hemorrhage and pain. Radiographic studies show that in contrast with renal tumors, renal cysts have smooth contours. Are almost always avascular, and produce fluid rather than solid tissue signals on ultrasonography. (Saunders et al., 2013).

2.3.11Gout

The excretion of increased amount of urates by the kidneys may result in crystal formation in the medulla. The crystals are deposited mainly in the collecting tubules where they cause local destruction of the tubular wall and become surrounded by a gain-cell reaction and eventually by fibrous tissue. They are usually at first needle-shaped, but tend to become amorphous. (Anderson et al., 1980).

The destructive changes in the collecting tubules result in atrophy of the corresponding nephrons and the kidney may be reduced in size with a granular surface and scarring of the medulla. Urate stones may develop in the renal pelvis and may cause renal colic, hematuria and obstruction. (Anderson et al., 1980).

2.3.12renal vein thrombosis

Renal vein thrombosis occurs most frequently in children who are severely dehydrated. On the adult, thrombosis is most often a complication of another renal disease (chronic glomerulonephritis, amyloidosis, and pyelonephritis), trauma, and the extension of a thrombus from the inferior vena cava, or direct invasion or extrinsicpressure resulting from renal tumors. (Mosby et al., 1995).

2.3.13Acute Renal Failure

Acute renal failure refers to a rapid deterioration in kidney function that is sufficient to result in the accumulation of nitrogen-containing wastes in the blood and a characteristic odor of ammonia on the breath. In prerenal failure, There is decreased blood flow to the kidneys cause by low blood volume (e.g. hemorrhage, dehydration, surgical, shook), cardiac failure, or obstruction of both renal arteries (Mosby et al., 1995).

2.3.13.1Chronic Renal Failure

Like acute renal failure, chronic kidney dysfunction may reflect prerenal, postrenal, or intrinsic kidney disease. Therefore underlying causes of chronic renal failure include bilateral renal artery stenosis, bilateral ureteral obstruction, and intrinsic disorders such as chronic glomerulonephritis, pyelonephritis, and familial cystic diseases. (Mosby et al., 1995).

2.3.13.2What Causes Kidney Disease?

As mentioned previously, there are two types of kidney disease:

1) Acute Kidney Failure, and

2) Chronic Kidney Disease (which can lead to Chronic Kidney Failure). Each has its own causes. (Empowered et al., 2009)

2.3.13.3Causes of Kidney Disease

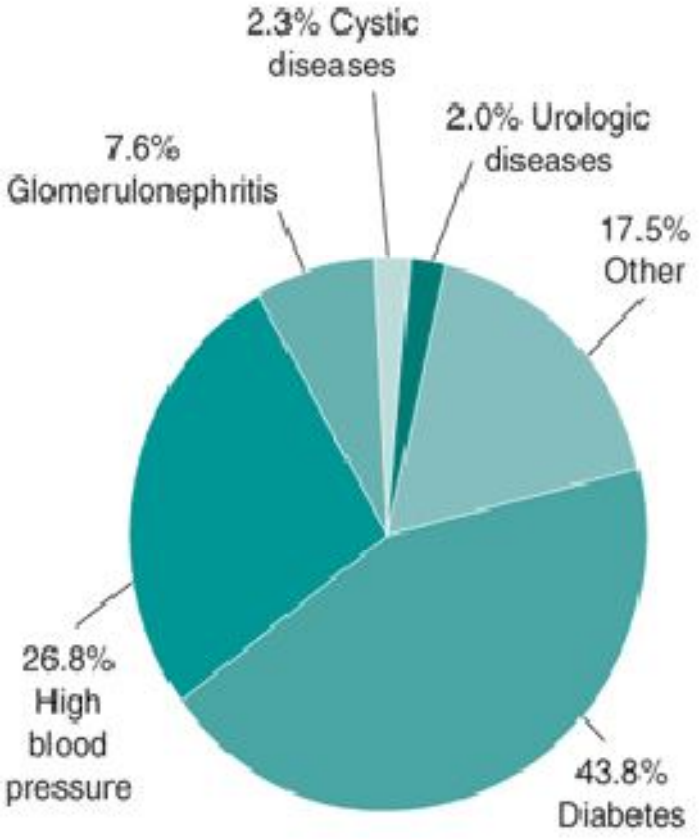


Fig. 2-15Kidney Disease

2.3.13.4Chronic Kidney Disease

2.3.14Diabetes

From the image above, diabetes is the number one cause of kidney disease, present in a staggering 43.8% of all cases! This is something that needs urgent attention, and scarily the number of people developing diabetes each year is only growing... enormously. The way diabetes causes kidney disease is threefold. (Empowered et al., 2009)

Damaged Blood Vessels – High sugar levels within the blood of diabetics causes the tiny blood vessels within the kidneys to become narrow and clogged, essentially cutting off the blood supply to the kidneys and causing death of tissue. (Empowered et al., 2009).

Damaged Nerve Supply - In this instance, high blood sugar levels cause the nerve supply to (but not limited to) the bladder to become weakened and incommunicative with the rest of the body. Therefore, as the kidneys begin to excrete urine and the urine begins to accumulate within the bladder, the nervous system's messenger system gets confused – it does not tell the brain that the bladder is full. This creates a back-up of pressure in the bladder, which in turn places added stress on the kidneys. (Empowered et al., 2009)

Urinary Tract - High blood sugar causes an increased likelihood of urinary tract infections, as sugar is the favourite food of bacteria. Urine with a high concentration of sugar in it becomes a breeding ground for infections. This can later develop into infections to the kidneys. (Empowered et al., 2009).

2.3.14.1Diabetic Nephropathy

Urinary tract infections are said to be more common in patients with diabetes but the evidence is inconclusive. Certain organisms, e.g. coagulase positive staphylococci,occur more frequently and, if associated with acute pyelonephritis, may result in acute papillary necrosis.(Blackwell et al., 1991). Diabetic glomruloslerosis this condition is usually associated with other diabetic microangiopathies, including retinopathy and neuropathy. Insulin dependent diabetics are at a special risk, and present with proteinuria, nephritic syndrome or renal failure. (Blackwell et al., 1991).

Renal failure is the cause of death in 10% of all diabetics and up to 50% of cases of the insulin-dependent (type I) diabetes mellitus (p. 236). There is damage to large and small blood vessels in many parts of the body.. (Blackwell et al., 1991).

2.3.14.2The effects include

Progressive glomerulosclerosis followed by atrophy of the tubules

Acute pyelonephritis with papillary necrosis. Atheroma of the renal arteries and their branches, leading to renal ischemia and hypertension (Ch. 5)

Nephrotic syndrome.(Elsevier et al., 2004).

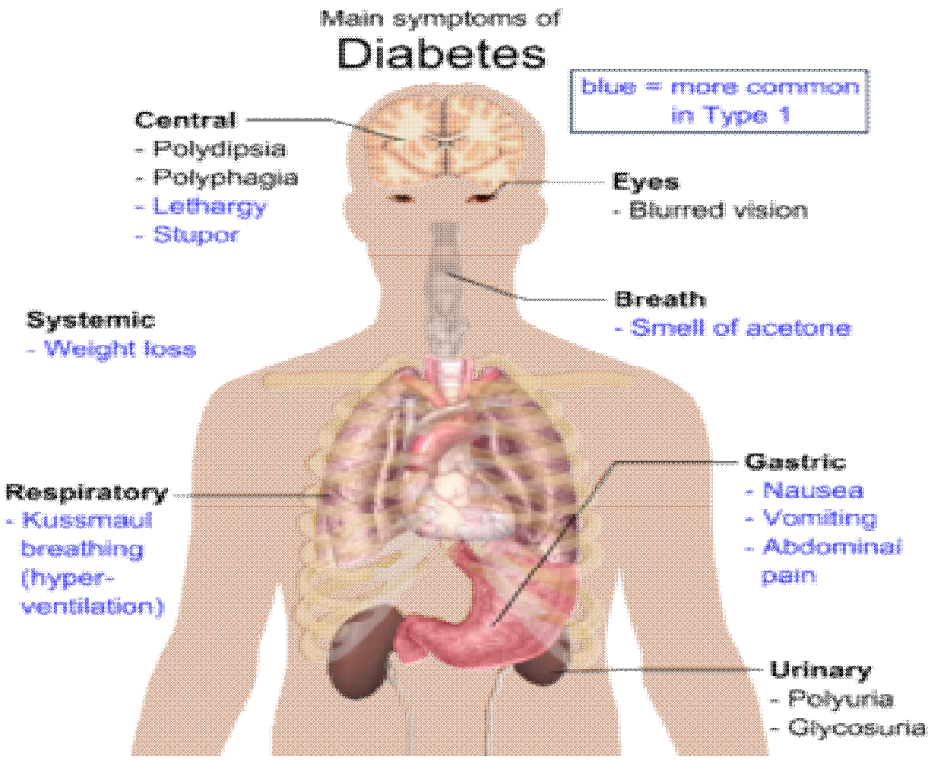


Fig.16main symptoms of diabetes(Markus 2015).

Diabetes is the most common cause of chronic renal failure. Characterized

By proteinuria, glomerular lesions that are associated with eventual capillary collapse glomruloslerosis, and loss of GFR. Hyperglycemia and insulin deficiency play a major role in diabetic nephropathy at least in the development of “nephron hypertension” and hyperfiltration. In many instances the patient begins with an above-normal GFR. (Kaplan et al., 2014).

The first sign of renal disease is microalbuminuria. AS GFR decreases the proteinuria increases. Diabetic nephropathy (DN) is renal manifestation of diabetes mellitus; it is glomerulosclerosis caused by lesions of the arterioles and glomeruli and associated with pyelonephritis and necrosis of the renal papillae. Diabetic nephropathy,or diabetic glomerulosclerosis, is a very

important complication of adult- onset diabetes mellitus and the most (Kaplan et al., 2014).

Important complication leading to death in juvenile-onset diabetes.The changes are related to the duration of the diabetes state. All insulin-dependent diabetic patients can expect to develop DN. Once proteinuria occurs, the renal changes invariably progress. Patients with diabetic nephropathy have increased morbidity and mortality. (Mosby et al., 1992).

Although the survival of diabetic patients treated with dialysis or transplantation has improved somewhat in recent years, the outcomes are not nearly as good as in nondiabetic patients. Diabetic patients have particular problems with atherosclerosis,coronary artery disease, peripheral vascular disease, retinopathy, and neurologic deficits. The likelihood of their successful rehabilitation is limited but has increased in recent years. (Mosby et al., 1992).

Diabetes mellitus is a disease characterized by a high blood sugar and a concomitant excretion of glucose in the urine. It usually caused by an insufficient insulin secretion by the pancreas. The insulin deficiency may be due to an initial defect in the beta cells, or it may be the result of an overstimulation, followed by exhaustion of the beta cells. In addition, abnormally high blood sugar levels maintained for a long period of time may exhaust the beta cell diabetes.(Fleur et al., 1978).

2.3.14.3 Pathophysiology

The glomeruli are affected by diffuse sclerosis and thickening of the basement membrane and mesangial areas. Nodular glomerulosclerosis may

also occur. Both afferent and efferent areterioles are affected by thickened walls and hyaline deposits. The glomerular filtration rate decreases, and azotemia occurs. (Mosby et al., 1992).

The diabetic patient may appear clinically uremic at GFR levels higher than individuals vary considerably to renal failure, possibly because of genetic defects or vascular changes related to metabolism of carbohydrates, fat, and protein. Poor control of blood pressure and glucose levels appears to be important. (Mosby et al., 1992).

2.3.14.4Medical Management

2.3.14.4.1General Management

Some authorities believe that controlling blood pressure and fluctuations in blood sugar slows the deterioration of renal function. Other believes that diabetic nephropathy follows an inexorable downhill course. Weight reduction is advocated. Protein is restricted early in the course of renal failure. (Mosby et al., 1992).

Intermediate levels of renal failure require low-protein diets with drugs to lower cholesterol. Late in the course of renal failure, insulin requirements degrease but protein, carbohydrate, and fat intake must still be controlled. Nutritional modifications are made to achieve or maintain adequate nutritional statues and to reduce the work of diseased kidneys. (Mosby et al., 1992).

2.3.14.5Microalbuminuria

Normal urine contains minute quantities of albumin (<15mg per minute). It has been shown that an albumin secretion rate above 15 mg per minute (Microalbuminuria), is associated with likely development of diabetic

glomerulosclerosis; for which there is no specific treatment. It is, however, hoped that better control of diabetes and any associated hypertension may reduce the incidence of diabetic glomerulosclerosis and associated complications, including retinopathy and vascular disease. (Blackwell et al., 1991).

2.4Radiological investigation

2.4.1Conventional radiographs

Conventional radiographs (plain films) can occasionally provide important clues to diseases of the urinary tract. Radiograph of the abdomen when used to evaluate the urinary tract are often referred to as KUBs (kidney, ureter, and bladder). KUBs may serve a role as preliminary films (scout) prior to an examination such as an intravenous urography, or they may be used as a general evaluation of the abdomen or the urinary tract. (McGraw et al., 2004).

Explain the procedure and its purpose. Describe the procedure, and assure the patient that it is painless and will take only a few minutes. Explain to the patient that the KUB cannot detect radiolucent stones and may not detect small radiopaque ones. Tell the patient that he will be taken to a radiologic suite and placed in supine position. (Mosby et al., 1992).

An intravenous needle will be placed, and contrast material will be injected in a single bolus after a small initial dose to determine immediate allergic response.Serial x-rays will be taken over a period of minutes to hours, depending on the patient's clinical condition and hospital protocols. (Mosby et al., 1992).

Warn the patient that he may experience sensations of flushing, an unpleasant taste in the mouth, or nausea as the contrast is given, but reassure him that these responses are transient. If the patient asks specific questions about radiation exposure, advise him to discuss his concerns with the radiologist or attending physician.(Mosby et al., 1992).

Renal ultrasonography and excretory urography (or IV pyelography) traditionally have been the primary means of investigating the kidney, but CT has rapidly gained ground and conventional IV pyelography is now rarely performed. (Saunders et al., 2009).

Ultrasonography is a useful technique for evaluation of the urinary tract, made especially attractive by its ease of use and lack of complications (no contrast material or ionizing radiation). The renal medulla is hypo echoic (darker) relative to renal cortex and can be identified in most normal adult as cone-shaped central structures. (McGraw et al., 2004).

(Occasionally, thiscorticomedullary distinction is not visible.) `The renal cortex is isoechoic or slightly hypo echoic compared with the echogenicity of the adjacent liver. In addition to echogenicity, the kidneys should be assessed for size, location, and symmetry. (McGraw et al., 2004).

Because the kidneys actively concentrate contrast within the parenchyma, virtually all renal abnormalities are best seen on CT following contrast administration. The only indication to perform an unenhanced CT is to demonstrate calcifications and calculi which may be obscured by contrast (Saunders et al., 1991).

2.4.2The meaning of Computed tomography

The word “tomography” is not new it can be traced back to the early 1920s, when a number of investigators were developing methods to image a specific layer or section of the body section. At that time, term such as “body section radiography” and “stratigraphy” (from stratum, meaning layer) were used to describe the technique. (Saunders et al., 2009).

However, it was not until 1935, when Gross-man, who refined the technique, labeled it tomography (from the Greek tomos, meaning section).A conventional tomogram is an image of a section of the patient that is oriented parallel to the film. (Saunders et al., 2009).

2.4.2.1 Computed tomography

Computed tomography (CT) has become a very important toot in diagnostic medicine, opening up a new world in diagnosis and treatment of disease. Computed tomography uses special detectors to measure the nonabsorbed X-rays passing through a given part of the human anatomy. This information is then sent to a computer to be reconstructed using mathematical equations called algorithms. (Raven et al., 1995).

An image is then displayed on a cathode ray tube (CRT). There are three major sections of the basic CT system (1) the imaging system (gantry, x-ray tube, and detectors) ;(2) the computer system (develops raw data acquired from detectors and controls thescanner); and (3) display system (operator and viewing console). (Raven et al., 1995).

The high density resolution of computed tomography (CT) allows demonstration of structures within parenchymal organs and determinations of differences in density in these structures. (William et al., 1981).

2.4.2.2 General comments

Although computed tomography is largely an automated process, neither the care of equipment nor the management of a patient must be neglected. Computer requires a dust-free environment, controlled for temperature and humidity, which is most easily obtained by housing the computer in a small separate air-conditioned room or cupboard. (William et al., 2009).

The equipment is serviced at regular intervals by the manufacturing company, who proved a service contact, but regular checks by the technician or radiographer is also essential. The weekly and daily settings up procedures are listed in the hand book and graticule alignment or tuning-fork tests particularly important. If the graticule is out of alignment non-movement streak artefacts occur, particularly at tangents to dense area such as the spine and pelvis. (William et al., 2009).

2.4.2.3 Principles of Multislice computed tomographic technology

Since the introduction of multislice helical computed tomographic (MSCT) scanner in 1998, this technology has achievend widespread clinical assurance across the country and around the world. The ability to acquire four or more images with each rotation of the computed tomography (CT) gantry has made a significant impact in patient throughput. Particularly when combined with high-heat -capacity x-ray tubes. (Lippincott et al., 2002).

The frequently heard marketing promise of nonstop CT scanning with no more delays for x-ray tubes to cool has finally arrived in busy clinical radiology departments. Clinical applications that have experienced the most important with this technology are those in which the data-acquisition time factor is critical. (Lippincott et al., 2002).

This new technology is also referred to as multidetector or multirow or multidetector- multirow CT; we will use the term multislice CT (MSCT) to reflect the outcome, rather than the scanner design. This new technology can decrease examination times by as much as eightfold. The most striking different between the single - slice helical technology and the MSCT system design is the configuration of the radiation detectors. (Lippincott et al., 2002).

In the past, these detectors were long and narrow, with the length of a shingle detector element aligned in the z-axis direction This geometry allowed the collimation of the x-ray beam to crest images of varying slice thickness, all using the same set of detector. MSCT technology has incorporated a detector array that is segmented in the z axis direction, forming a mosaic of element in the detector assembly. (Lippincott et al., 2002).

This physical separation of detector element allows for simultaneous acquisition of multiple images in the scan plane with one rotation of x-ray tube about the patient. The first advantage is the ability to scan the same anatomic region of interest (ROI) in much less time, using a similar slice thickness. (Lippincott et al., 2002).

The second advantage is the ability to scan the same anatomic (ROI) in less time using thinner slices. The third advantage is the ability to achieve much more anatomic coverage in the same acquisition time, using thinner slices thickness (Lippincott et al., 2002).

Fig. (2.17) NeuViz 128 128-Slice CT scanner System**.**

2.4.2.4 Preparation for CT Examinations

There is a considerable variation in the preparation needed for CT examination of the various regions of the body, but irrespective of the clinical problem each patient should receive an explanation of the procedure and the nature of the apparatus. . (William et al., 2009).

It is especially important to tell patients that they will be examined in a short tunnel and that the machine can be somewhat noisy. Reassurance and explanation are at all times the basis of good management in radiography and particularly so with CT examinations.(William et al., 2009).

Correct preparation and good patient management result in scans of good diagnostic quality which is of course the whole purpose of the examination. The type of preparation depends not only on the region being examined but Also on the equipment, and it is therefore important to understand the reason for the kind of preparation being advised. (William et al., 2009).

There are two main reasons for patient preparation. The first is to overcome any movement artifacts that can be produced by restless, uncooperative patients, from breathing and from bowel movements. The second major problem is to recognize bowel on abdominal scans. (William et al., 2009).

2.4.3 Magnetic Resonance Imaging

Just like CT, technical advances in magnetic (MR) imaging have led to increasing use in urinary imaging. Fast-scanning techniques that allow breath- hold imaging, combined with the spectacular tissue contrast of MR imaging and the ability to directly image in any plane, make this an attractive modality for evaluating the urinary tract. (McGraw et al., 2004).

Lack of ionizing radiation add to its appeal, but, coast, availability, claustrophobia, and the contraindication of certain materials including the pacemakers remain major drawbacks. (McGraw et al., 2004).

Finally, MR imaging of the kidney is performed with gadolinium as the contrast agent, not iodinated contrast material. In renal imaging one of the main advantages of gadolinium versus iodine is the virtual lack of nephrotoxicity at clinical doses. (McGraw et al., 2004)

On MR imaging, the kidneys appear to be f variable signal intensity, depending on the imaging factors and, like CT contrast-enhanced phases of

imaging (arterial, corticomedullary, nephrographic, and excretory) are all visible. (McGraw et al., 2004).

2.4.4 Nuclear Medicine

Nuclear medicine studies of the kidneys involve administration of an I.V. radionuclide which is filtered through the kidneys at a specific rate and concentration. A series of films document the effectiveness of renal perfusion and function. The disadvantages of nuclear medicine studies are they rely on function and demonstrate only gross anatomy. (Mark H, Beers M 2010).

2.5Previous study

In the study carried out by (Roentgen, et al., 1993) found that the normal sonographic measurements of the kidney in adult volunteers. Length, width, and thickness of the kidney and its central echogenic area and the parenchymal thickness of the upper pole were measured in an age- and sex-stratified random sample of 665 volunteers 30, 40, 50, 60, and 70 years old. Measurements were made with the volunteers prone. Volumes of the kidney, the central echogenic area, and the renal parenchyma were calculated. Renal dimensions and renal and parenchymal volume were correlated with age, height, weight, body mass index, and total body area. In 94 subjects, renal length was measured with the volunteers Median renal lengths were 11.2 cm on the left side and 10.9 cm on the right side. Median renal volumes were 146 cm3 in the left kidney and 134 cm3 in the right kidney. Renal size decreased with age, almost entirely because of parenchymal reduction. Renal volume correlated best with total body area. Renal length correlated best with body height. Measurements of renal length obtained with the subjects supine were not significantly different from those obtained with the subjects prone. The most exact measurement of renal size is renal volume, which showed the strongest correlation with height, weight, and total body area. Clinically, measurement of renal length is most practical and can be done with the subject prone or supine. (Wiley, et al., 1998)they studied and evaluated the sonographic measured absolute and relative lengths of normal kidneys according to subject height, sex, and age. Real-time zoography was performed on 202 subjects. Measurements of longitudinal renal diameter represented absolute renal length. Relative renal length was calculated using the kidney length: body height ratio (KBR). They found that in 175 subjects without renal impairment (104 men and 71 women) whose ages ranged from

17 to 85 years (mean ± SD, 46.3 ± 17.1). The mean heights of the subjects were 176 ± 7 cm for men and 167 ± 6 cm for women. The left kidney was absolutely (mean ± SD, 112 ± 9 mm) and relatively (mean KBR ± SD, 0.655 ± 0.042) longer than the right kidney (absolute length, 110 ± 8 mm; KBR, 0.641 ± 0.038), regardless of sex ($p< 0.01$). The absolute renal length was significantly greater in men than in women for both kidneys ($p< 0.01$), but there was no significant difference between KBRs ($p> 0.05$). Renal length decreased with age, and the rate of decrease seemed to accelerate at 60 years and older. When height and age were included in the multivariate regression analysis, sex was not a significant predictor of kidney length. (Jpma, et al., 2000) they found that Ultrasonographic kidney measurements were performed on 194 adult Pakistani population patients without known kidney lesions. Measurements included length, width, cortical thickness and estimation of renal size which was obtained by multiplying the first three variables. The effect of age, gender, side, height, weight, BMI, hypertension and diabetes mellitus was statistically analyzed. They reported that the mean kidney length was 10.4 ±0.8 cm, mean with 4.5 + 0.6 cm and mean cortical thickness 1.6 ± 0.2 cm. The estimated mean renal size was 76 ±22 cm3. Kidney length did not significantly differ between right and left, however, kidney width, cortical thickness and size did ($p<0.05$). Right kidneys were smaller than the left ones. In univariate analysis, the mean renal size correlated with age, sex, side, BMI and absence or presence of hypertension and diabetes mellitus. In a multivariate analysis, however, the only significant factors affecting renal size were sex and BMI.

In the study carried out by (Maaji, et al., 2015) found that A total of 104 volunteers, 50 females and 54 males were scanned. The mean age was 30.4 ± standard deviation 19 years (18-70). The mean kidney length was 11.3 ± 8.8 and 11.6 ± 9.8 for right and left kidney, respectively. The mean height and weight was 1.67 ± 0.85 and 70.9 ± 11.2, respectively. The mean kidney width was 4.4 ± 0.71 and 5.2 ± 5.26 for right and left kidney, respectively. The mean renal thickness was 4.7 ± 0.67 and 4.5 ± 0.68 for right and left kidney, respectively. The renal volume was 109.6 ± 29.3 and 119.7 ± 32.8 for right and left kidney, respectively. The body mass index was calculated to be 25.1 ± 3.96 (16.18) and 26.0 ± 5.36 (24.7) for female and male, respectively. Renal measurements were correlated with the subject's height, weight, body mass index using the Pearson's correlation. The strongest correlation with renal volume is the age, the correlation coefficient was 0.997(P<0.001). (July, et al., 2011)), the present study was undertakento investigate the normal values of RPV (Renal parenchymal volume) and kidney length as measured by non-enhanced multidetector computed tomography (CT). He reported that RPV obtained by the CT method was within 2% of the RPV determined by the water displacement method. The normal values of RPV (M ± 1.96 standard deviation (SD) were 145.72 ± 54.37 mL for men and 132.46 ± 41.94 mL for women. The normal values of kidney length (M ± 1.96 SD) were 10.27 ± 1.98 cm for men and 9.93 ± 1.58 cm for women. RPV did not significantly correlate with BSA or weight in women, but correlated significantly with height and age in both men and women. Of the assessed factors age, weight, height, BSA, and BMI, age, and Height were the independent factors that best reflected RPV, in both men and

Women.Study done by Emamian et al.(Mazzotta, et al., 2002) based on Denmark population with 665 adult volunteers which consist of different ranged of age had shown that the median renal lengths were 11.2cm on the left side and 10.9cm on the right side. The mean renal volumes for the left kidney were 146cm3 and 134cm3 for the right kidney. As compared to our study, the mean renal length for Malaysian is 1.3cm on the left and 1.2cm on the right shorter than those who are from Denmark. For the renal volume, the Malaysian is having a smaller renal volume where. The difference is 52.4cm3 and 62.5cm3 on the left and right respectively. Another study from Mexican population by J. Oyuela- Carrasco et al. (Wing, et al., 2010). Had reported the renal length by ultrasound in 153 Mexican adults. The differences between Malaysian and Mexican in the whole group were 0.68 ± 1.71cm and 0.73 ±1.43cm on the left and right kidney respectively in the male category, the difference for left renal length was 0.67 ±1.57cm and 0.9 ±1.27cm for right renal length. In the female category, the differences were 0.66 ± 1.82cm and 0.5 ±1.52cm for left and right respectively. What we can say here is that all the differences show that Mexican has greater renal length than Malaysian. Next, the results of this study were also compared with the study based on Caucasians population. The studies done by Mc Minn and Williams's et.al. Were compared with this study. From what we can conclude from the comparison was that Caucasian without doubt have larger renal size if compared to our population. The difference between our study and their studies can be seen obviously where their renal length are longer than ours to the maximum of 2cm. Another comparison was made between Southeast.

Nigerians (Seyed, et al., 1993), and Malaysian population. The overall mean renal length in Nigeria for left Kidney was10.6cm and 10.3cm for the right kidney. If we look at the overall mean renal length of Malaysian in Table 1, our population is in fact shorter in renal length when compared to Nigerian Population. Mean renal length on right side was 101.6±8.9 mm, renal width 42.7±7.1 mm, and parenchymal thickness 14.4±2.9 mm. On left side, mean renal length was 102.7±9.2 mm, width 47.6±7.0 mm, and parenchymal thickness 15.1±3.1 mm. Mean renal volume on right was 99.8±37.2 cm3 and on left was 124.4±41.3 cm3. Left renal size was significantly larger than right in both genders. Relationship of mean renal length was significant when correlated with age, side, gender, height and weight, and body mass index. (Ayub, et al., 2011)), he reported that length, width, thickness and volume were obtained and mean renal length and volume were correlated with body mass index and other factors like age, side, gender, weight and height of the subjects. TheMean renal length on right side was 101.6±8.9 mm, renal width 42.7±7.1 mm, and parenchymal thickness 14.4±2.9 mm. On left side, mean renal length was 102.7±9.2 mm, width 47.6±7.0 mm, and parenchymal thickness 15.1±3.1 mm. Mean renal volume on right was 99.8±37.2 cm3 and on left was 124.4±41.3 cm3. Left renal size was significantly larger than right in both genders. Relationship of mean renal length was significant when correlated with age, side, gender, height and weight, and body mass index. In the study carried out by (Glodny, et al., 2009) found that normal renal dimensions using a 64-slice MDCT. Their study confirms that the accuracy and reliability of CT assessment of renal dimensions when meticulous scanning techniques are employed. His result show that LPP (pole-to-pole kidney length) was 108.5 ± 12.2 mm for the right, and 111.3 ± 12.6 mm for the left kidney ($p < 0.0001$ each). PW on the

right side was 15.4 ± 2.8 mm, slightly less than 15.9 ± 2.7 mm on the left side ($p < 0.0001$), the cortical width (CW) was the same (6.6 ± 1.9 mm). The most significant independent predictors for LPP, CW, and parenchymal width (PW) were body size, BMI, age, and gender ($p < 0.001$ each). In men, the LPP increases up to the fifth decade of life ($p < 0.01$) (Imam, 2015) he studied and assessed the kidney size in diabetic patients by using CT. He founded in his results among of 50 patients studied, diabetic patients (31 males and 19 females), 3 of them are type 1 diabetic mellitus, and 47 are type 2, their age ranged between 45-58 years old and there was 100 normal patient as control group. The duration of diabetes increase the length and width decrease but the CT number increase. Furthermore, it reveals that increase in duration of diabetes has direct impact on kidney texture. The study aimed to establish preliminary data for Sudanese population kidney dimensions in individuals with known Diabetes Mellitus (DM) using ultrasound. Ultrasonographic kidney measurements were performed for 205 patients with known DM.Measurements included length, width, corticomedullary differentiation. The effect of age, gender, onset, renal parenchymal disease and pyelonephritis was statistically analyzed. There was association between renal length renal failure, renal parenchymal disease and pyelonephritis ($P= 0.000$, 0.429 and 0.068 respectively. relation was statistically significant since $P<0.05$. (Mohammed, et al., 2009) studied the ultrasonographiccharacteristics of diabetes impacts in Kidneys' Morphology. They assessed of 150 diabetic male patients and investigated by ultrasound system general electric using gray-scale B-mode imaging with curvilinear transducer 3 MHz to assess the impact of diabetes in kidney morphology and it is distributed in Sudan. The analyzed data show that the diabetes has been as endemic disease in central Sudan (Khartoum & Jazeera)

representing 55% and in the west of Sudan representing 38%. The BMI of diabetic patients has been significantly (R2 = 0.6) decreasing following aging. The kidney size increases significantly as R2 = 0.75 and 0.6 for left and right kidney respectively. Their correlation is fitted in the following equations: y = 3.95x + 27.26 and y = 2.41x + 35.12 for the left and right kidney respectively. The impact of duration was a reduction in size significantly as R2 = 0.61 and 0.55 with a correlation fitted in the following equations: y = –2.22x + 139.9 and y = –1.51x + 96.59 for the left and right kidney respectively. The mean kidney length was (14.5 cm) and the renal cortex in the range of 2 - 2.3 cm, the kidneys size were so enlarged as 92.4 ± 11.7 and 121 ± 17.1 for the right and left kidney respectively while in late case of diabetes, the kidney is more echogenic, atrophied size with loss of corticomedullary differentiation. Studies by (Zohreh, et al., 2015) on renal dimensions, including length and parenchymal thickness were measured by sonography in 103 individuals with no renal disease in normal renal dimensions in Iranian adults measured by ultrasound. Statistical analyses were done to find the effect of different variables such as side, age, and gender. The correlation of renal dimensions with anthropometric parameters, including weight, height, and body mass index (BMI) wasanalyzed using the Pearson correlation coefficient. She reported that Mean (SD) kidney length was 104.96(6.6) mm for the right, and 106.22(6.16) mm for the left kidney (P=0.02). Mean (SD) parenchymal thickness for the right kidney was 16.9(1.6) mm and on the left side, it was 18.2(1.7) mm (P<0.001). Gender related analysis showed significant differences between male and female renal length and parenchymal thickness (P<0.05). Age group analysis regardless of sex showed significant decrease in renal length and parenchymal thickness beyond the fifth decade of life. There was a positive

correlation between bilateral renal length and body weight as well as BMI. Also, there was a weak positive correlation with body height. In the study carried out by (Werner, et al., 2011) found that normal renal dimensions usingCT images of 514 patients who received routine abdominal CT scans. He reported that the mean renal length was 108 mm with a standard deviation of 9.82 mm. Statistical analysis demonstrated a relationship between kidney size and body weight and height, both individually and collectively. The most accurate prediction model was ‘kidney size = 49.18 + 0.21 x weight + 0.27 x height’, with a R2-value of 0.32. Additionally, kidneys were generally larger in the white population than in the black, and also in males than females.

Chapter Three

Materials and Methods

3.1 Materials

3.1.1 Machine:

Neusoft multi-slice CT Scanner System Model: NeuViz 128, Volt: 3N-380/400v, Power: 90KVA (120 kV, 40MA) (5 mm slice) in complex of general Omer Sawyer was performed, Antalya medical center (general electrical 4 slices) and modern medical center, (general electrical 16 slices).

3.1.2Population of the study:

The population of this study consisted of two groups of patient, those with normal kidneys free from any pathology as control group, group two patients diagnosed as having diabetic nephropathy. The study includes both genders with their age ranged from 10 years to 70years old.

In this study, 300 kidneys (right and left) of 150 patients were examined. The study population was randomly selected from the age groups (younger , adults, and old) starting from 10 up to 70 years old according to the availability as a sample of diabetic patients cases. Meanwhile, the samples of the study after the data collection they were (female 77, and male 73)

This study is analytic study of a case control type deals with CT scan pattern of diabetic nephropathy.

The study population consisted of patients who referred to the CT scan department for CT abdomen; each patient was examined with CT (MDCT) scan by a qualified technologist. Between August 2014 to April 2017, the period of the study is three years. In Sudan (Omer Sawyer hospital, Omdurman hospital, modern medical center, and Antalya medical center.

3.2 Methods of data analysis

Methods were used: axial, coronal single image, coronal multiimage 150 patients referred forabdomen CT scans were included in the study. Patients whose both kidneys were investigated and had been studied. Multi-slice CT was used in this research because by the obtained coronal and axial cuts, the actual length of kidney can be obtained easily. After that CT images were stored in computer disk were viewed by the Radiant, DICOM viewer Digital imaging and communication on medical in computer to selected the coronal images that suit the criteria of research population then uploaded into the computer based software Interactive Data Language (IDL) Then the image were read by IDLthe first order were extracted from Multi-slice CT A non contrast to obtain coronal, Axial and sagittal cuts, to Measure the renal parenchymal thickness (PT) on CT scans through A, upper calyx; B, renal pelvis; and C, lower calyx levels. PT was measured at four locations: anterior (a), posterior (b), medial (c), and lateral (d), at right angles to each other and oriented such that a-b paralleled the renal vessels. The width of the L1 vertebral body (VB), the length and the width of the kidneys, CT No of cortex andmedulla, was also measured. And also Multi-slice CT with contrast was used to obtain Axial cuts, to measure the cortex a medulla.

3.2.1Technique

CT scans were performed including protocol of axial images from the xiphoid process covers all abdominal area and pelvic down to pubic bone with patient in supine position, head first. The images were made at 100/120 kV and 60/80 MAs, with 5 mm slice thickness reformat 1.2mm. Reconstruction used 5mm to obtain coronal views. Light diets for 6 hrs was preparation for patients, contrast used Iodine 75ml for normal patients and

70ml for diabetic patients. Technical developments of multidetector-row CT (MDCT) have dramatically changed the application of CT angiography in the assessment of abdominal vascular pathologies. The simultaneous acquisition of multiple thin collimated slices in combination with enhanced gantry rotation speed offers thin slice coverage of extended volumes without any loss in spatial resolution. It also provides sufficient information about extra-renal anatomy important for diabetic nephropathy and determination of organ suitability.

The major development in technology has been multidetector CT (MDCT), Which has dramatically increased the performance capability of CT. Successive Generation of systems capable of acquiring 4, 8 or 16 sections simultaneously has been introduced (Berland,et al., 1998), (Kalender, et al., 2000).Even greater configurations are now becoming available; with latest cone beam system capable of simultaneously acquiring 256 sections (MORI et al., 2006).

The incorporation of slip ring technology into the design of scanner in the late 1980s removed the need for rigid mechanical linkage between the power capable and the x-ray tube. (Springer et al., 2007).

CT is now the dominant radiologic imaging. The advent of multidetector spiral CT has further propelled CT to the forefront of urologic imaging. Several factors make CT effective in assessing the urinary tract. The high contrast resolution and spiral resolution affected by CT allow detection and evaluation of subtle differences in very small structures. (McGraw et al., 2004).

Mathematical calculations of the attenuation of the CT x-ray beam allow quantitative evaluation of the relative density of structures (i.e., their Hounsfield units), and it is through these “CT numbers” that much unique diagnostic information of the urinary tract is gained. (McGraw et al., 2004).

Examination can be performed amazingly fast because thin-slice CT scans of the entire urinary tract are now obtainable in just a few seconds. Finally, the wide availability and relative safety of CT further its appeal. CT scans of the urinary tract may be performed with and/or without intravenous iodinated contrast material depending on the indications. (McGraw et al., 2004).

With rapid Scanning and contrast bolus timing, several sequential phases of pacification within the kidney can be delineated by CT including coticomedullary, Nephrographic, and excretory phase. The corticomedullary phase can be seen if scanning is performed during the first 20 to 90 seconds after contrast administration and represents the early preferential blood flow to the renal cortex however, small masses could be missed during this phase, being obscured within the unenhanced renal medulla. (McGraw et al., 2004).

Subsequently, contrast begins to pass into the distal collecting tubules within the renal medulla, resulting in a more homogeneous Opacification of the renal parenchyma, termed the CT nephrographic phase. This generally occurs around 2 to4 minutes after contrast medium injection. (McGraw et al., 2004).

Finally, the excretory phase is seen when contrast opacifies the collecting system. Each different disease processes and thus various scanning protocols are used to evaluate the kidneys depending on the indication. One of the

major recent advances in imaging has been the ability to noninvasively evaluate the vascular system, and thin-section early CT images accurately demonstrate the main arterial and venous structures of the kidney. (McGraw et al., 2004).

Flat- Panel digital detectors similar to the ones used in digital radiography are now being considered for use in CT: however, these scanners are still in the prototype Development and are not available for use in clinical imaging. Perhaps they may be labeled seven –generation. The x-ray tube and detectors are coupled and positioned in the CT gantry. (Seeram et al., 2009).

The detectors consist of a cesium iodide (CsI) scintilla-tor coupled to an amorphous silicon thin-film transistor (TFT) array. These flat- Panel detectors produce excellent spatial resolution but lack good contrast resolution; therefore, they are also being used in angiography to image blood vessels, for example, where the image sharpness is of primary importance. In addition, flat- Panel detectors are also being investigated for use in CT breast. (Seeram et al., 2009)

3.2.2Image interpretation دا اضافة حسب العناوين الجانبية التى وصت عليها د. اسماء

A computed tomography (CT) scan can create cross-sectional images of any part of your body using special X-rays and a computer. This type of radiology study is an important part of diagnosing medical diseases. To read a CT scan if you understand the normal anatomy and what the shades of white, grey, and black on the films mean.Read the information on the CT scan. Check to see what is printed on the films to determine they are yours and what part of the body is represented in the films.Read up on your anatomy. The CT scan images are sharp with good definition, but they are

still x-rays. The structures inside of you are shown in shades of white, gray, and black. You must have an idea of what you are looking at and what is normal.Hold the film in the proper orientation. The words on the film will let you know which side of the film should be facing towards you and where the top is. This should not be an issue if the CT films are on a disk, but you still should check .

When you look at a CT scan, it is like looking in a mirror. The right side of your body will be on the left side of the film and the left side of your body will be on right. The anterior or front part of your body will be on the top of the film and the posterior or back part of your body will be on the bottom. Put the films in the correct order. Numbers will be printed on the CT films. The CT scan cuts your body into cross-sections which are like very thin slices of bread. As you look at the images in order, you will notice a normal and natural flow. Any sudden breaks can suggest disease or an abnormality.Take note of the shades of white, gray, and black. The soft tissues, fat, air, and bone inside of you are represented in these different shades. An unexpected color in a part of your body could be a sign of an abnormality .

Dense tissues like bone show up as white areas. Both air and fat show up as dark gray or black. Your soft tissues and any fluid, including blood, will show up in various shades of gray. Different types of contrast, which shine bright white on the films, are used to better define the structures inside you. You swallow one type to show the fluid inside your stomach and intestines. But, another type is injected into your into vein to show the blood in your vessels or the fluid around an organ. The latter could be a sign of inflammation, infection, or bleeding.Compare the two sides to help you see

abnormalities.Talk to your doctor. A radiologist is a doctor who specializes in interpreting all types of X-rays, including CT scans, has read your films. She sent a report to your doctor with a detailed description of what she saw on your films .Your doctor ordered the CT scan either to find a diagnosis to explain your symptoms or as follow-up for a medical problem.You have a copy of the CT and you decide to take a look. Reading a CT correctly takes a lot of practice and the proper lighting. Let your doctor and the radiologist have the final word on what is normal and abnormal on your CT scan

In order to differentiate between different types of fluid and tissue in the abdomen, it is important to understand the concept of Hounsfield units (HU) and how they are derived. Historically, the recreated images from CT scanners had a wide range of values of 12-bit digital data, measured in standard transform (ST). The inventor of the original CT, Sir Godfrey Hounsfield, developed a method to standardize the density measurements between different machines. Hounsfield's absolute density scale defined air as the minimum density, with a value of 1000 HU, and placed water as the benchmark of 0. The densest materials in the human body, bone, has an upper limit of +1000 HU. The raw data could be translated to HU by the equation HU = ST scale + offset (e.g. scale = 1.0, offset = -1000). 2 This scale can be applied directly to the analysis of free fluid in the abdomen, especially as it relates to identifying blood. The appearance of blood in intra-abdominal hemorrhage can vary depending on the recency of the bleed, and this can help to determine if there is active bleeding or if clotting has occurred. Clotted blood has a heterogeneous appearance and is generally between 45 and 70 HU. Clotted blood tends to congregate close to the original hemorrhage site, producing the so-called "sentinel clot." Freely

flowing blood, however, will have a less dense appearance, and typically ranges from 20 to 45 HU. 4 Blood can also be identified by extravasation of contrast material, which can accumulate in the abdominal cavity or demonstrate sites of vascular disruption.

3.2.3 Statistical analysis

Data were initially summarized into means, standard deviations (SD); mean ±SD and percentages in a form of comparison tables and graphs. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS, USA) version 22 for windows and (P-value) was used for significance.

-Significant difference if $P < 0.05$.

-Highly significant difference if $P < 0.001$.

-Non significant difference if $P > 0.05$.

The smaller the P-value obtained the more significant are the results

Chapter Four

Results

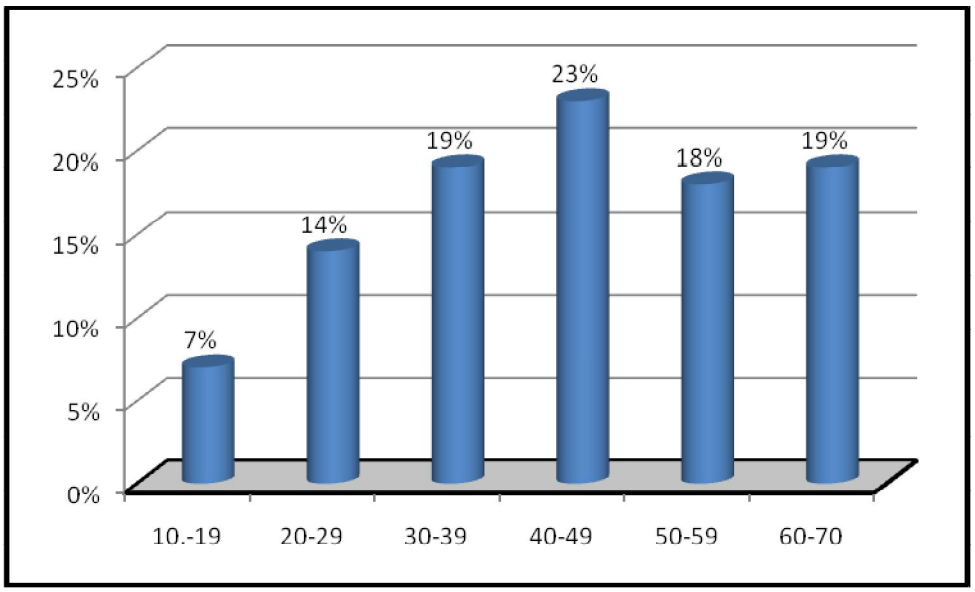


Figure 4-1: a bar graph illustrate the % frequency Distribution of study sample according to Participant's age

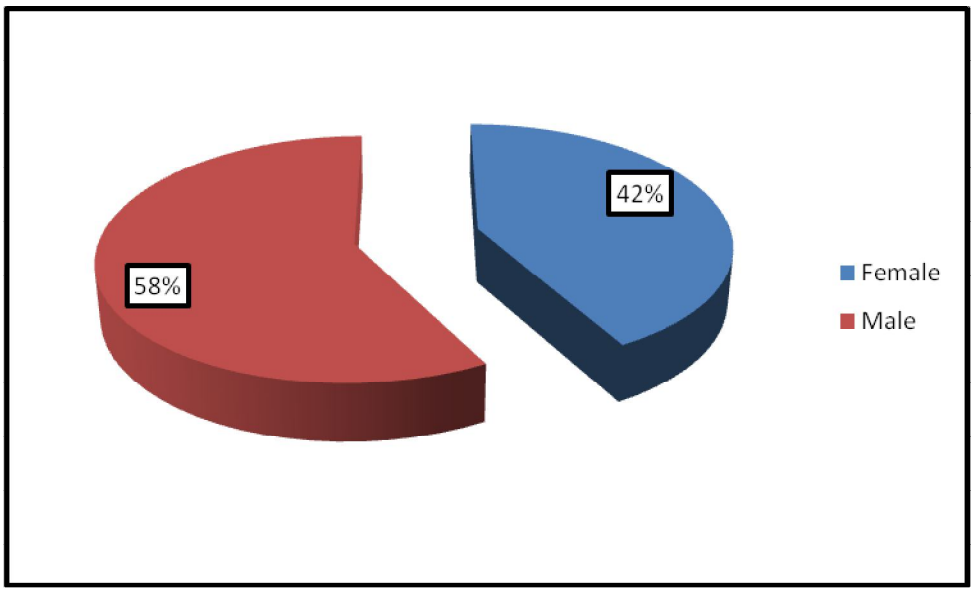


Figure 4-2: a bar graph illustrate the % frequencyDistribution of study sample according to Participant's gender

Table 4-1: Descriptive Statistics of kidneys characteristics data and CT (HU) for cortex and medulla for both right and left kidneys and T-Test.

	Side	***N***	***Mean***	***Std. Deviation***	***P-value***
Length Of Kidney	Left	100	95.73	11.40	0.495
	Right	100	96.75	9.61	
Width Of Kidney	Left	100	42.51	5.15	0.041
	Right	100	41.00	5.24	
Cortex(Axial)	Left	100	5.26	0.82	0.633
	Right	100	5.21	0.82	
Medulla(Axial)	Left	100	11.21	1.68	0.125
	Right	100	10.82	1.84	

Table4-2: Descriptive Statistics of the both kidneys measurements at the upper calyx, renal pelvis, Lower calyx measured at all directions and T-Test.

	Upper Calyx				***Renal Pelvis***			***Lower Calyx***		
	Side	Mean	Std. V	P-value	Mean	Std. V	P-value	Mean	Std. V	P-value
Anterior (a)	Left	12.00	2.60	0.771	0.00	0.00	-	10.88	2.44	0.357
	Right	11.88	3.14		0.00	0.00		19.45	92.32	
Posterior(p)	Left	16.11	3.95	0.847	22.37	3.63	0.859	18.85	3.85	0.431
	Right	16.21	4.09		22.28	3.65		18.40	4.10	
Medial (c)	Left	12.99	2.85	0.001	13.40	3.09	0.981	12.45	3.09	0.146
	Right	11.74	2.39		13.41	2.43		13.15	3.61	
Lateral (d)	Left	15.52	3.92	0.941	14.02	2.99	0.507	12.29	2.70	0.018
	Right	15.56	3.80		14.33	3.64		13.35	3.51	

Table 4-3: Descriptive Statistics of the Kidneys length, width, cortex width and medulla width and CT (HU) and ANOVA Test

Kidney	*Variable*	*Gender*	*N*	*Mean*	*Std. V*	*95% Confidence Interval for Mean*		*Min*	*Max*	*P-value*
Left	length of kidney	Male	42	95.00	11.28	91.49	98.52	71.30	117.80	.591
		Female	58	96.25	11.55	93.21	99.29	65.30	123.40	
		Total	100	95.73	11.40	93.47	97.99	65.30	123.40	
	width of kidney	Male	42	42.27	5.24	40.64	43.91	31.50	54.70	.696
		Female	58	42.68	5.11	41.34	44.03	33.20	57.60	
		Total	100	42.51	5.15	41.49	43.53	31.50	57.60	
	Cortex (axial)	Male	41	5.37	0.87	5.10	5.65	3.20	6.85	.282
		Female	58	5.19	0.79	4.98	5.40	3.10	6.70	
		Total	99	5.26	0.82	5.10	5.43	3.10	6.85	
	Medulla (axial)	Male	42	11.15	1.34	10.73	11.57	7.60	15.00	.762
		Female	58	11.25	1.90	10.75	11.75	6.80	17.60	
		Total	100	11.21	1.68	10.87	11.54	6.80	17.60	
Right	length of kidney	Male	42	95.11	8.61	92.43	97.79	79.60	113.40	.148
		Female	58	97.94	10.19	95.26	100.62	75.30	121.90	
		Total	100	96.75	9.61	94.8	98.66	75.30	121.90	
	width of kidney	Male	42	41.76	5.76	39.97	43.56	31.70	55.90	.219
		Female	58	40.45	4.81	39.19	41.72	30.00	51.90	
		Total	100	41.00	5.24	39.96	42.04	30.00	55.90	
	Cortex (axial)	Male	42	5.27	0.87	4.99	5.54	3.30	6.90	.554
		Female	57	5.17	0.7	4.95	5.38	3.20	6.70	
		Total	99	5.21	0.82	5.04	5.37	3.20	6.90	
	Medulla (axial)	Male	42	11.18	1.85	10.61	11.76	7.10	14.10	.093
		Female	58	10.55	1.80	10.07	11.03	5.40	14.80	
		Total	100	10.82	1.84	10.45	11.19	5.40	14.80	

Table 4-4: Descriptive Statistics of the Kidneys measurements at upper calyxes distributed according to gender and ANOVA test

Kidney	*Upper Calyx*	*Gender*	*N*	*Mean*	*Std. V*	*95% Confidence Interval for Mean*		*Min*	*Max*	*P-value*
Left	Anterior (a)	Male	42	12.05	2.83	11.16	12.93	4.70	20.00	.871
		Female	58	11.96	2.44	11.32	12.60	5.90	16.90	
		Total	100	12.00	2.60	11.48	12.51	4.70	20.00	
	Posterior (p)	Male	42	16.28	3.28	15.25	17.30	11.20	24.30	.715
		Female	58	15.98	4.40	14.82	17.14	8.60	24.60	
		Total	100	16.11	3.95	15.32	16.89	8.60	24.60	
	Medial (c)	Male	42	13.04	2.68	12.21	13.88	7.77	20.60	.883
		Female	58	12.96	2.98	12.17	13.74	4.70	23.40	
		Total	100	12.99	2.85	12.43	13.56	4.70	23.40	
	lateral (d)	Male	42	15.63	3.95	14.40	16.86	8.20	25.70	.814
		Female	58	15.44	3.94	14.41	16.48	7.31	26.10	
		Total	100	15.52	3.92	14.74	16.30	7.31	26.10	
Right	Anterior (a)	Male	42	12.04	2.91	11.13	12.95	7.00	16.70	.662
		Female	58	11.76	3.32	10.89	12.64	5.50	20.30	
		Total	100	11.88	3.14	11.25	12.50	5.50	20.30	
	Posterior (p)	Male	42	16.74	4.20	15.43	18.05	10.50	26.50	.277
		Female	58	15.83	3.99	14.78	16.89	8.30	24.90	
		Total	100	16.21	4.09	15.40	17.03	8.30	26.50	
	medial (c)	Male	42	12.02	2.51	11.24	12.81	7.50	18.00	.314
		Female	58	11.53	2.30	10.93	12.14	5.90	17.70	
		Total	100	11.74	2.39	11.26	12.21	5.90	18.00	
	lateral (d)	Male	42	16.28	4.25	14.95	17.60	9.60	30.60	.110
		Female	58	15.04	3.39	14.15	15.93	7.34	22.20	
		Total	100	15.56	3.80	14.81	16.32	7.34	30.60	

Table 4-5: Descriptive Statistics of the Kidneys measurements at renal pelvis distributed according to gender and ANOVA test

Kidney	*Renal Pelvis*	*Gender*	*N*	*Mean*	*Std. V*	*95% Confidence Interval for Mean*		*Min*	*Max*	*P-value*
Left	Posterior (p)	Male	42	22.48	2.85	21.59	23.37	18.10	29.20	.789
		Female	58	22.28	4.13	21.20	23.37	12.90	32.90	

		Total	100	22.37	3.63	21.65	23.09	12.90	32.90	
	Medial (c)	Male	42	14.57	2.50	13.79	15.35	10.30	21.00	.001
		Female	58	12.54	3.21	11.70	13.39	1.16	18.90	
		Total	100	13.40	3.09	12.78	14.01	1.16	21.00	
	lateral (d)	Male	42	14.74	3.25	13.72	15.75	9.70	27.10	.040
		Female	58	13.50	2.69	12.79	14.21	7.20	19.10	
		Total	100	14.02	2.99	13.42	14.61	7.20	27.10	
Right	Posterior (p)	Male	42	23.22	3.48	22.14	24.31	17.10	32.50	.026
		Female	57	21.58	3.65	20.61	22.55	14.50	29.80	
		Total	99	22.28	3.65	21.55	23.01	14.50	32.50	
	Medial (c)	Male	42	13.99	2.38	13.24	14.73	8.84	18.80	.041
		Female	58	12.98	2.40	12.35	13.62	8.84	20.40	
		Total	100	13.41	2.43	12.92	13.89	8.84	20.40	
	lateral (d)	Male	42	15.21	3.61	14.08	16.34	10.10	24.60	.040
		Female	58	13.70	3.55	12.76	14.63	6.62	24.50	
		Total	100	14.33	3.64	13.61	15.05	6.62	24.60	

Table 4-6: Descriptive Statistics of the Kidneys measurements at Lower Calyx distributed according to gender and ANOVA test

Kidney	***lower calyx***	***Gender***	***N***	***Mean***	***Std. V***	***95% Confidence Interval for Mean***		***Min***	***Max***	***p-Value***
Left	Anterior (a)	Male	41	10.86	2.58	10.04	11.67	4.40	15.80	.923
		Female	58	10.90	2.37	10.28	11.53	6.40	17.30	
		Total	99	10.88	2.44	10.40	11.37	4.40	17.30	
	Posterior (p)	Male	42	19.50	3.09	18.53	20.46	13.20	26.20	.152
		Female	58	18.37	4.28	17.25	19.50	8.80	28.80	
		Total	100	18.85	3.85	18.08	19.61	8.80	28.80	
	Medial (c)	Male	42	12.71	3.14	11.73	13.69	6.14	22.00	.479
		Female	57	12.26	3.06	11.45	13.08	6.50	23.40	
		Total	99	12.45	3.09	11.83	13.07	6.14	23.40	
	lateral (d)	Male	42	12.59	2.76	11.72	13.45	5.60	19.80	.357
		Female	58	12.08	2.65	11.38	12.78	6.78	22.00	
		Total	100	12.29	2.70	11.76	12.83	5.60	22.00	
Right	Anterior (a)	Male	42	32.26	142.40	12.11	76.63	2.60	933.00	.240
		Female	58	10.17	3.04	9.37	10.97	4.00	19.60	
		Total	100	19.45	92.32	1.13	37.76	2.60	933.00	
	Posterior (p)	Male	42	19.20	3.51	18.11	20.30	11.90	27.10	.097
		Female	58	17.82	4.42	16.66	18.98	10.00	33.30	
		Total	100	18.40	4.10	17.59	19.22	10.00	33.30	
	Medial (c)	Male	42	13.58	2.91	12.68	14.49	8.36	22.30	.307
		Female	58	12.83	4.04	11.77	13.90	7.28	27.30	
		Total	100	13.15	3.61	12.43	13.87	7.28	27.30	

	lateral (d)	Male	42	13.73	2.95	12.81	14.65	9.80	22.00	.353
		Female	58	13.07	3.87	12.05	14.08	7.68	25.70	
		Total	100	13.35	3.51	12.65	14.04	7.68	25.70	

Table 4-7: Descriptive Statistics of the Kidneys measurements distributed according to age and ANOVA test

Kidney	*Variable*	*Age class*	*N*	*Mean*	*Std. V*	*95% Confidence Interval for Mean*		*Min*	*Max*	*P-value*
Left	Length Of Kidney	10-19	7	96.14	10.73	86.21	106.07	85.90	112.30	.702
		20-29	14	97.60	10.52	91.52	103.67	76.40	115.20	
		30-39	19	93.17	10.77	87.98	98.36	65.90	114.50	
		40-49	23	98.43	11.29	93.55	103.31	82.20	121.20	
		50-59	18	94.19	15.70	86.38	102.00	65.30	123.40	
		60-70	19	94.95	8.36	90.92	98.98	81.30	114.80	
		Total	100	95.73	11.40	93.47	97.99	65.30	123.40	
	Width Of Kidney	10-19	7	40.58	4.98	35.97	45.19	34.10	46.00	.315
		20-29	14	40.74	5.04	37.82	43.65	33.40	52.00	
		30-39	19	41.73	3.93	39.84	43.63	33.20	47.10	
		40-49	23	43.25	3.65	41.66	44.83	37.50	54.00	
		50-59	18	44.38	5.17	41.81	46.96	35.90	57.60	
		60-70	19	42.65	7.30	39.13	46.17	31.50	55.30	
		Total	100	42.51	5.15	41.49	43.53	31.50	57.60	
Right	Length Of Kidney	10-19	7	96.88	13.57	84.33	109.43	79.60	116.50	0.255
		20-29	14	94.50	10.80	88.27	100.74	75.70	111.70	
		30-39	18	94.35	8.09	90.32	98.38	79.70	110.00	
		40-49	23	99.95	8.37	96.32	103.57	83.10	118.40	
		50-59	19	99.04	9.64	94.39	103.69	75.30	121.90	
		60-70	19	94.46	9.41	89.92	99.00	76.30	113.40	
		Total	100	96.75	9.61	94.84	98.66	75.30	121.90	
	Width Of Kidney	10-19	7	39.48	4.72	35.11	43.85	34.20	47.70	0.254
		20-29	14	39.01	4.82	36.22	41.79	30.00	45.80	
		30-39	18	40.91	3.66	39.08	42.73	33.80	48.10	
		40-49	23	40.30	4.51	38.35	42.26	31.60	49.40	
		50-59	19	43.10	5.97	40.22	45.98	33.50	51.90	
		60-70	19	41.87	6.61	38.68	45.06	31.70	55.90	
		Total	100	41.00	5.24	39.96	42.04	30.00	55.90	

Table 4-8: Descriptive Statistics of the Kidneys cortex and medulla measurements and CT (HU) distributed according to age and ANOVA test

Kidney	*Variable*	*Age class*	*N*	*Mean*	*Std. V*	*95% Confidence Interval for Mean*		*Min*	*Max*	*P-value*
Left	Cortex (axial)	10-19	7	5.16	.53	4.66	5.65	4.22	6.00	.400
		20-29	14	5.69	.73	5.26	6.11	4.45	6.70	
		30-39	19	5.19	.88	4.76	5.61	3.72	6.85	
		40-49	23	5.12	.83	4.76	5.48	3.20	6.60	
		50-59	18	5.15	.81	4.75	5.56	3.40	6.00	
		60-70	18	5.36	.91	4.90	5.81	3.10	6.10	
		Total	99	5.26	.82	5.10	5.43	3.10	6.85	
	Medulla (axial)	10-19	7	10.11	1.96	8.28	11.93	7.40	12.08	.318
		20-29	14	11.10	1.53	10.21	11.99	8.10	13.60	
		30-39	19	11.02	1.58	10.25	11.78	7.10	13.10	
		40-49	23	11.07	1.53	10.40	11.73	6.80	13.90	
		50-59	18	11.59	1.65	10.77	12.42	9.00	15.20	
		60-70	19	11.68	1.91	10.76	12.61	9.34	17.60	
		Total	100	11.21	1.68	10.87	11.54	6.80	17.60	
Right	Cortex (axial)	10-19	7	5.23	.82	4.46	5.99	4.09	6.70	.873
		20-29	14	5.45	.63	5.09	5.82	4.40	6.50	
		30-39	18	5.11	.84	4.69	5.53	3.67	6.60	
		40-49	23	5.15	.81	4.80	5.51	3.31	6.90	
		50-59	18	5.12	.82	4.71	5.53	3.30	6.30	
		60-70	19	5.26	1.00	4.78	5.75	3.20	6.50	
		Total	99	5.21	.82	5.04	5.37	3.20	6.90	
	Medulla (axial)	10-19	7	9.38	2.09	7.44	11.31	5.40	12.07	.109
		20-29	14	10.75	1.49	9.89	11.62	8.30	13.30	
		30-39	18	10.48	1.91	9.53	11.43	7.40	14.00	
		40-49	23	10.64	1.72	9.90	11.39	6.50	13.70	
		50-59	18	11.26	1.891	10.32	12.20	6.80	14.10	
		60-70	19	11.53	1.82	10.65	12.41	7.80	14.80	
		Total	99	10.82	1.84	10.45	11.19	5.40	14.80	
		Total	99	37.23	4.63	36.30	38.15	29.00	49.00	

Table 4-9: Descriptive Statistics of both Kidneys upper calyx measurements at different sites distributed according to age and ANOVA test

Kidney	*Upper Calyx*	*Age Class*	*N*	*Mean*	*Std. V*	*95% Confidence Interval for Mean*		*Min*	*Max*	*P-Value*
Left	Anterior (a)	10-19	7	12.25	1.37	10.98	13.53	11.00	14.70	.959
		20-29	14	11.60	3.12	9.80	13.41	4.70	16.70	
		30-39	19	11.87	2.73	10.55	13.18	5.90	16.60	
		40-49	23	11.85	2.47	10.78	12.92	8.20	16.90	
		50-59	18	12.46	2.96	10.98	13.93	9.30	20.00	
		60-70	19	12.06	2.43	10.89	13.23	7.90	16.80	
		Total	100	12.00	2.60	11.48	12.51	4.70	20.00	
	posterior (p)	10-19	7	16.85	5.61	11.66	22.05	9.20	22.90	.689
		20-29	14	16.57	3.39	14.60	18.53	11.40	22.50	
		30-39	19	14.88	3.58	13.15	16.61	8.60	24.60	
		40-49	23	16.23	4.43	14.31	18.15	9.20	23.20	
		50-59	18	16.91	3.71	15.06	18.75	11.40	24.30	
		60-70	19	15.81	3.80	13.97	17.64	9.30	22.70	
		Total	100	16.11	3.95	15.32	16.89	8.60	24.60	
	medial (c)	10-19	7	13.36	5.20	8.54	18.18	7.77	23.40	.640
		20-29	14	12.94	2.53	11.47	14.40	10.00	18.00	
		30-39	19	12.05	3.15	10.53	13.57	4.70	17.70	
		40-49	23	12.86	1.91	12.03	13.69	9.50	16.20	
		50-59	18	13.46	2.26	12.33	14.58	8.50	16.70	
		60-70	19	13.56	3.19	12.02	15.10	8.00	20.60	
		Total	100	12.99	2.85	12.43	13.56	4.70	23.40	
	Lateral (d)	10-19	7	14.90	4.96	10.30	19.49	10.40	22.40	.930
		20-29	14	14.77	3.72	12.62	16.92	9.70	21.10	
		30-39	19	15.22	4.31	13.14	17.30	7.31	25.70	
		40-49	23	16.06	4.02	14.31	17.80	9.58	26.10	
		50-59	18	15.60	3.51	13.85	17.34	8.20	21.60	
		60-70	19	15.88	3.90	14.00	17.77	9.10	20.70	
		Total	100	15.52	3.92	14.74	16.30	7.31	26.10	
Right	Anterior (a)	10-19	7	13.37	3.46	10.16	16.58	9.20	19.50	.168
		20-29	14	11.67	3.73	9.52	13.83	5.50	17.40	
		30-39	18	12.73	3.30	11.08	14.37	7.36	20.30	
		40-49	23	12.29	2.92	11.02	13.56	7.50	18.40	
		50-59	19	10.37	2.94	8.95	11.79	6.27	18.20	

		60-70	19	11.69	2.58	10.44	12.94	7.33	16.50	
		Total	100	11.88	3.14	11.25	12.50	5.50	20.30	
	posterior (p)	10-19	7	18.10	2.07	16.18	20.01	14.70	20.70	.842
		20-29	14	16.27	4.93	13.42	19.12	8.30	23.70	
		30-39	18	16.38	3.53	14.62	18.13	9.30	24.90	
		40-49	23	15.92	4.30	14.06	17.78	9.07	23.20	
		50-59	19	16.3	3.76	14.51	18.14	11.90	25.30	
		60-70	19	15.57	4.74	13.29	17.86	10.50	26.50	
		Total	100	16.21	4.09	15.40	17.03	8.30	26.50	
	Medial (c)	10-19	7	11.33	2.65	8.87	13.78	9.01	16.00	.715
		20-29	14	11.42	2.10	10.21	12.64	8.00	14.50	
		30-39	18	11.22	2.39	10.02	12.41	5.90	17.60	
		40-49	23	11.82	2.53	10.72	12.91	8.10	17.80	
		50-59	19	11.83	2.10	10.81	12.84	7.50	18.00	
		60-70	19	12.44	2.71	11.13	13.75	8.10	17.70	
		Total	100	11.74	2.39	11.26	12.21	5.90	18.00	
	lateral (d)	10-19	7	14.64	3.38	11.51	17.76	11.20	20.40	.440
		20-29	14	14.02	3.24	12.14	15.89	9.60	19.70	
		30-39	18	15.80	4.33	13.65	17.95	7.34	23.90	
		40-49	23	16.70	3.59	15.15	18.25	11.20	25.00	
		50-59	19	15.45	3.09	13.96	16.94	10.40	21.70	
		60-70	19	15.54	4.62	13.32	17.77	10.00	30.60	
		Total	100	15.56	3.80	14.81	16.32	7.34	30.60	

Table 4-10: Descriptive Statistics of both Kidneys renal pelvis measurements at different sites distributed according to age and ANOVA test

Kidney	***Renal Pelvis***	***Age Class***	***N***	***Mean***	***Std. V***	***95% Confidence Interval For Mean***		***Min***	***Max***	**P-Value**
Left	Posterior (p)	10-19	7	20.57	2.58	18.18	22.95	17.80	26.10	.166
		20-29	14	23.66	4.30	21.17	26.15	19.90	32.90	
		30-39	19	21.08	3.52	19.39	22.78	13.60	26.30	
		40-49	23	23.41	2.53	22.31	24.51	19.20	29.00	
		50-59	18	22.21	4.34	20.04	24.37	13.50	31.50	
		60-70	19	22.25	3.64	20.50	24.01	12.90	27.10	

		Total	100	22.37	3.63	21.65	23.09	12.90	32.90	
	Medial (c)	10-19	7	12.28	3.21	9.31	15.26	10.30	18.70	.264
		20-29	14	12.27	3.53	10.22	14.31	6.80	18.90	
		30-39	19	13.16	2.59	11.91	14.41	9.50	19.80	
		40-49	23	13.14	3.44	11.65	14.63	1.16	20.70	
		50-59	18	14.12	2.24	13.01	15.24	8.90	17.90	
		60-70	19	14.50	3.26	12.93	16.07	6.60	21.00	
		Total	100	13.40	3.09	12.78	14.01	1.16	21.00	
	lateral (d)	10-19	7	13.70	2.25	11.61	15.78	10.50	15.60	.006
		20-29	14	12.13	3.15	10.30	13.95	7.20	19.10	
		30-39	19	14.78	3.15	13.26	16.31	7.60	20.00	
		40-49	23	13.26	1.98	12.41	14.12	10.10	17.70	
		50-59	18	13.85	2.04	12.83	14.87	9.67	16.60	
		60-70	19	15.84	3.74	14.03	17.64	11.50	27.10	
		Total	100	14.02	2.99	13.42	14.61	7.20	27.10	
Right	Posterior (p)	10-19	7	22.80	3.35	19.70	25.89	20.20	28.40	.841
		20-29	14	22.32	3.57	20.25	24.38	19.00	29.80	
		30-39	18	22.20	3.35	20.53	23.87	15.50	28.80	
		40-49	23	21.74	2.67	20.58	22.89	16.00	25.60	
		50-59	19	21.87	4.71	19.60	24.14	14.50	32.50	
		60-70	18	23.23	4.21	21.14	25.33	14.80	28.90	
		Total	99	22.28	3.65	21.55	23.01	14.50	32.50	
	Medial (c)	10-19	7	11.86	2.33	9.71	14.02	8.84	14.70	.445
		20-29	14	12.93	2.27	11.62	14.25	9.30	18.50	
		30-39	18	13.37	2.43	12.16	14.58	9.43	17.30	
		40-49	23	13.94	2.44	12.89	15.00	10.30	18.80	
		50-59	19	13.74	3.03	12.27	15.20	9.00	20.40	
		60-70	19	13.37	1.83	12.49	14.26	10.20	17.40	
		Total	100	13.41	2.43	12.92	13.89	8.84	20.40	
	Lateral (d)	10-19	7	14.14	3.06	11.30	16.97	11.00	20.00	.416
		20-29	14	13.30	3.27	11.41	15.20	10.40	21.70	
		30-39	18	15.59	3.51	13.84	17.34	11.30	24.60	
		40-49	23	13.46	4.00	11.72	15.19	6.62	24.50	
		50-59	19	14.51	4.02	12.58	16.45	9.76	21.80	
		60-70	19	14.85	3.29	13.26	16.44	9.15	22.20	
		Total	100	14.33	3.64	13.61	15.05	6.62	24.60	

Table 4-11: Descriptive Statistics of both Kidneys lower calyex measurements at different sites distributed according to age and ANOVA test

Kidney	*lower calyx*	*Age class*	*N*	*Mean*	*Std. V*	*95% Confidence Interval for Mean*		*Min*	*Max*	*P-Value*
Left	Anterior (a)	10-19	7	10.14	1.77	8.51	11.78	8.70	13.80	.122
		20-29	14	10.33	2.59	8.83	11.83	4.40	14.40	
		30-39	19	12.30	2.41	11.14	13.46	8.05	17.30	
		40-49	23	10.64	2.36	9.61	11.66	6.90	16.30	
		50-59	17	10.39	2.33	9.19	11.59	7.00	15.80	
		60-70	19	10.89	2.53	9.67	12.11	6.11	15.60	
		Total	99	10.88	2.44	10.40	11.37	4.40	17.30	
	Posterior (p)	10-19	7	18.11	4.71	13.75	22.47	8.80	23.30	.589
		20-29	14	20.00	2.35	18.64	21.35	13.80	22.50	
		30-39	19	18.96	3.56	17.24	20.68	13.30	28.80	
		40-49	23	18.49	3.95	16.78	20.20	12.20	28.40	
		50-59	18	17.78	4.42	15.58	19.98	9.30	27.10	
		60-70	19	19.59	4.09	17.62	21.56	8.90	26.20	
		Total	100	18.85	3.85	18.08	19.61	8.80	28.80	
	Medial (c)	10-19	6	10.52	2.10	8.31	12.73	8.20	13.10	.026
		20-29	14	11.21	2.38	9.83	12.59	7.20	13.90	
		30-39	19	11.56	2.56	10.32	12.79	6.50	17.70	
		40-49	23	13.27	2.80	12.06	14.48	8.96	19.90	
		50-59	18	14.00	3.58	12.22	15.79	8.42	23.40	
		60-70	19	12.41	3.45	10.75	14.08	6.14	22.00	
		Total	99	12.45	3.09	11.83	13.07	6.14	23.40	
	lateral (d)	10-19	7	13.64	3.90	10.03	17.25	11.20	22.00	.154
		20-29	14	11.41	2.23	10.12	12.71	8.80	15.50	
		30-39	19	12.93	2.80	11.57	14.28	8.00	18.70	
		40-49	23	11.62	2.26	10.64	12.61	8.34	18.80	
		50-59	18	11.78	2.73	10.42	13.15	5.60	15.90	
		60-70	19	13.10	2.62	11.83	14.36	9.50	19.80	
		Total	100	12.29	2.70	11.76	12.83	5.60	22.00	
Right	Anterior (a)	10-19	7	12.20	2.58	9.81	14.59	9.44	16.50	.496
		20-29	14	9.73	2.66	8.19	11.27	4.80	13.60	
		30-39	18	60.95	217.65	47.27	169.19	2.60	933.00	
		40-49	23	9.78	3.38	8.32	11.25	4.00	19.60	
		50-59	19	10.61	2.71	9.30	11.92	5.73	15.30	

		60-70	19	10.49	3.07	9.00	11.97	5.12	17.50	
		Total	100	19.45	92.32	1.13	37.76	2.60	933.00	
	Posterior (p)	10-19	7	20.95	2.78	18.37	23.53	15.80	23.30	.347
		20-29	14	19.72	4.11	17.35	22.10	11.70	25.80	
		30-39	18	18.30	3.07	16.77	19.82	13.70	23.60	
		40-49	23	17.47	5.37	15.14	19.79	10.00	33.30	
		50-59	19	17.96	3.61	16.22	19.70	11.90	25.10	
		60-70	19	18.16	3.90	16.27	20.04	13.10	27.10	
		Total	100	18.40	4.10	17.59	19.22	10.00	33.30	
	Medial (c)	10-19	7	11.82	3.62	8.46	15.17	7.90	17.60	.292
		20-29	14	12.47	3.23	10.60	14.33	8.21	18.70	
		30-39	18	14.93	4.94	12.47	17.38	7.28	27.30	
		40-49	23	13.17	3.77	11.54	14.80	8.10	19.80	
		50-59	19	12.86	3.06	11.39	14.34	8.26	17.60	
		60-70	19	12.72	2.38	11.57	13.87	8.87	17.60	
		Total	100	13.15	3.61	12.43	13.87	7.28	27.30	
	Lateral (d)	10-19	7	14.78	2.48	12.48	17.08	11.70	18.90	.556
		20-29	14	13.20	2.31	11.87	14.54	10.40	18.70	
		30-39	18	14.12	4.41	11.92	16.32	7.68	25.70	
		40-49	23	13.33	4.46	11.39	15.26	7.97	24.40	
		50-59	19	12.22	2.70	10.92	13.53	7.74	17.20	
		60-70	19	13.34	3.01	11.88	14.79	8.50	22.00	
		Total	100	13.35	3.51	12.65	14.04	7.68	25.70	

Table 4-12: The right and left kidneys length, width, cortex and medulla measurements, CT number (HU) for cortex and medulla in the two studied groups (normal and diabetes), presented as mean and standard deviation and p-value.

Variables	Left Kidney	N	Mean	STDV	P-value	Right Kidney	Mean	STDV	P-value
length of kidney	Left(Normal)	100	95.73	11.40	.120	Right(Normal)	98.30	12.25	.396
	Left (DM)	50	98.77	12.11		Right(DM)	96.75	9.61	
	Total	150	97.25	11.75		Total	97.27	10.56	
width of kidney	Left(Normal)	100	42.51	5.15	.019	Right(Normal)	45.02	7.09	.000
	Left (DM)	50	44.91	7.14		Right(DM)	41.00	5.24	
	Total	151	43.32	5.98		Total	42.34	6.20	
cortex (axial)	Left(Normal)	99	5.26	.82	.000	Right(Normal)	6.17	.84	.000
	Left (DM)	51	6.12	.79		Right(DM)	5.21	.82	

	Total	150	5.55	.90		Total	5.54	.94	
medulla (axial)	Left(Normal)	100	11.21	1.68	.001	Right(Normal)	10.00	1.82	.010
	Left (DM)	50	10.11	1.97		Right(DM)	10.82	1.84	
	Total	150	10.84	1.85		Right(Normal)	10.54	1.87	
CT no cortex	Left(Normal)	100	19.18	6.23	.000	Right (DM)	29.60	4.05	.000
	Left (DM)	50	29.54	4.08		Right(Normal)	22.64	7.17	
	Total	150	22.68	7.44		Right(DM)	24.99	7.09	
CT no medulla	Left(Normal)	100	37.67	4.75	.041	Right(Normal)	36.29	3.36	.002
	Left (DM)	50	36.13	3.29		Right(DM)	37.23	4.63	
	Total	151	37.15	4.36		Total	36.91	4.25	

Table 4-13: The right and left kidneys upper calyx measurements, for anterior, posterior, medial and lateral segments in the two studied groups (normal and diabetes), presented as mean and standard deviation and p-value

Upper Calyx	Left Kidney	N	Mean	STDV	P-value	Right Kidney	Mean	STDV	P-value
Anterior (a)	Left(Normal)	100	12.00	2.60	.024	Right(Normal)	13.52	3.80	.005
	Left (DM)	50	13.13	3.35		Right(DM)	11.88	3.14	
	Total	151	12.38	2.91		Total	12.43	3.45	
Posterior (P)	Left(Normal)	100	16.11	3.95	.692	Right(Normal)	16.97	3.53	.262
	Left (DM)	50	16.38	3.95		Right(DM)	16.21	4.09	
	Total	151	16.20	3.94		Total	16.47	3.91	
Medial (C)	Left(Normal)	100	12.99	2.85	.218	Right(Normal)	13.52	2.59	.000
	Left (DM)	50	13.60	2.90		Right(DM)	11.74	2.39	
	Total	150	13.20	2.87		Total	12.34	2.59	
Lateral (D)	Left(Normal)	100	15.52	3.92	.504	Right(Normal)	17.67	15.08	.189
	Left (DM)	50	15.97	3.82		Right(DM)	15.56	3.80	
	Total	150	15.67	3.88		Total	16.27	9.29	

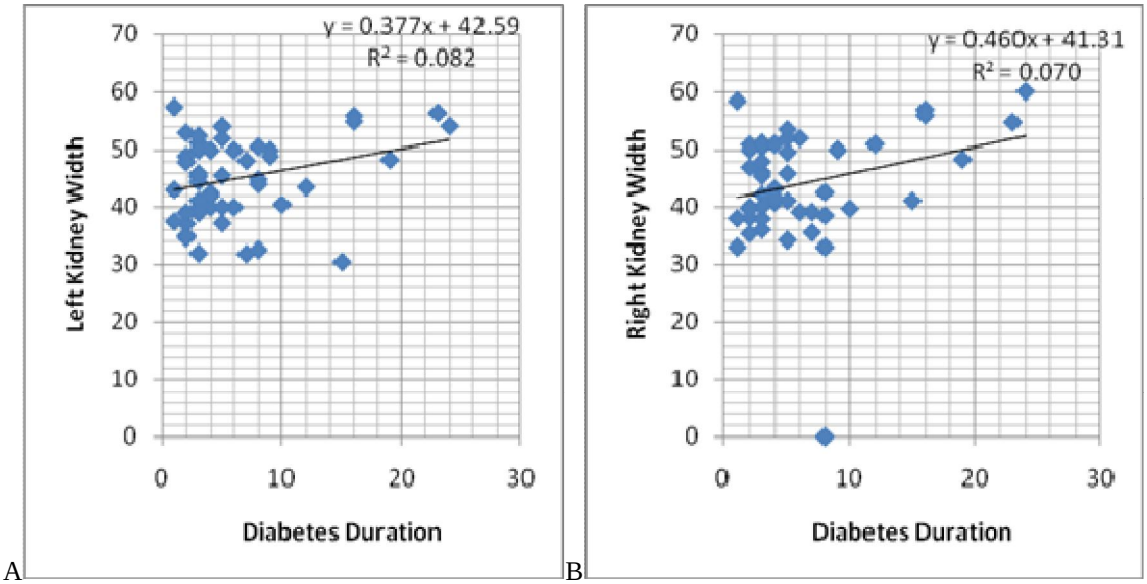
Table 4-14: The right and left kidneys renal pelvis measurements, for posterior, medial and lateral segments in the two studied groups (normal and diabetes), presented as mean and standard deviation and p-value

Renal Pelvis	Left Kidney	N	Mean	STDV	P-value	Right Kidney	Mean	STDV	P-value
Posterior (P)	Left (Normal)	100	22.37	3.63	.003	Right (Normal)	21.03	3.94	.056
	Left (DM)	50	20.48	3.53		Right (DM)	22.28	3.65	
	Total	150	21.73	3.70		Total	21.85	3.79	
Medial (C)	Left (Normal)	100	13.40	3.09	.185	Right (Normal)	13.89	3.34	.309
	Left (DM)	50	14.14	3.56		Right (DM)	13.41	2.43	
	Total	150	13.65	3.26		Total	13.57	2.77	
Lateral (D)	Left (Normal)	100	14.02	2.99	.553	Right (Normal)	14.45	2.91	.836
	Left (DM)	50	14.32	2.63		Right (DM)	14.33	3.64	
	Total	150	14.12	2.87		Total	14.37	3.40	

Table 4-15: The right and left kidneys Lower Calyx measurements, for posterior, medial and lateral segments in the two studied groups (normal and diabetes), presented as mean and standard deviation and p-value

Lower Calyx	Left Kidney	N	Mean	STDV	P-value	Right Kidney	Mean	STDV	P-value
Anterior (a)	Left (Normal)	99	10.88	2.44	.039	Right (Normal)	11.96	3.43	.564
	Left (DM)	51	11.81	2.83		Right (DM)	19.45	92.32	
	Total	150	11.20	2.61		Total	16.92	75.11	
Posterior (P)	Left (Normal)	100	18.85	3.85	.649	Right (Normal)	18.85	2.95	.487
	Left (DM)	50	18.55	3.39		Right (DM)	18.40	4.10	
	Total	151	18.75	3.69		Total	18.55	3.75	
Medial (C)	Left (Normal)	99	12.45	3.09	.002	Right (Normal)	13.76	2.89	.294
	Left (DM)	51	14.08	2.68		Right (DM)	13.15	3.61	
	Total	150	13.01	3.05		Total	13.36	3.39	
Lateral	Left	100	12.29	2.70	.005	Right	13.35	2.46	.987

(D)	(Normal)					(Normal)			
	Left (DM)	50	13.63	2.86		Right (DM)	13.35	3.51	
	Total	150	12.74	2.82		Total	13.35	3.18	



A B

Figure 4-3**A:** a scatter plot diagram shows the relation between the diabetes duration and left kidney width, as the diabetes duration increased the left kidney width increased by 0.377mm starting from 42.59mm and the impact/contribution of the diabetes to do effect on the left kidney width measurement is 82%. **B:** a scatter plot diagram shows the relation between the diabetes duration and right kidney width, as the diabetes duration increased the right kidney width increased by 0.460mm starting from 41.31mm and the impact/contribution of the diabetes to do effect on the width measurement is 70%.

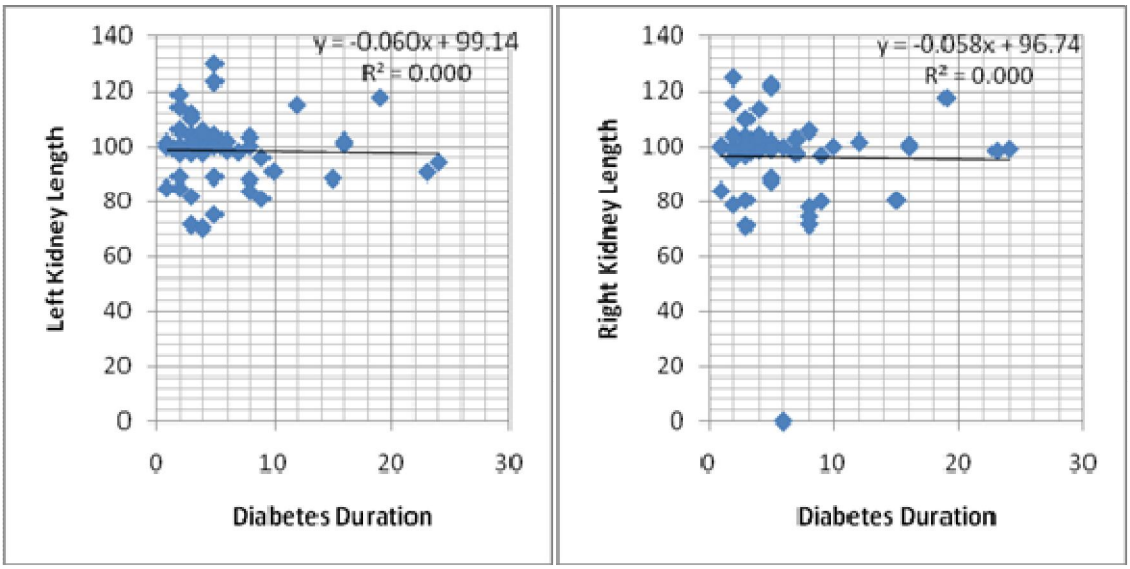


Figure 4-4**A:**a scatter plot diagram shows the relation between the diabetes duration and left kidney length, as the diabetes duration increased the left kidney length decreased by 0.063mm starting from 99.14mm and the impact/contribution of the diabetes to do effect on the left kidney length measurement is 0%.**B:**a scatter plot diagram shows the relation between the diabetes duration and right kidney length, as the diabetes duration increased the right kidney width decreased by 0.058mm starting from 96.74mm and the impact/contribution of the diabetes to do effect on the length measurement is 0%.

Figure 4. 5:a scatter plot diagram shows the relation betweenNormal Left kidney Length and Age,impact/contribution of the normal to do effect on the left kidney length measurement is 13%.

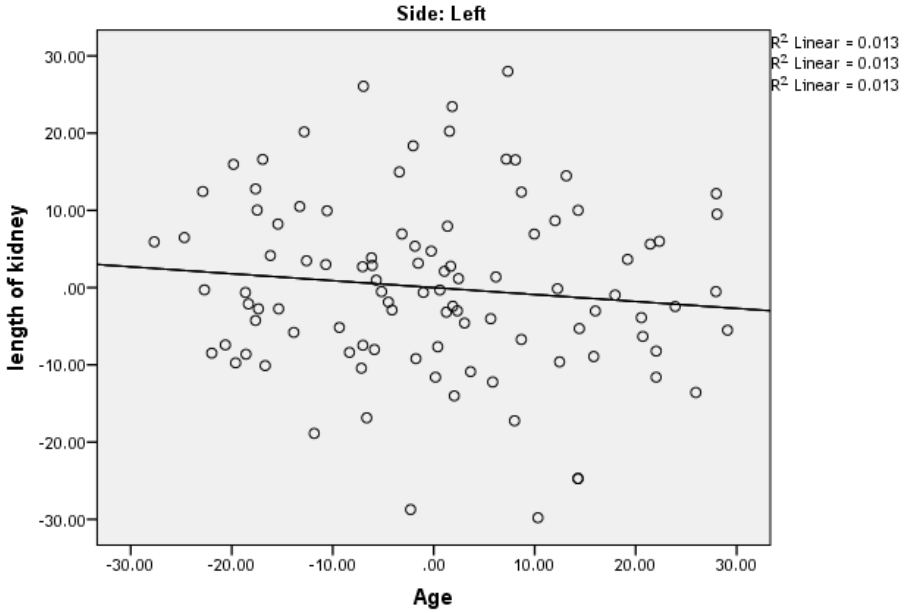


Figure4. 6:a scatter plot diagram shows the relation betweenNormal Rite kidney Length and Age,impact/contribution of the normal to do effect on the Rite kidney length measurement is 5%.

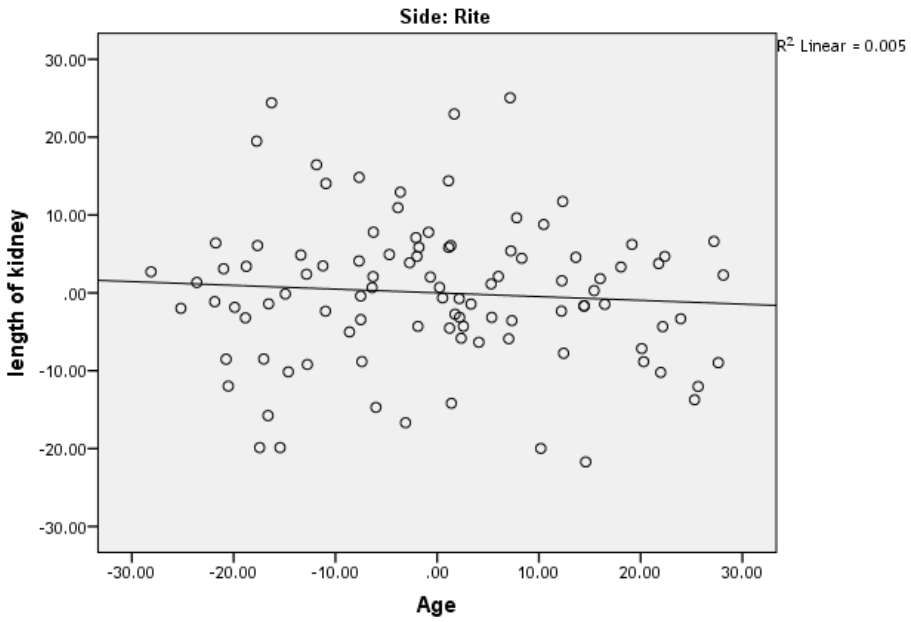


Figure 4. 7: a scatter plot diagram shows the relation between Normal Left kidney Width and BMI, impact/contribution of the normal to do effect on the left kidney Width measurement is 57%.

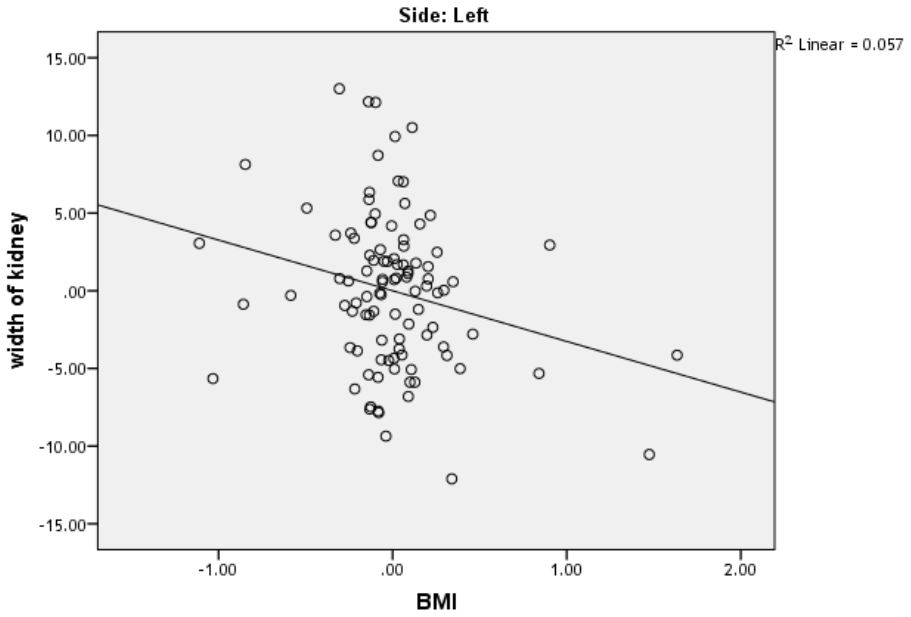


Figure 4. 8: a scatter plot diagram shows the relation between Normal Rite kidney Width and BMI, impact/contribution of the normal to do effect on the Rite kidney Width measurement is 2.3%.

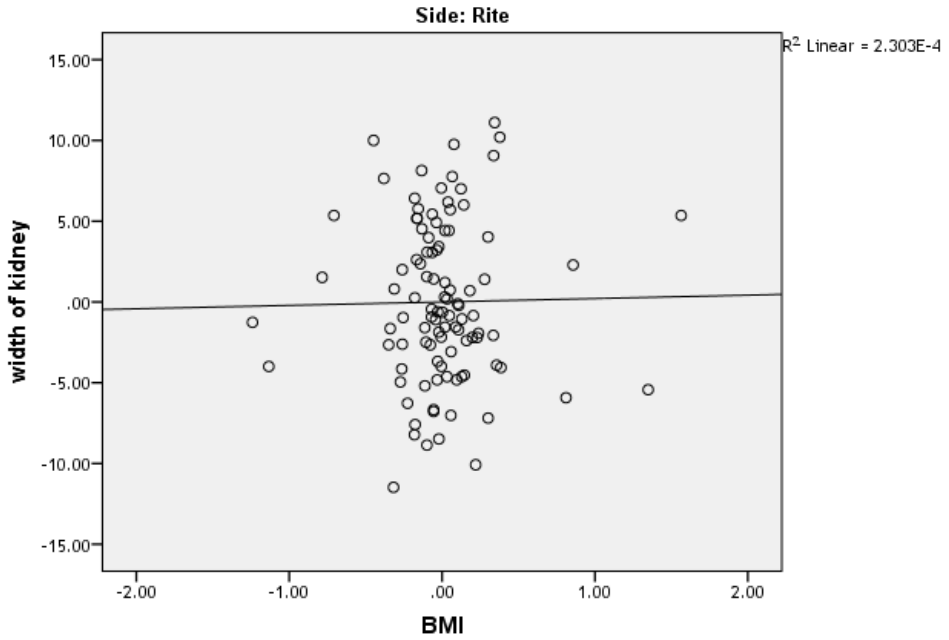


Figure 4. 7: Figure 4. 6: a scatter plot diagram shows the relation between Normal Rite kidney Length and BMI, impact/contribution of the normal to do effect on the Rite kidney Weight measurement is 40%

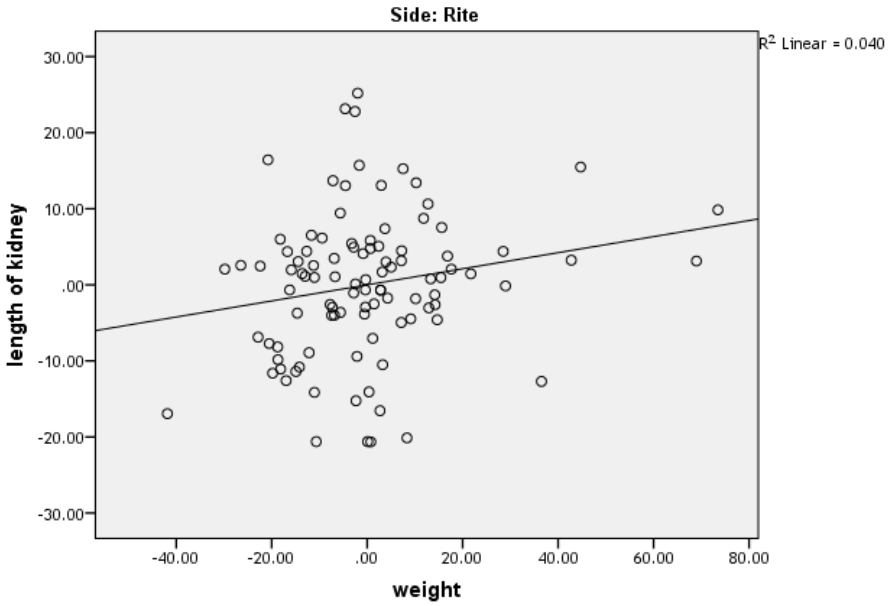
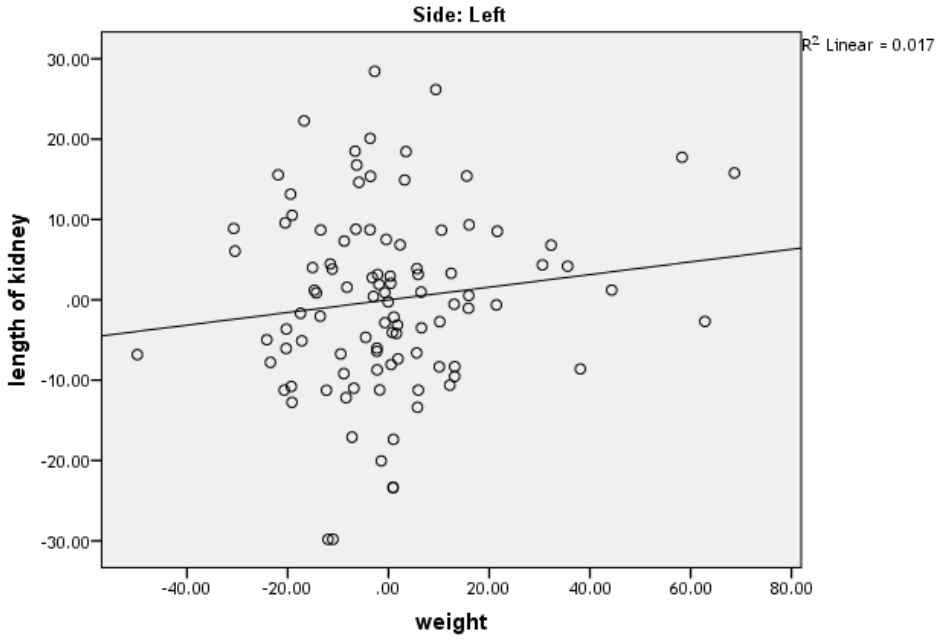


Figure 4. 6: a scatter plot diagram shows the relation between Normal Left kidney Length and Weight, impact/contribution of the normal to do effect on the left kidney length measurement is 17%.



Chapter Five

Discussion, conclusion and Recommendation

5-1 Discussion

This discussion study consist of data that were obtained for both left and right kidney from all the participants were renal length, width and CT number as well as renal character in the upper pole, calyces and lower pole as well as renal pelvis. All measurements were taken in mm .When comparing the right and left kidneys the study showed that there is no significant difference between the two kidneys length where were significant difference in kidneys width at $p \leq 0.041$, left kidney is greater than the right by 1.5cm (table 4-1).

The research agreed with previous studies done that left kidney is larger than the right [(Justo, et al., 2009), (Mazzotta, et al., 2002)] (Table 4-1) shows the

measurements of the kidneys as mean and standard deviation values. Both kidneys measurements at the upper calyx, renal pelvis, Lower calyx measured at all directions showed that the medial upper calyces for the left kidney measured in axial direction is larger significantly than the right kidney at $p \leq 0.001$ as well as the lateral (d) of the lower calyx differs significantly between the two kidneys at $p \leq 0.018$.Table (4-2).The likely due to the size of spleen which is smaller than the liver, thus the left kidney has more space for its growth. Another possible cause is that because of the left renal artery is shorter and straighter than the right one; this causes increased blood flow in the left artery which may result in relatively increased in measurements (Seyed, et al., 1993), (Wing, et al., 2009)].

The present data show that the kidney character including kidney length and width, cortex and medulla width were independent of gender; similar findings in other population have been mentioned. [(Justo, et al., 2009), (Wing, et al., 2010).

From the data obtained, we can also conclude that renal measurements in female population are relatively smaller compared to male population. However, the differences in renal measurements for upper and lower calyxes found in this study are quite minimal and not significant

Except for the measurement of the renal pelvis measurement were significantly differ between both genders for medial ,lateral measurements in both right and left kidneys at $p \leq 0.001$,0.040 and 0.041,0.040 respectively. The posterior measurement for the right kidney differed significantly between both genders at $p \leq 0.026$. In all cases the males have greater measurements than females regarding renal pelvis measurements.

Tables (4-3, 4-4, 4-5, 4- 6). In this study, renal size among different ethnicities for example Malaysian, Brazilian, Pakistani, Korean, Indian,

Caucasians etc. have been compared. Age, weight and height are also taken into account in this study. The study is done with ultrasound machine among Malaysian population and compare with other studies. The result shows that the renal size is different among different ethnicities.

The genders are not a predictor for changes in the renal measurements except for the medial and lateral renal pelvis segments for both right and left kidneys at ($P\leq$ 0.041, 0.040 and 0.001, 0.040). The age also is not a predictor for renal measurement except the renal pelvis lateral segment of the left kidney as well as lower calyx medial segment at $p\leq0.006$ and0.026.Tables (4-7, 4-11). A new chart for renal character and measurement were established according to different age classes from 10 years to 70 years and for both gendered s for Sudanese population.

Our study showed that meankidneylength was 96.75 mm for the right, and 95.73 mm for the left. The right kidneys width was 41.00 mm, less than the left 42.51mm at ($p <0.041$) when compared to the study done by Emamian et al.(Emamian, et al., 1993)based on Denmark population which consist of different ranged of age had shown that the renal lengths were 11.2cm on the left side and 10.9cm on the right side. The mean renal length for Denmark differs from Sudanese. Another study from Mexican population by (J. Oyuela, et al., 2009)had reported the renal length in Mexican adults differs as well as the gender has an impact in the kidneys measurements.

What we can say here is that all the differences in the previous studies were related to ethnic groups pointed that the results of this current study differ from other populations. Danish population left kidney length was found to be 11.2cm and the right kidney was 10.9cm, (Seyed, et al., 1993)In Mexicans; kidney length was 10.5cm for the left and 10.4cm for the right. (J. Oyuela, et al., 2009)Nigerian population has kidney length of 10.6 cm for

the left and 10.3cm for the right. (Okoye, et al., 2005). The Northwest Indian populations' measurements were 10.0cm for the left kidney length and 9.9cm for the right kidney (D. Shani, et al., 2001). Japanese have left kidney length of 11.5cm, right of 11.3 cm and width of 5.7 cm, 5.5cm for left and right in respectively (Tanaka, et al., 1989). Caucasians population have 12cm kidneys length and 6 cm kidneys width as mentioned by (Williams, et al., 1195).

It was mentioned that the renal hypertrophy has been noted in type1 diabetics (Christiansen, et al., 1981), it also exists in type 2 diabetes (Wirta, et al., 1996). Since the pioneer work of (Mogensen, et al., 1973), (Mogensen, et al., 1984)], the high risk of large kidneys in diabetic patients has been reported frequently (Lawson, et al., 1996), (Yamada, et al., 1992). However, all these studies were on the initial stages of renal involvement. Diabetic renal hypertrophy can persist for years despite good glucose control (Wiseman, et al., 1985), (Noortgate, et al., 200), (Zerbini, et al., 2006)].But with advanced renal insufficiency the kidneys become smaller (Boyd, R., et al., 1973) and this also occurs in diabetic patients, as reflected by the correlation between GFR and renal size as we found, in line with other authors (Zerbini, et al., 2006), (Yamada, et al., 1992) This late course raised the issue of whether kidney size remained a marker of progression in diabetic patients with more advanced chronic kidney disease.

Table (4-12) presented the measurement done for the right and left kidneys length, width, cortex and medulla measurements, CT number (HU) for cortex and medulla in the two studied groups (normal control group and diabetes group), presented as mean and standard deviation and p-value. There are significant difference between the kidney width of the control and diabetes group for the right and left kidneys at $p \leq 0.000$ and 0.019

respectively, as well as the measurements done in the axial planes for the cortex and medulla. A significant changes were detected for both kidneys in the cortex and medulla at p≤ 0.000 in each for the cortex and 0.010 and 0.001for the medulla when compared with the controls.

The measurements mean increased in diabetes group for length of the left kidney and decreased for length of the right kidney for the same patients ,the medulla width and CT number decreased in the left and increased in the right kidney,this findings was in consistent with what was mentioned previously that in fact; a review of kidney size in various nephropathies studies failed to include diabetes as a cause of bilateral enlargement (Boyd, R., et al., 1973) we also justify the finding of increasing the CT number is that in renal injury, accompanied the diabetic nephropathy the glomerular permeability increased and allow plasma proteins to escape into the urine. Some of these proteins will be taken up by the proximal tubular cells, which can initiate an inflammatory response that contributes to interstitial scarring eventually leading to fibrosis due to the stimulation of collagen and fibronectin(Hall P:2006). This lead to the difference in its attenuation values of the normal renal tissue.

Changes were also been detected in upper, and lower calyces as well as the renal pelvis for right and left kidneys of the diabetes group when compared with the controls and the differences were significant. These were presented in tables (4-13, 4-14, 4-15)

In the upper calyx, the anterior segments for both right and left were found to be changed significantly at p≤0.005, 0.024 respectively while only the medial segment is reduced significantly at p≤0.000 for the right kidney .In the renal pelvis assessment, the posterior segments for both right and left were found to be changed significantly at *p*≤0.056, 0.003 respectively. Left

segment is reduced and the right is increased. In the lower calyx assessment; the anterior, medial and lateral segments for the left kidney showed significant changes at $p \leq 0.039$, 0.002 and 0.005 respectively, while the right kidney did not show any changes in all segments when compared with the diabetes group.

The justification of the changes happened in the kidneys measurements are that early diabetes is heralded by glomerular hyperfiltration and an increase in GFR. This is believed to be related to increased cell growth and expansion in the kidneys, Long-standing hyperglycemia is known to be a significant risk factor for the development of diabetic nephropathy. Hyperglycemia may directly result in mesangial expansion and injury by an increase in the mesangial cell glucose concentration. The glomerular mesangium expands initially by cell proliferation and then by cell hypertrophy. Increased mesangial stretch and pressure can stimulate this expansion (Hall P: 2006).

The description of the fact of the pathogens and changes; is that the first major structural change after onset of type I diabetes is enlargement of the whole kidney (Christiansen, et al., 1981) and individual glomeruli (0sterby, et al., 1975).Studies work with the structural and functional natural history of diabetic nephropathy has identified the expansion of the mesangium and the reduction in peripheral capillary surface as constituting the mechanism leading to the demise in kidney function (Mauer, et al., 1984),(Ellis, et al., 1986),(Chavers, et al., 1989).It is well established that GFR is increased in early diabetes. ((Mogensen, el al., 1971), (Mogensen, el al., 1993) as well as in long-term diabetics. (Mogensen, 1972) In one study; it has been shown that the roentgenographic kidney size is increased. Therefore the current study presented the impact of the diabetes duration on the kidneys length and width.Figure 4-3(A and B) and figure 4-4(A and B) presented the results

and showed that as the diabetes duration increased the left kidney width increased by 0.377mm starting from 42.59mm and the impact/contribution of the diabetes to do effect on the left kidney width measurement is 82%. While the right kidney width increased by 0.460mm starting from 41.31mm and the impact/contribution of the diabetes to do effect on the width measurement is 70%. For the left kidney length, as the diabetes duration increased the left kidney length decreased by 0.060mm starting from 99.14mm and as the diabetes duration increased the right kidney length decreased by 0.058mm starting from 96.74mm.

The samples of the current study have diabetes duration from eight months up to 24 years. The limitation of our study is the small sample size without considering the drug used or the type of diabetes in the kidneys changes burden. Results of similar studies discuss the changes happened in the kidneys regarding the diabetes duration; they have mentioned that the majority of patients had diabetes for over fifteen years have a small and consistent decrease in kidney size as the duration of diabetes increased, and Kidneys remained enlarged in many instancesin patients with diabetes of well over twenty-five years' duration.(Charles B., 1974).

Several investigators (Mogensen, 1972), (Ditzel, J., 1968), (Mogensen, et al., 1973) have found increased glomerular filtration rates both early (Mogensen, 1972), (Ditzel, J., 1968)] andlate (Mogensen, et al., 1973) in the course of diabetes. (Mogensen et al. 1972) have shown that this increased glomerular filtration rate correlates closely with the increased kidney size seen in diabetic patients.

5-2 Conclusion

The CT scanning has been the best choice for kidneys diagnosis and diseases assessment. From the results, we conclude that: for normal patients, Right renal length is smaller than left kidney. There is weak positive correlation between age and kidney width and length. Renal length, width, cortex, and size are significantly larger in males than in females. the renal length and width in the current study is shorter than Denmark‘s and Pakistanian population renal length and width. .Also, it is smaller than Caucasian population renal length and width. Also there is a significant correlation between between normal left kidney width and BMI in a linear from as R2 = 0.057 and 2.303 for left and right kidney respectively as well as the kidney length versus duration with R2 = 0.000 and 0.000 for left and right kidney respectively

The result reveals that the diabetes has direct impact on kidney morphology in view of renal width of left kidney enlargement and cortical thickening an medulla in early stage, then atrophied in late stage, also the CT number (Hounsfield units) for cortex and medulla is increased . Diabetes affected the

parenchyma thickness, and CT number. Diabetes affect in the upper calyx, the anterior, posterior segments. Renal pelvis posterior for both right and left kidneys were found to be changed significantly

Such finding could be utilized successfully to assess the diabetes severity and stage as well as to determine the treatment model.

Recommendation

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

- The CT should be route in patients DM for kidneys measurements because it ishighly sophisticated and better than other modalities.
- CT could be used as routine checkup to help treatment and control of diabetic disorders.
- Execution of the using of other imaging modalities like MRI, ultrasound (especially duplex ultrasound for evaluating renal vasculature).
- Must increase awareness of diabetes programs and other approaches, e.g. social media. This includes the need to increase awareness among health professionals.
- Reviewed importance of the role of diabetes education in preventing hospital readmissions

- More study and researches are needed with bigger sample of population to have accurate result are needed.

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Appendix

Images

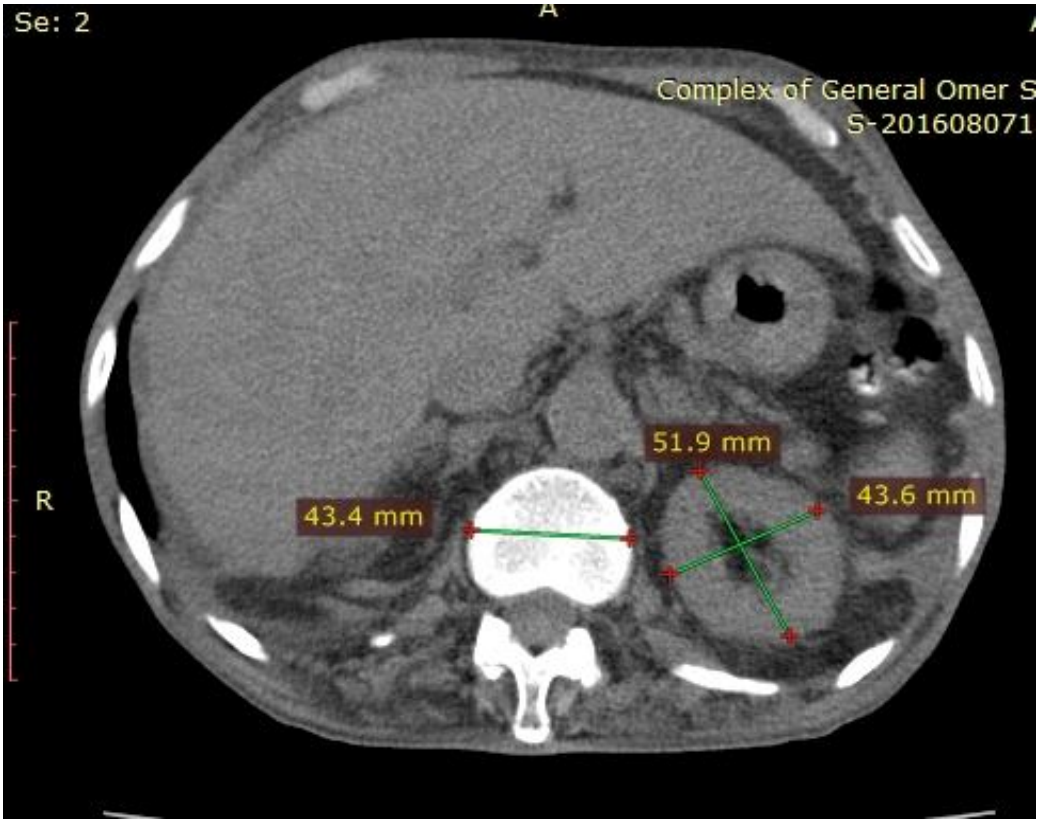
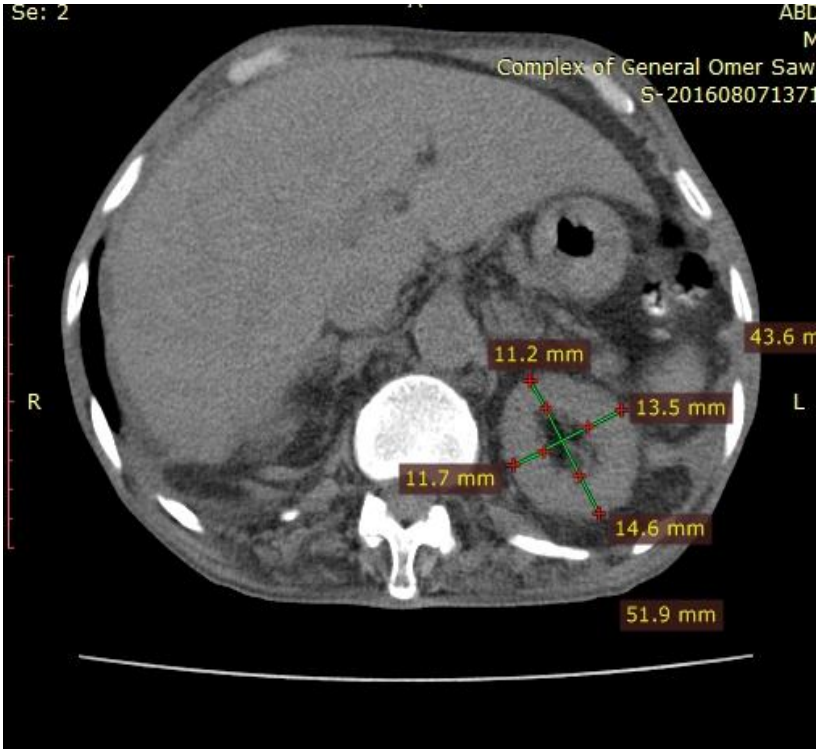
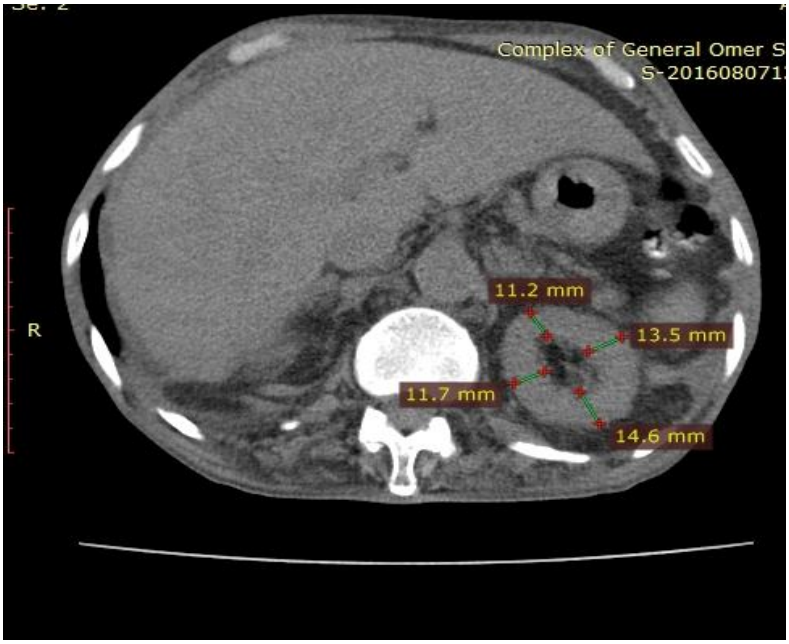


Fig. (A): axial view of left kidney in a 70-year old male patient with normal findings.

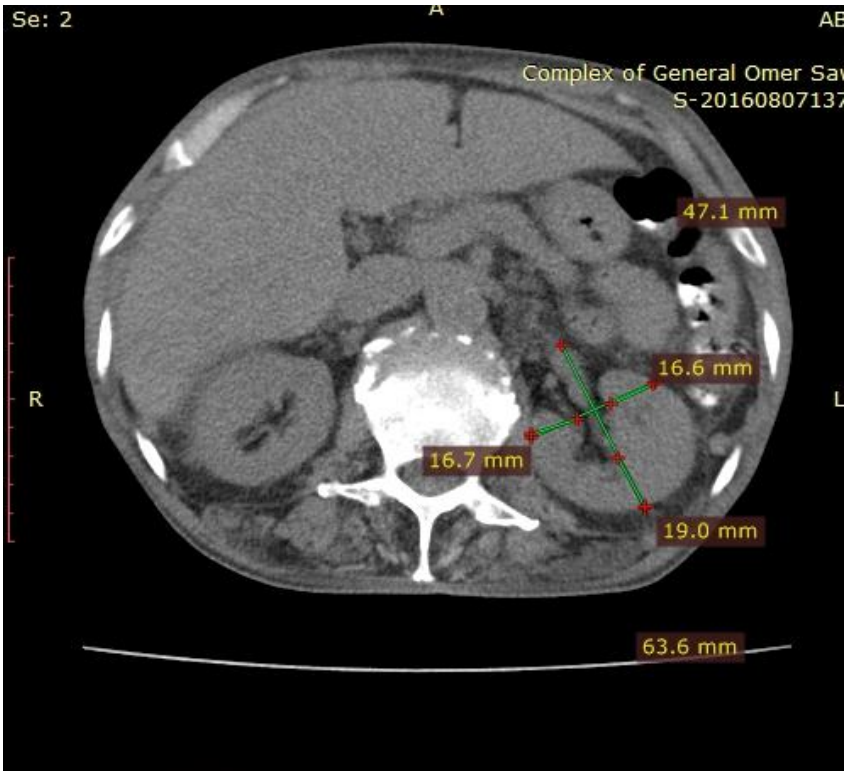
5-1 (A) Upper calyx and (D) L1



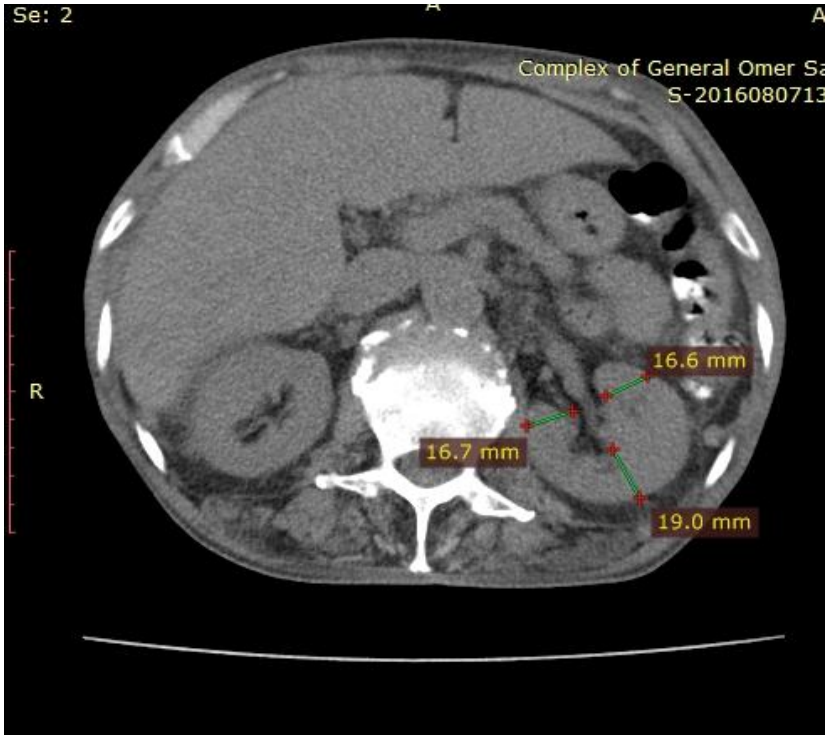
5-2 (A) Upper calyx



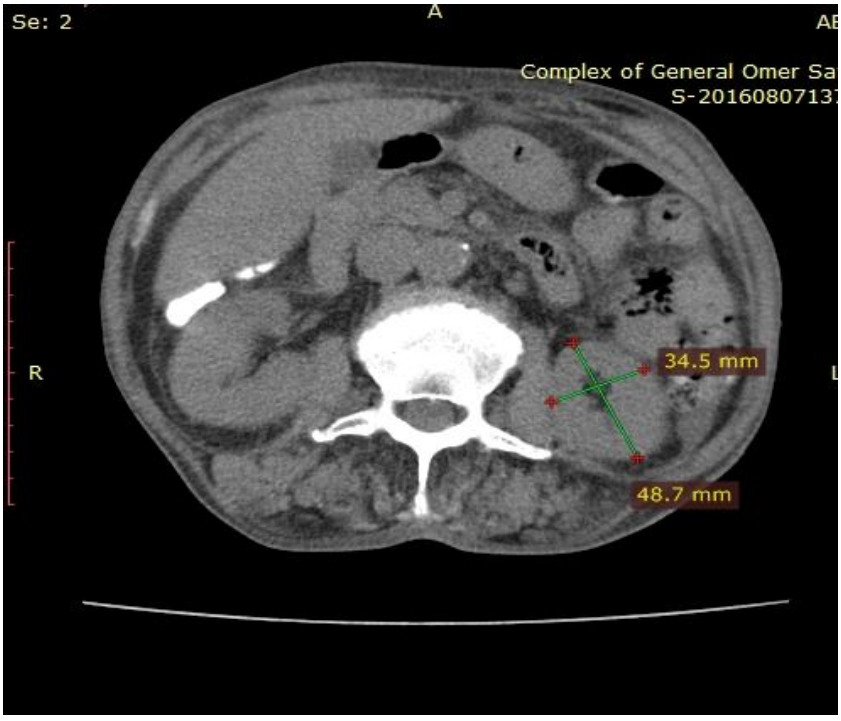
5-3A, upper calyx



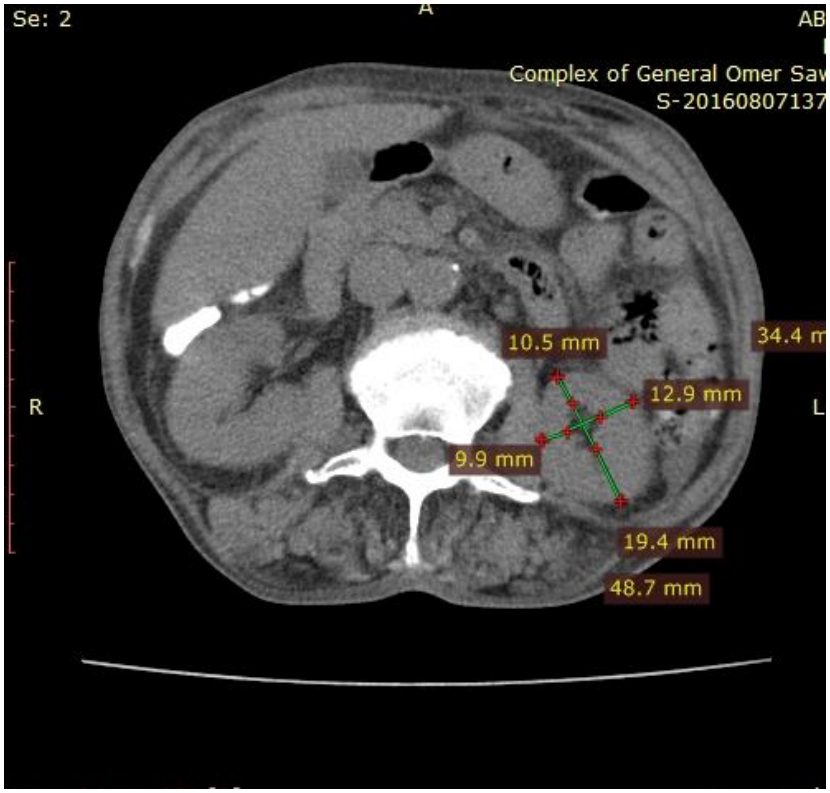
5-4B, renal pelvis



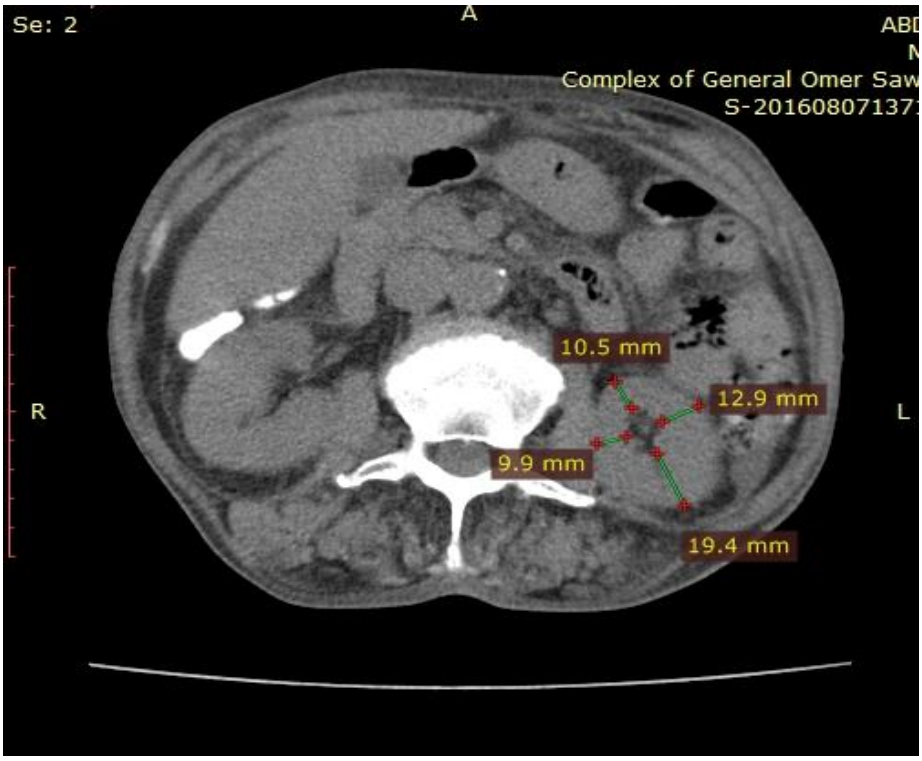
5-5B, renal pelvis



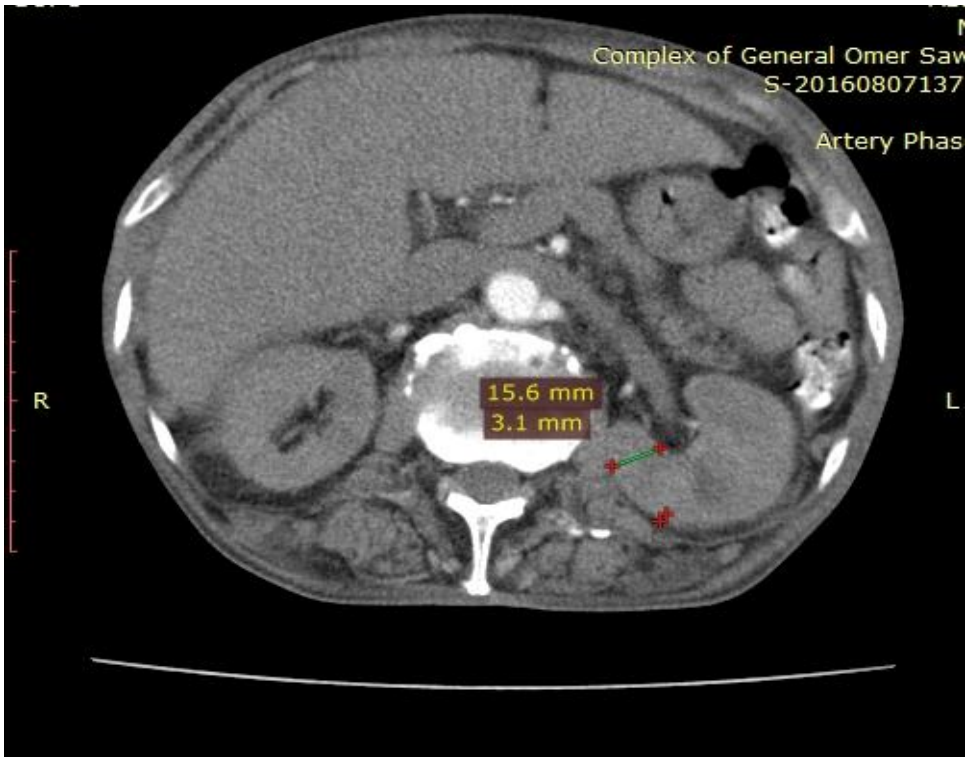
5-6 C, lower calyx



5-7 C, lower calyx



5-8C, lower calyx



5-9 Cortex and Medulla (axial)

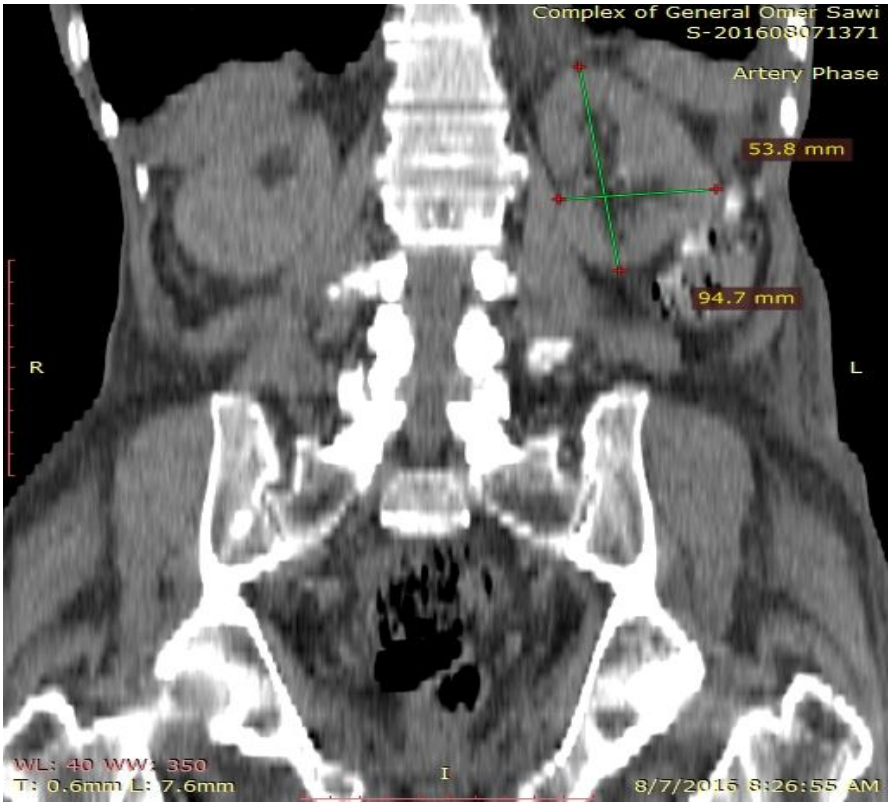
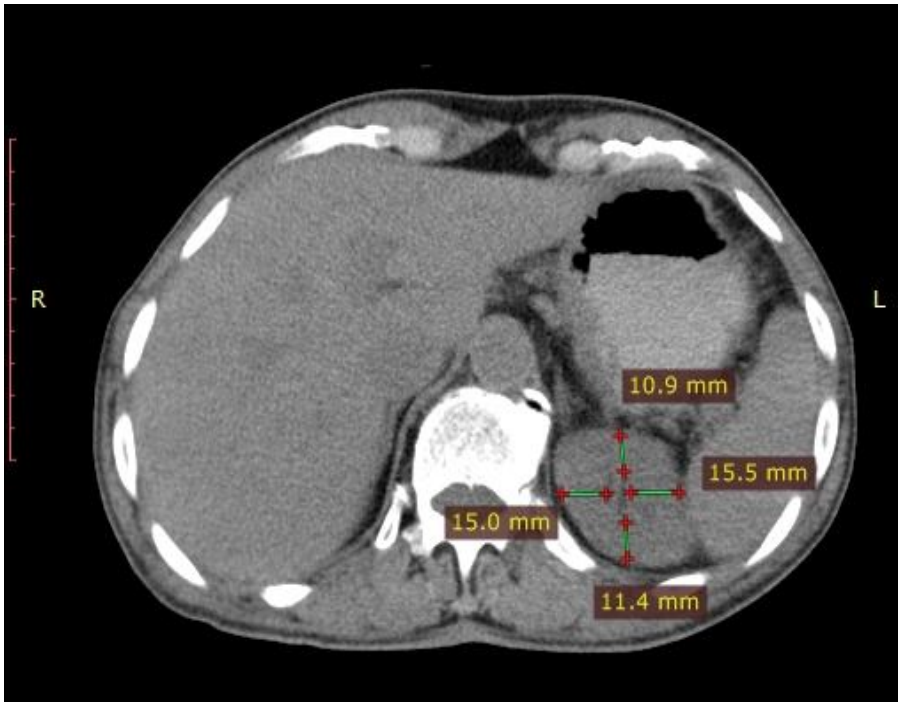
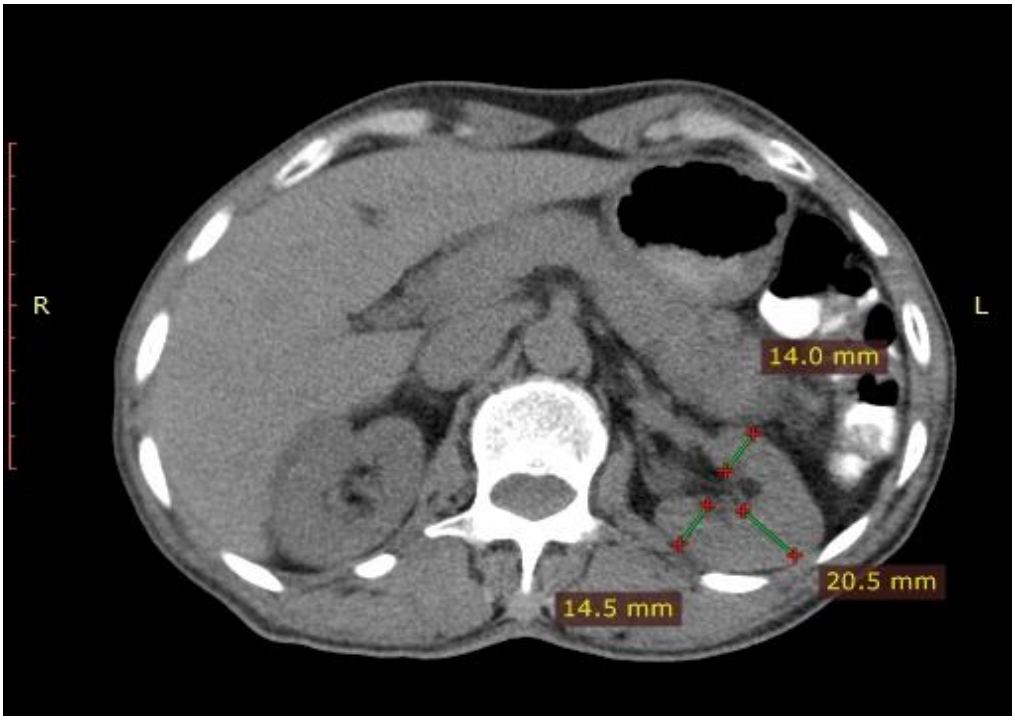


Fig. (A-1): axial view of left kidney in a 66 -year old male patient with normal finding

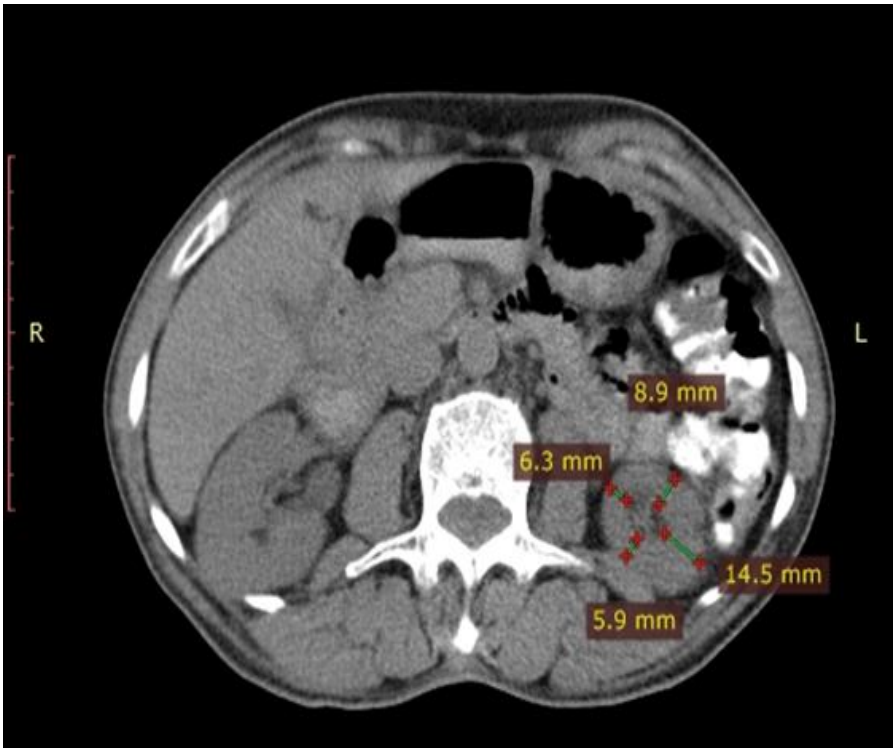
5-10 Length andwidth of left kidney (coronal)



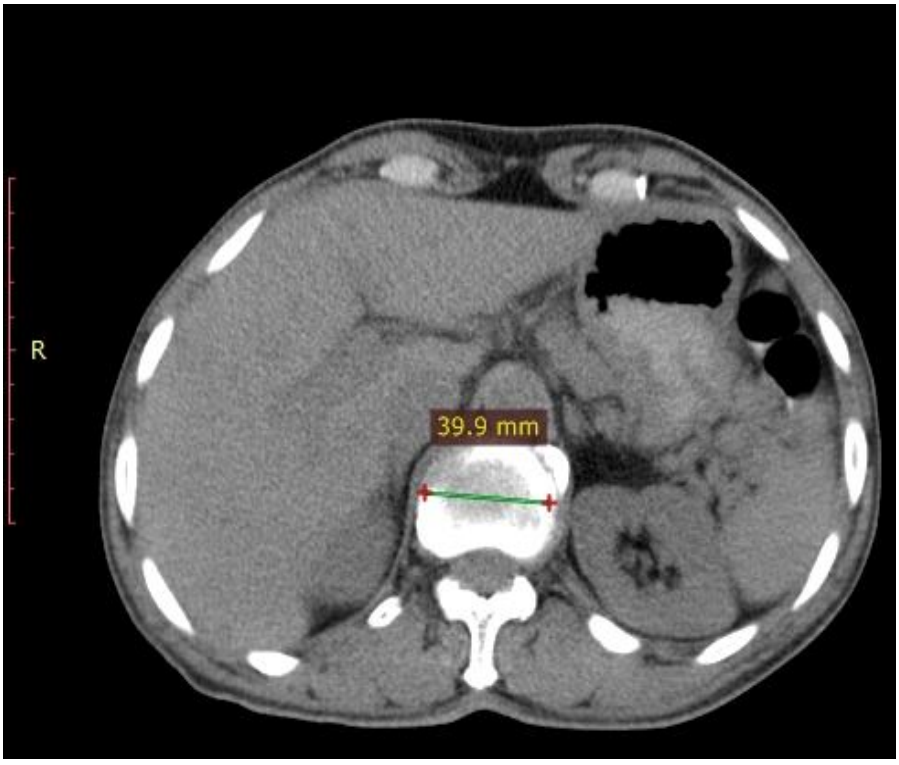
5-11(A-1), upper calyx



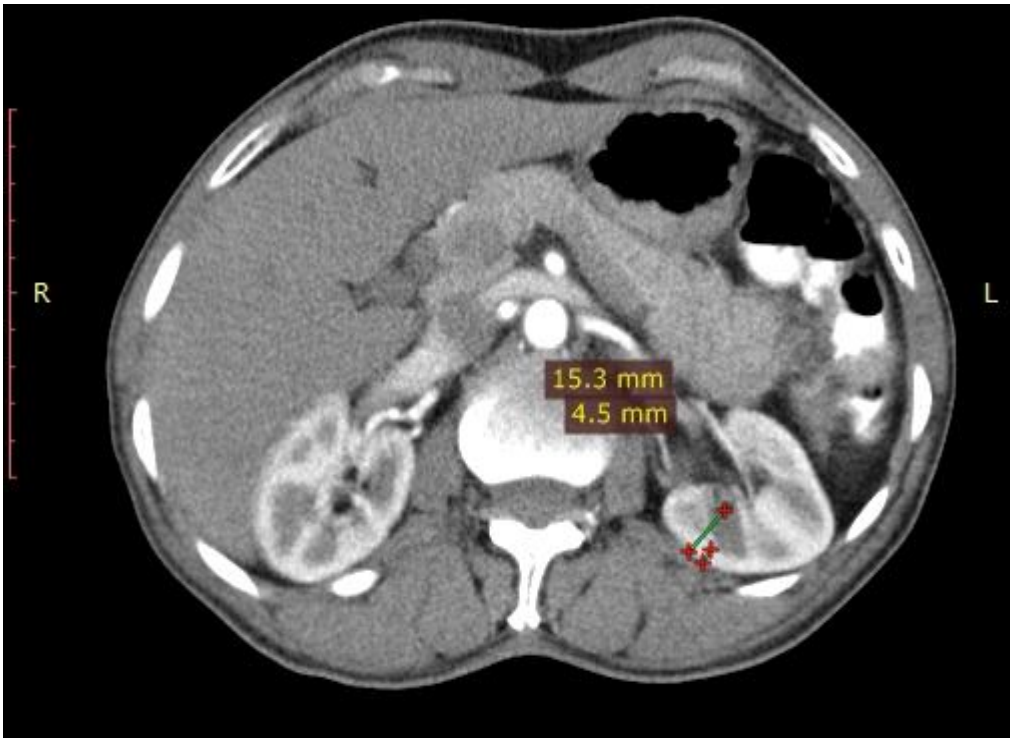
5-12(B-1), renal pelvis



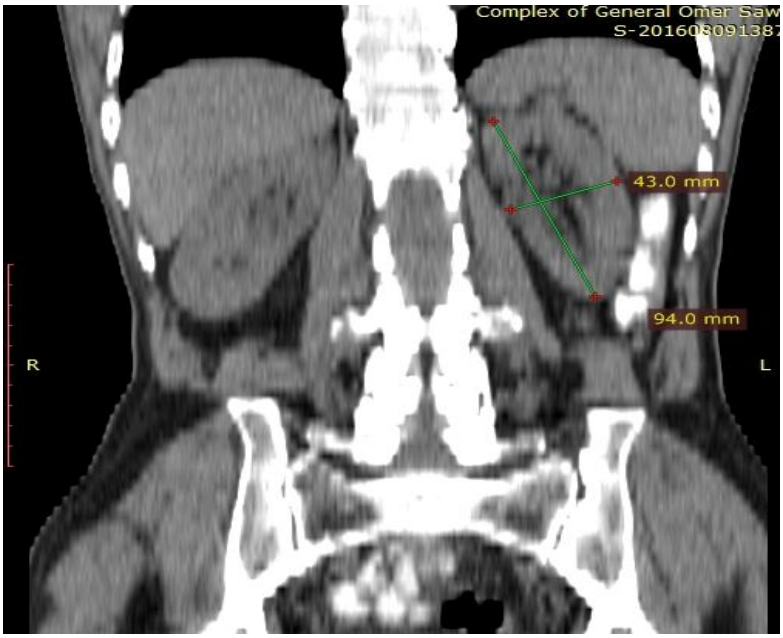
5-13(C-1), lower calyx



5-14(D-1) L1



5-15 Cortex and Medulla (axial)



5-16 Length and width of left kidney (coronal)

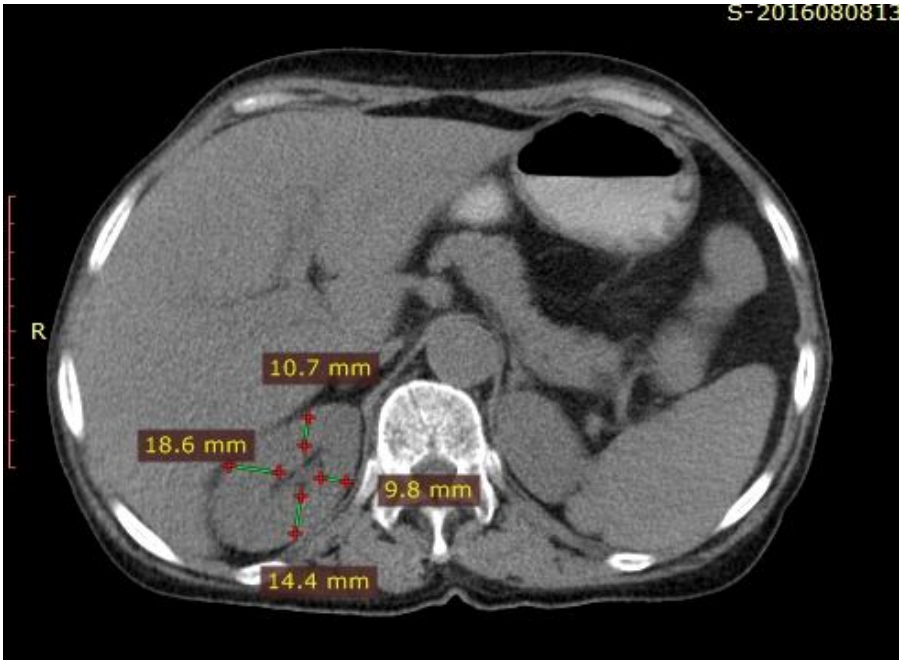
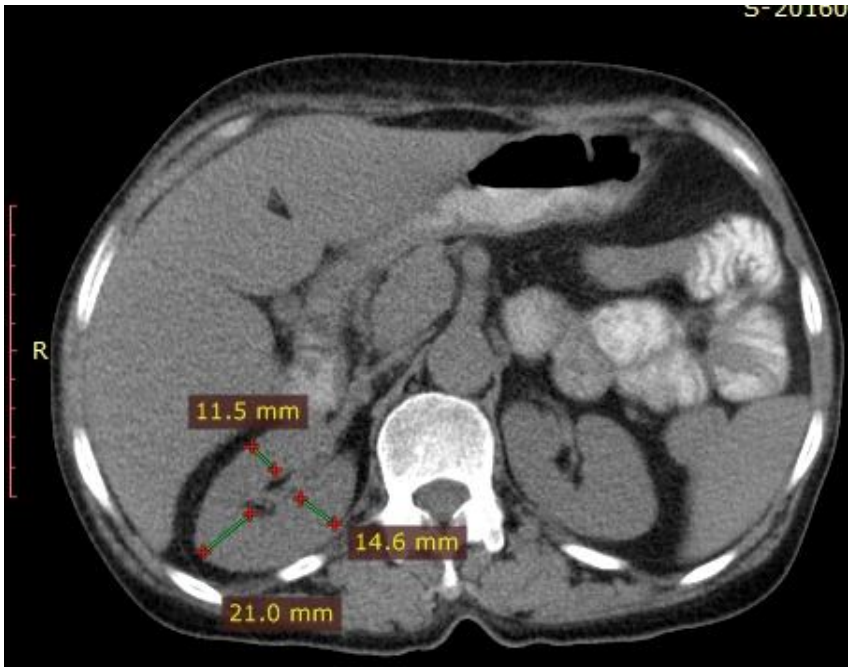
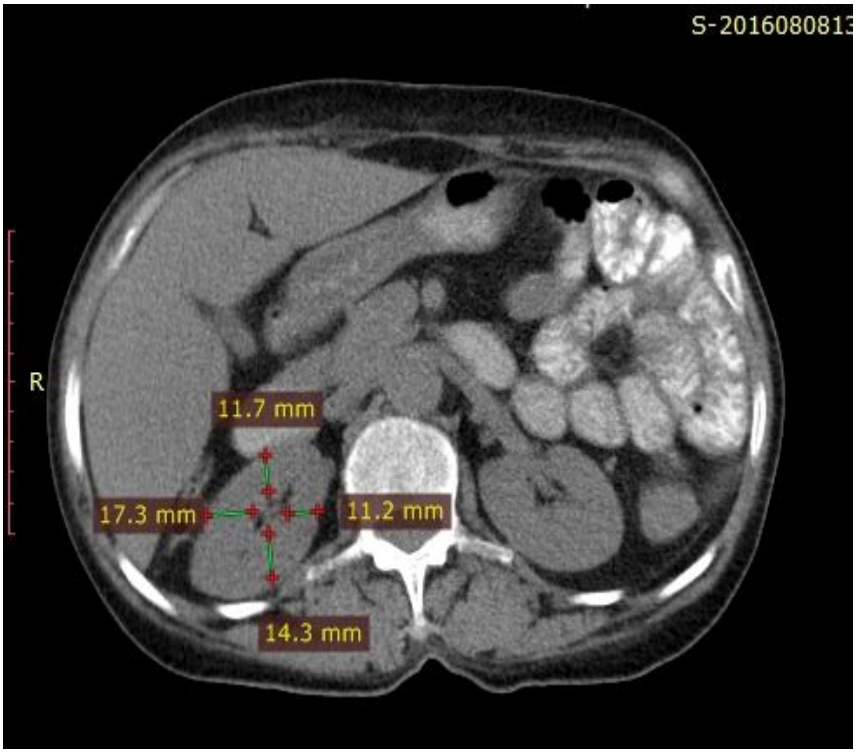


Fig. (A-2): axial view of rightkidney in a 65-year old female patient with normal findings

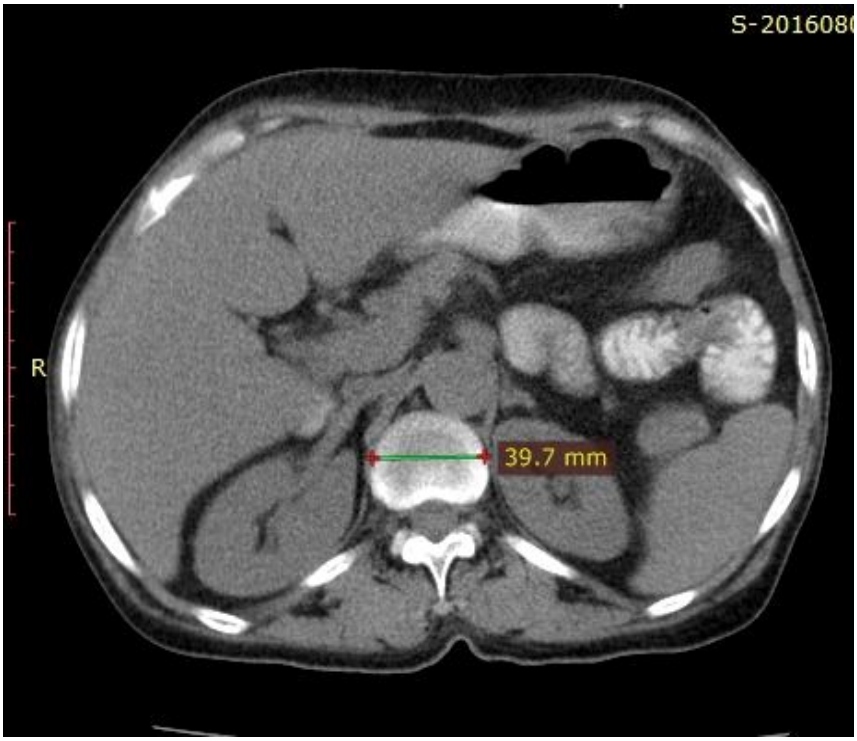
5-17(A-2), upper calyx (right)



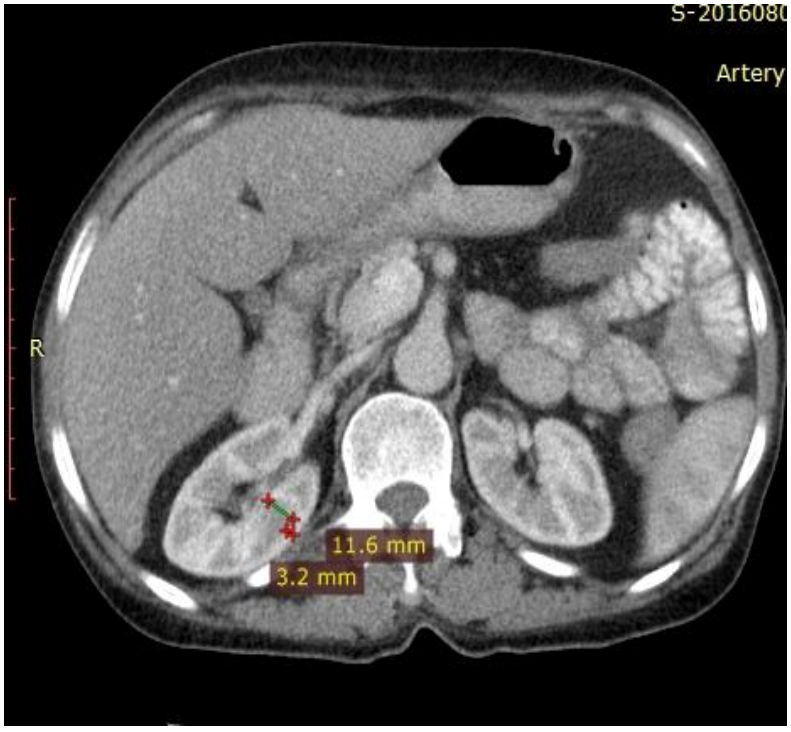
5-18(B-2), renal pelvis



5-19(C-2), lower calyx

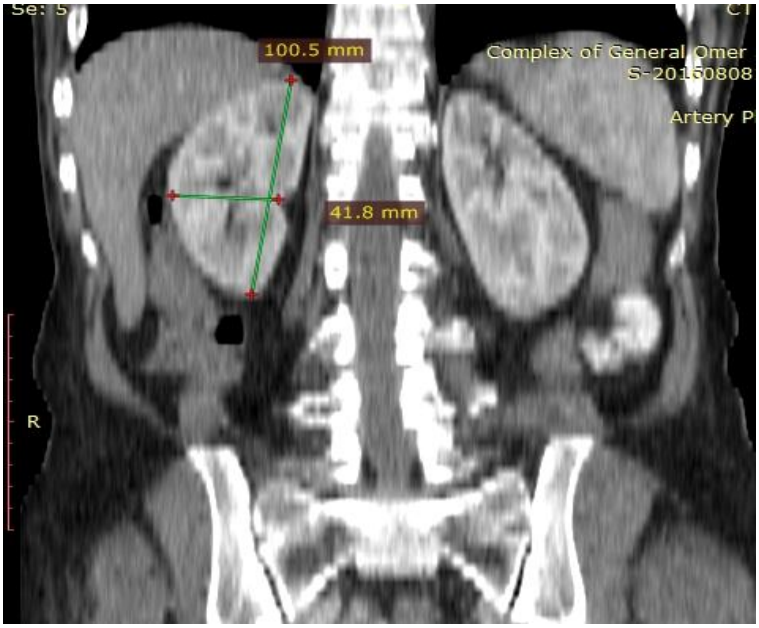


5-20 (D-2) L1



Length andwidth of right

5-21 Cortex and Medulla (axial)



5-22kidney (coronal)

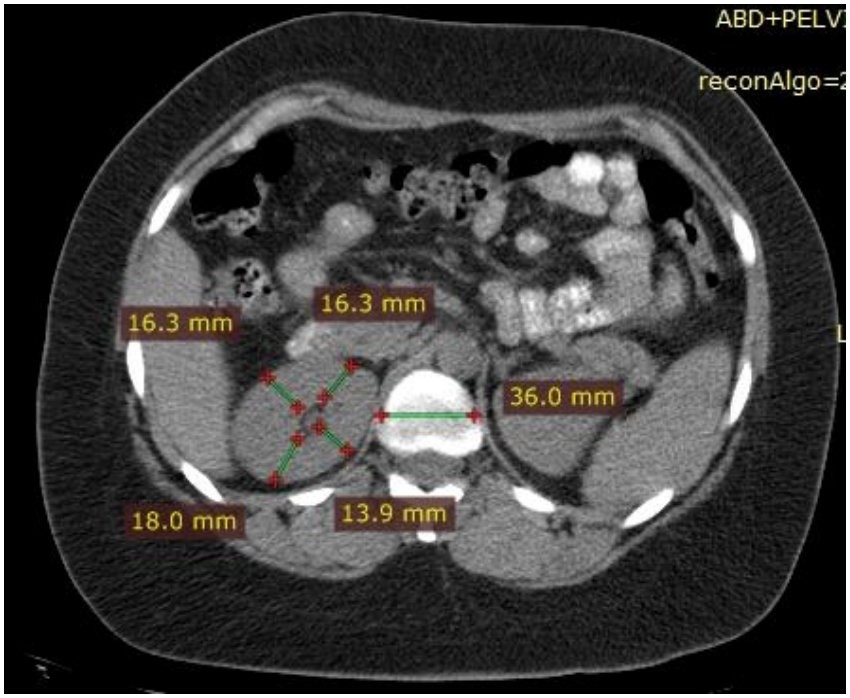
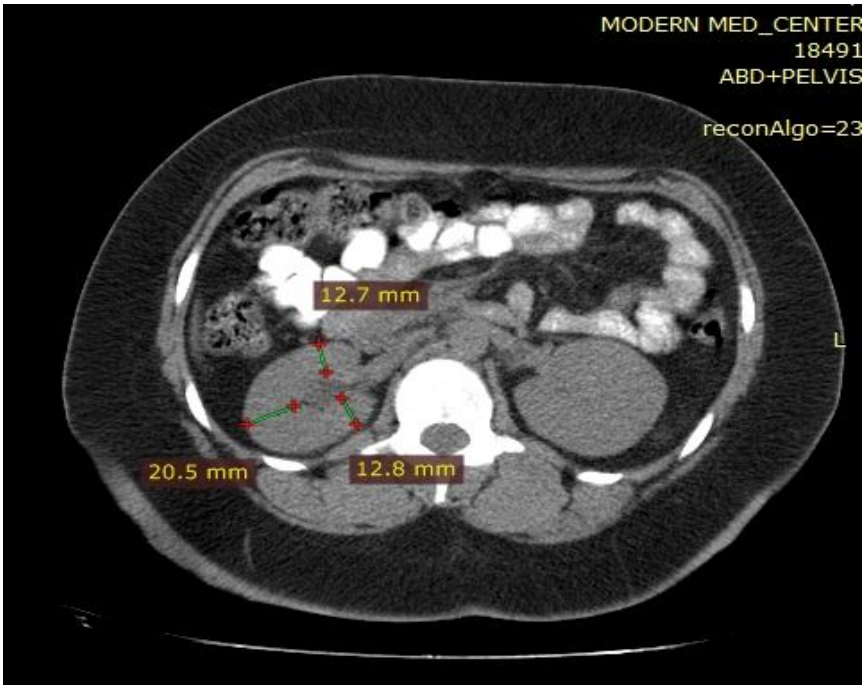
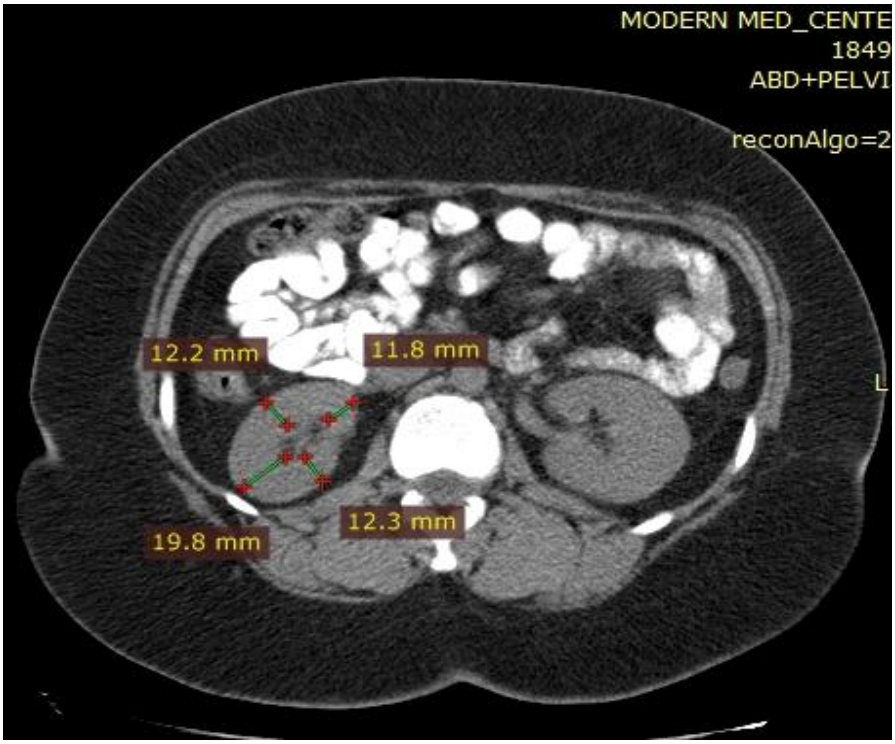


Fig. (A-3): axial view of right kidney in a 27-year old female patient with normal Findings

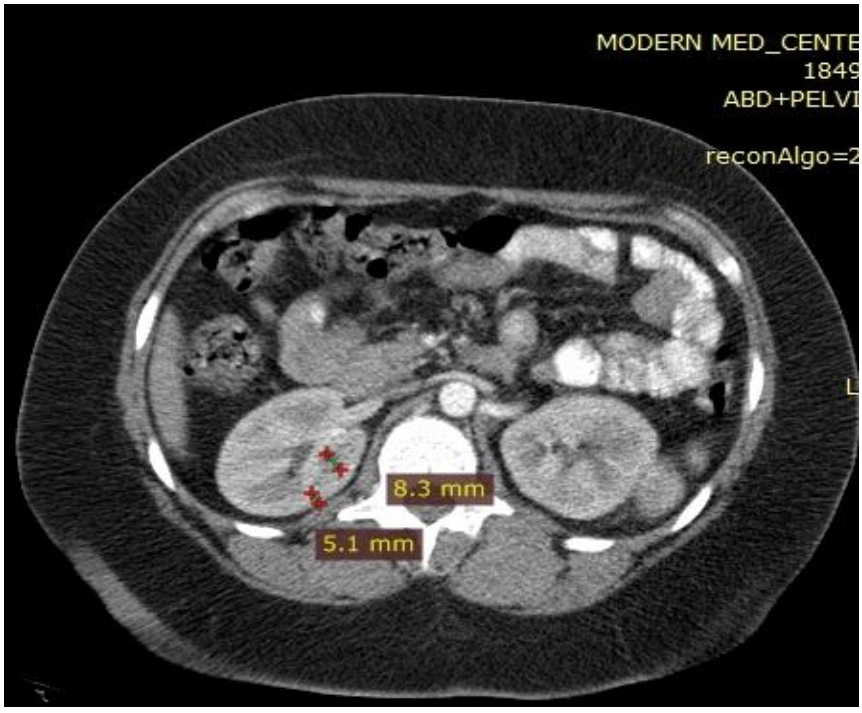
5-23(A-3), upper calyx and (D) L1



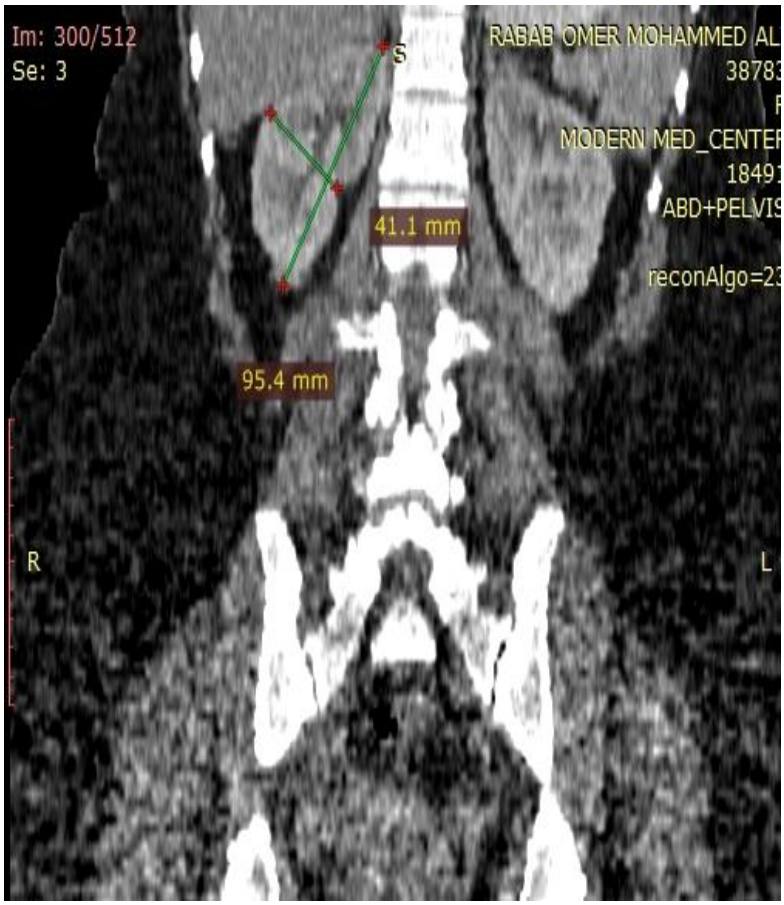
5-24(B-3), renal pelvis



5-25(C-4), lower calyx



5-26Cortex and Medulla (axial)



5-27Length and width of right kidney (coronal)

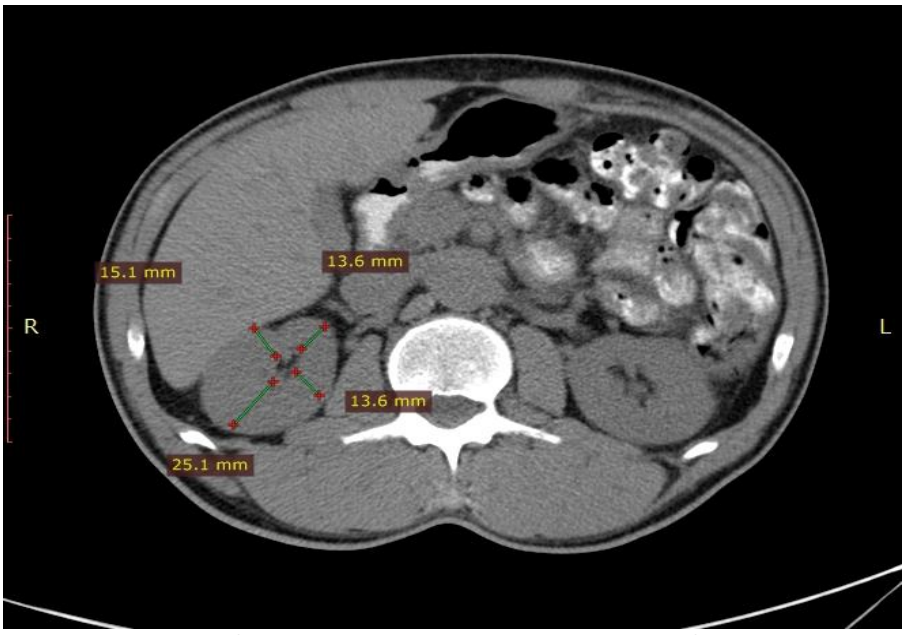
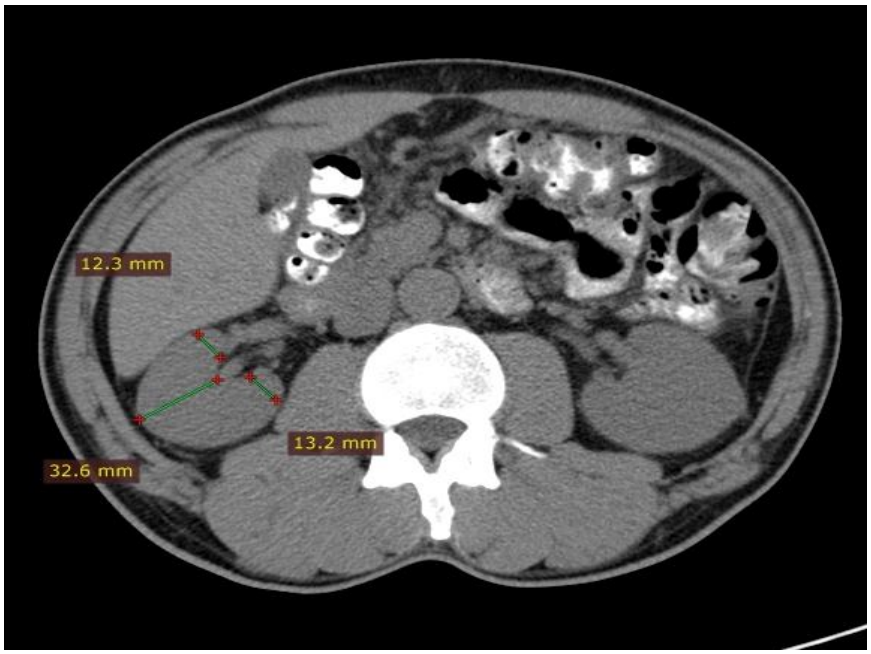
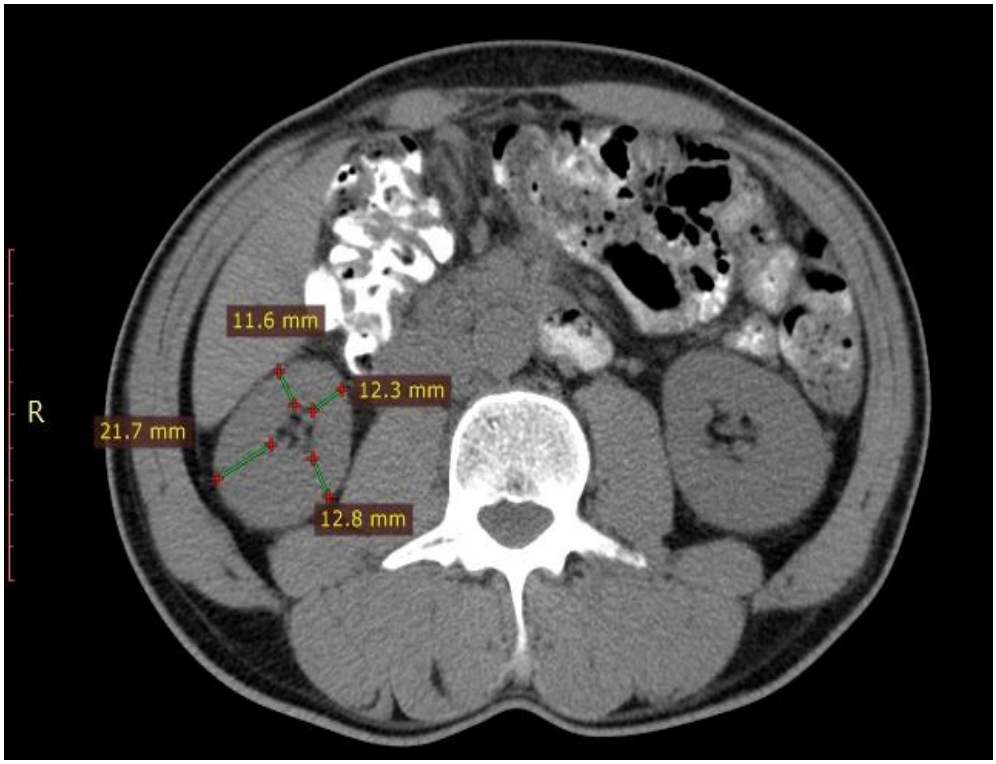


Fig. (A-4): axial view of right kidney in a 44-year old female patient with normal Findings

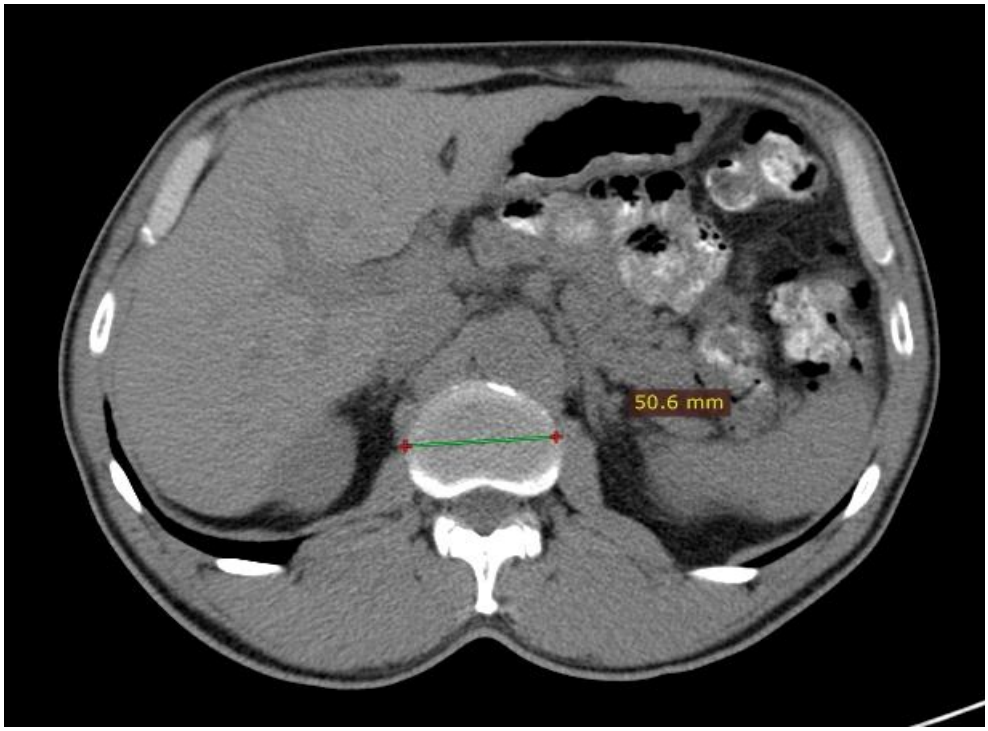
Upper calyx and L 5-28(A-4),



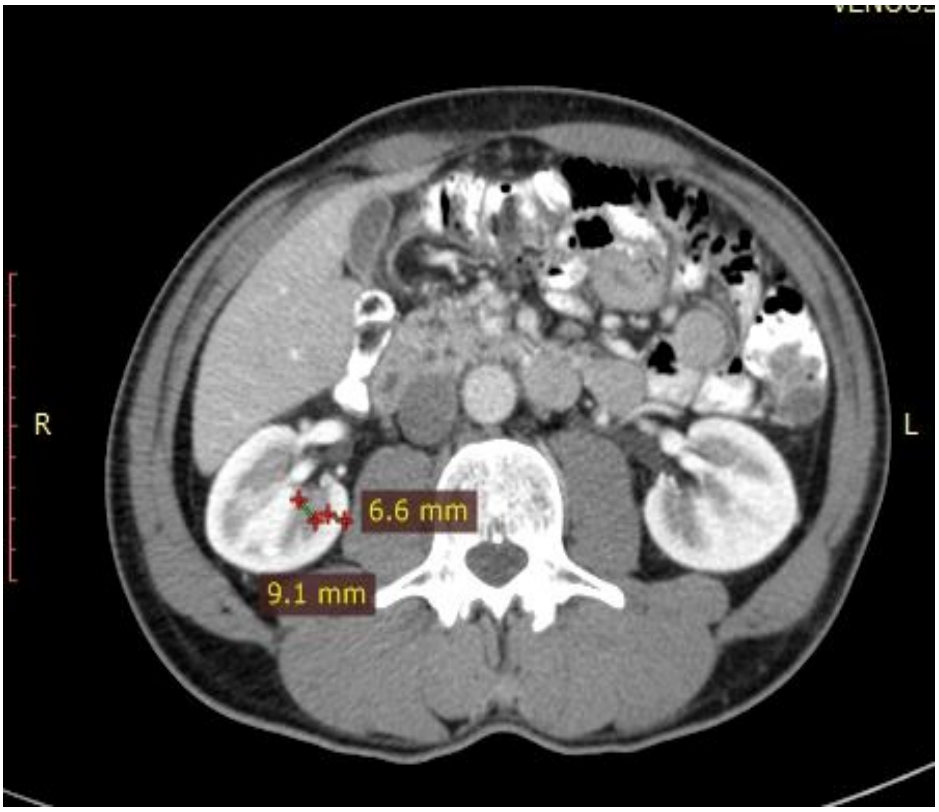
5-29 (B-4), renal pelvis



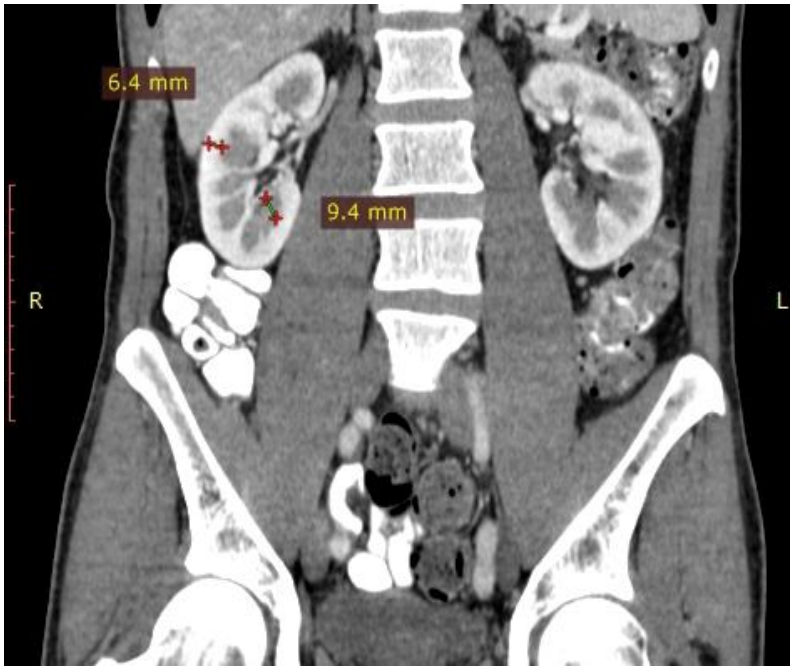
5-30(C-4), lower calyx



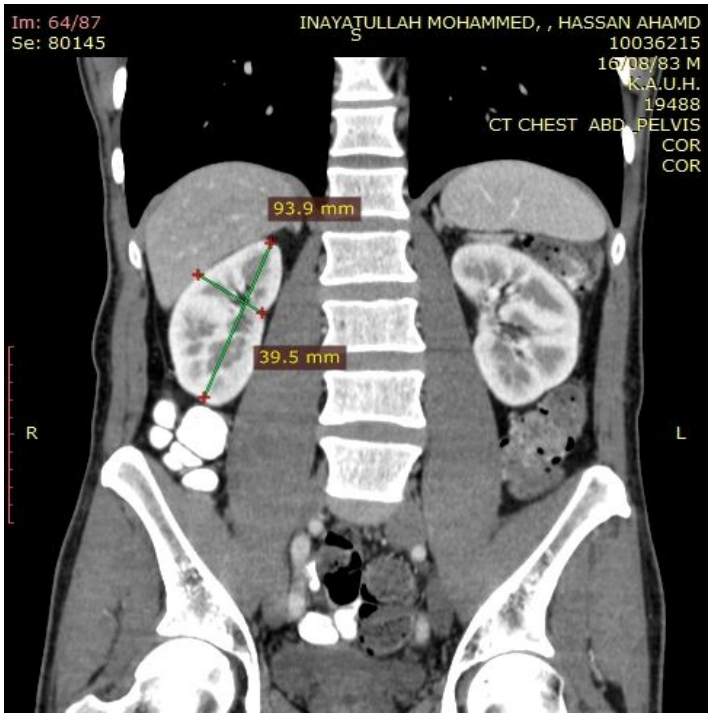
5-31(D-4) L1



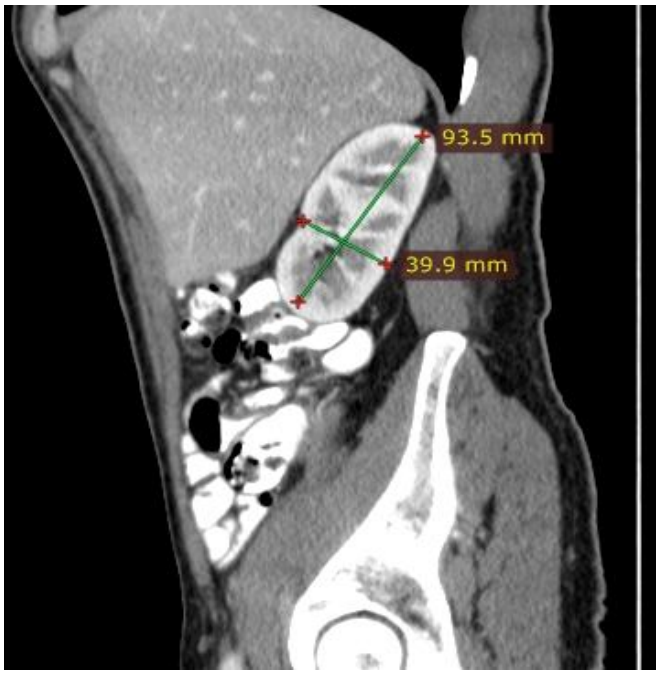
5-32Cortex and Medulla (axial)



5-33Cortex and Medulla kidney (coronal)



5-34Length and width of right kidney (coronal)



5-35 Length and width of right kidney (Sagittal)

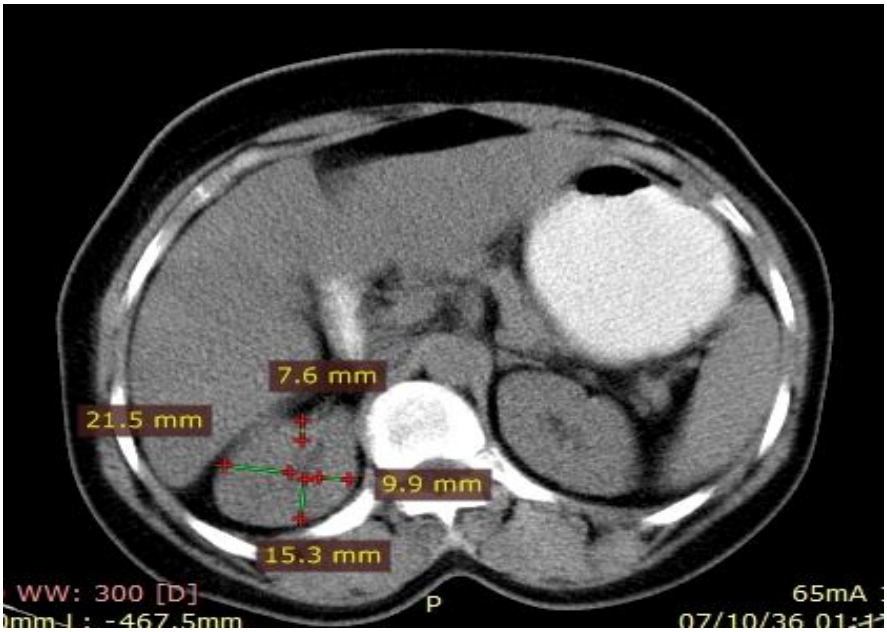
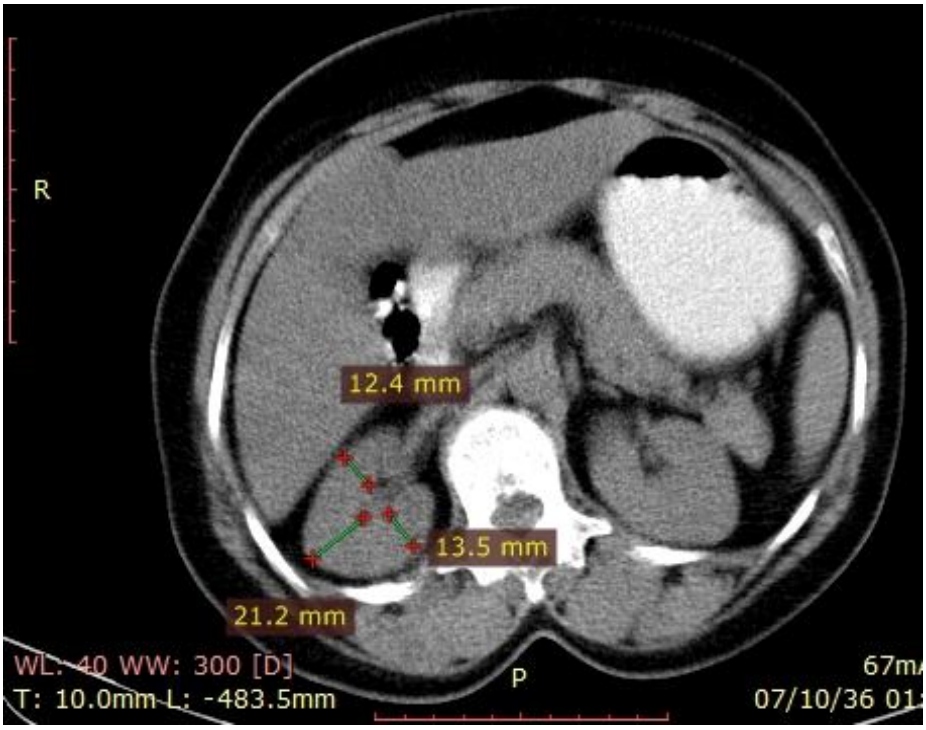
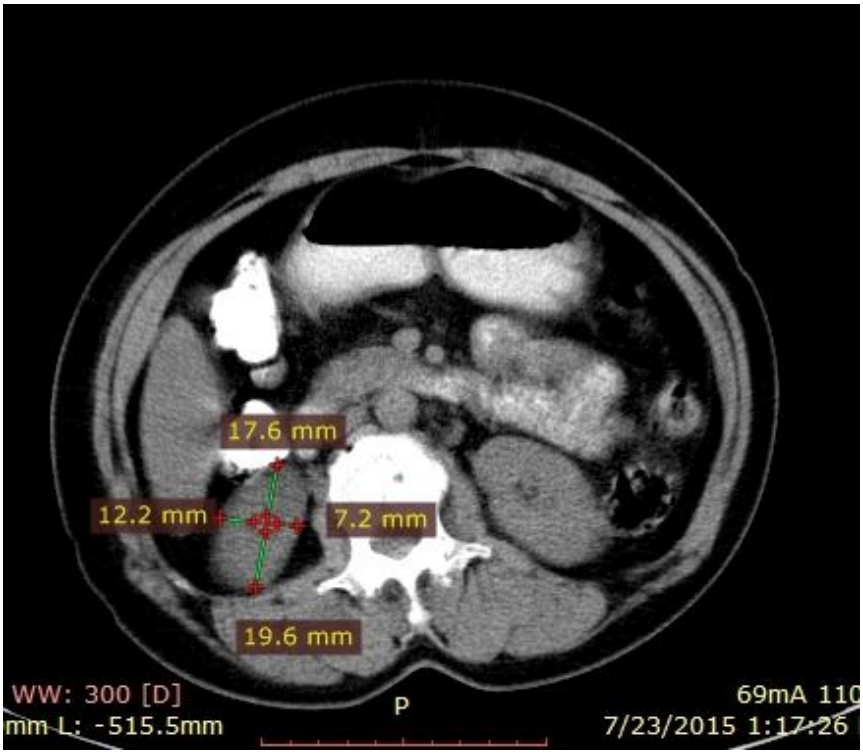


Fig. (A-5): axial view of rightkidney in a 65-year old female patient with normal findings

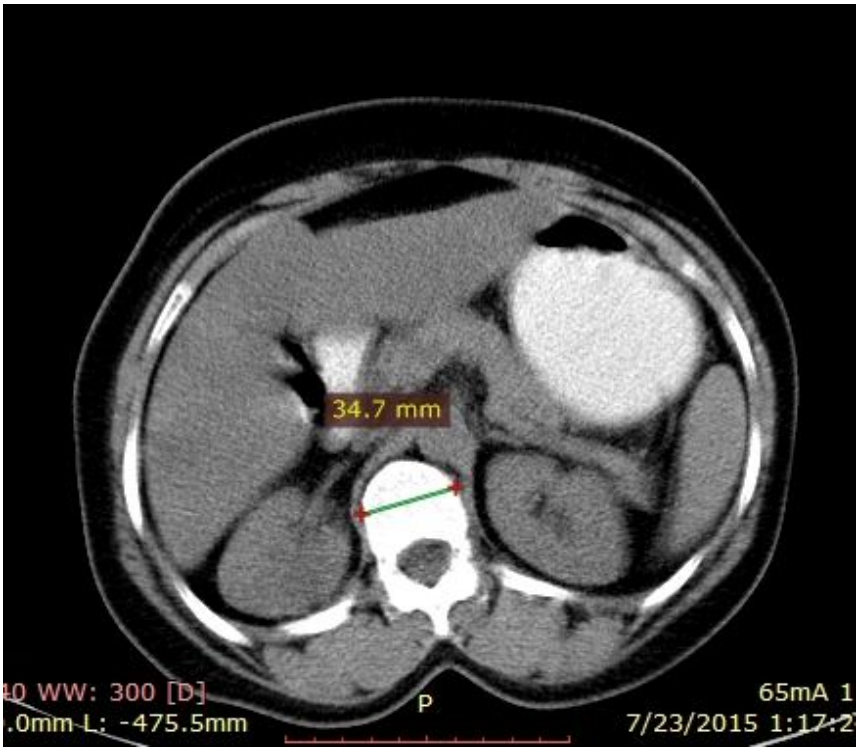
5-36(A-5), upper calyx (right)



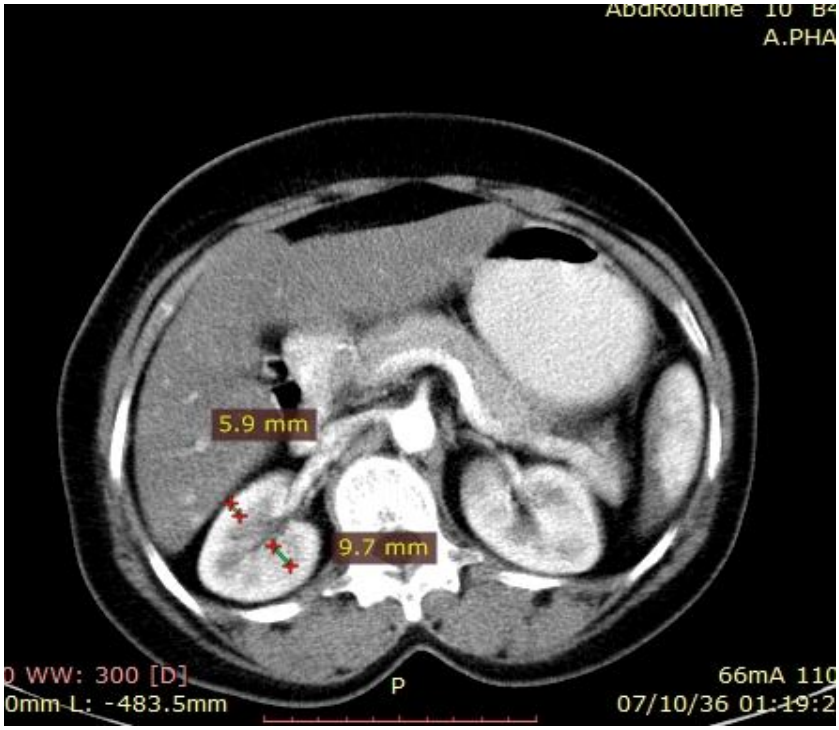
5-37(B-5), renal pelvis



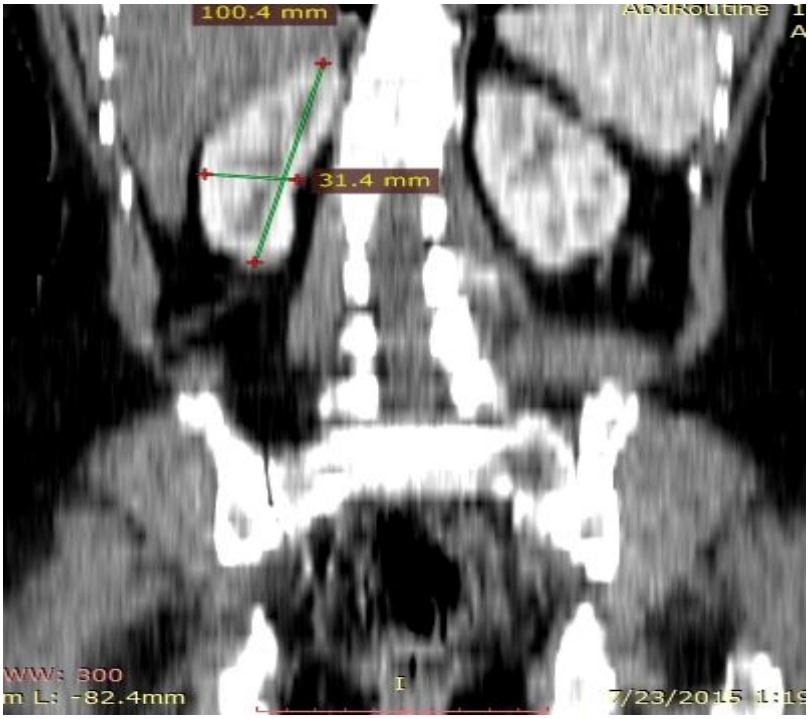
5-38(C-5), lower calyx



5-39(D-5) L1

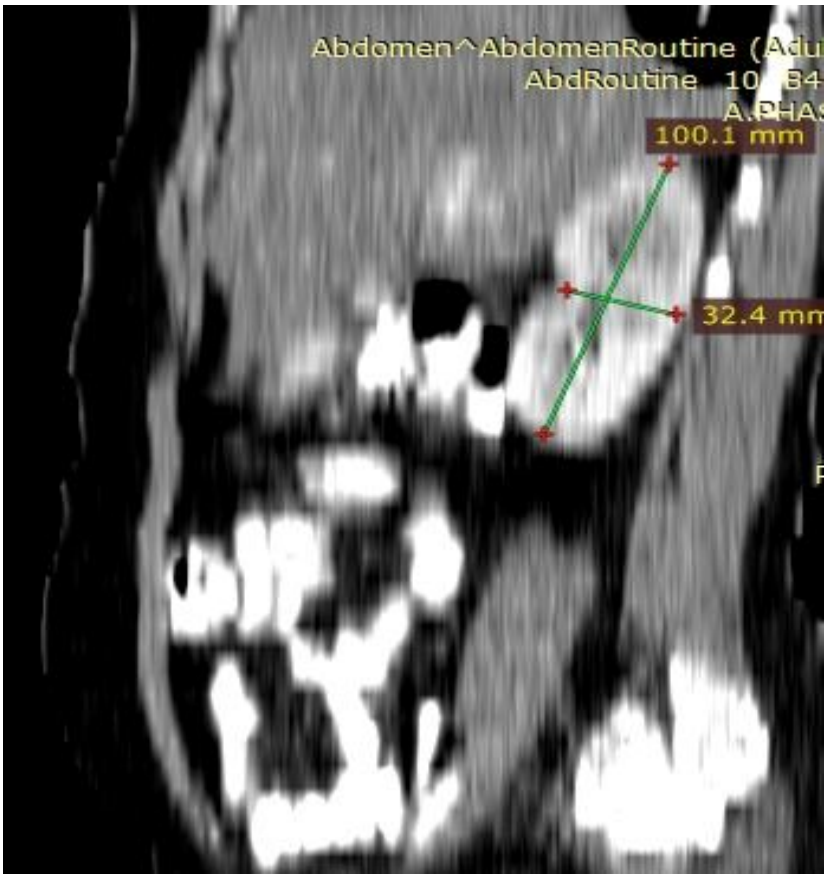


5-40Cortex and Medulla (axial)



5-41Length and width of right

kidney (coronal)



5-42 Length and width of right kidney (Sagittal)

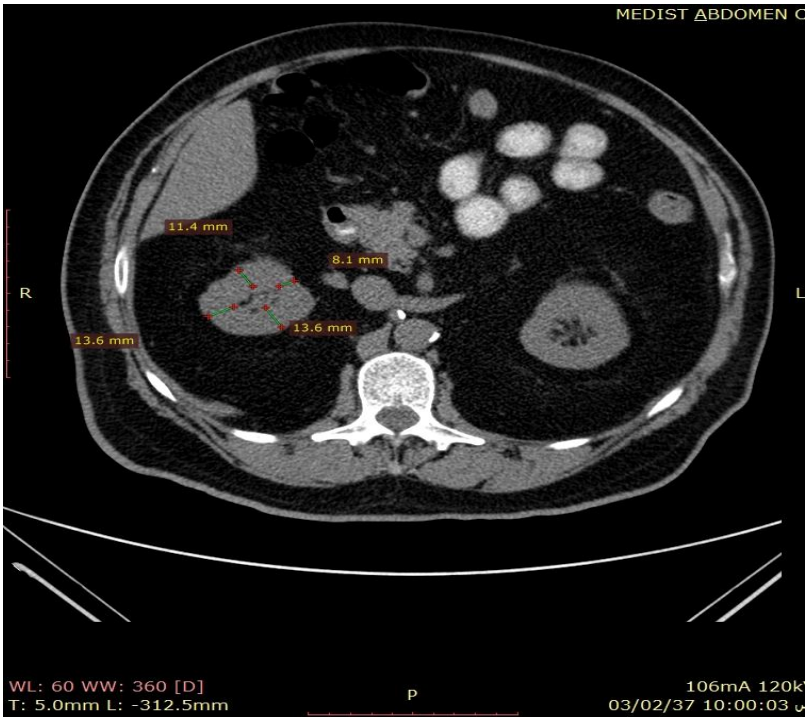
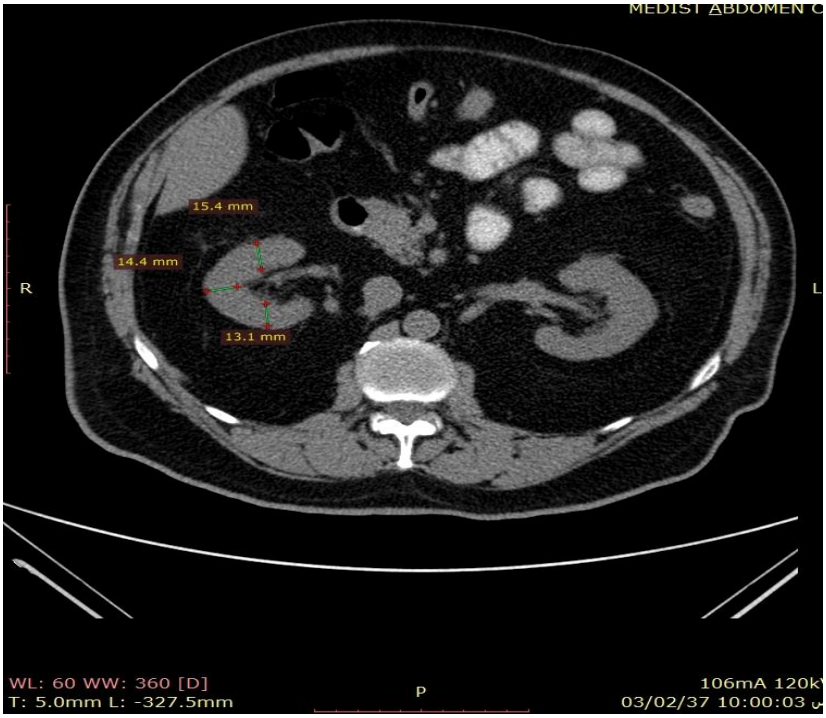
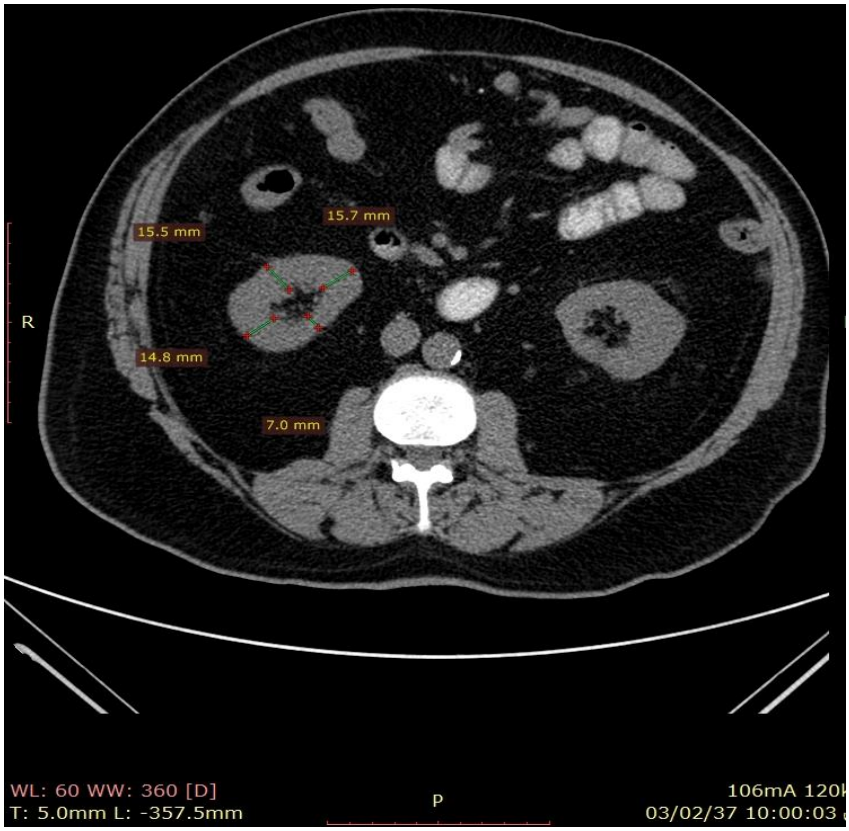


Fig. (A): axial view of right kidney in a 67-year old male patient with Diabetes.

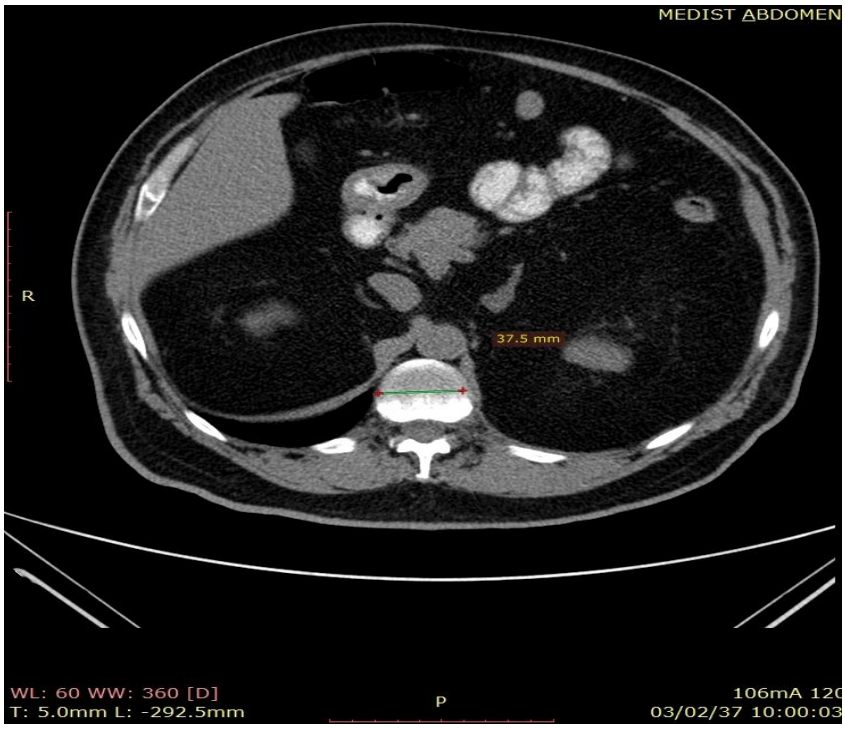
5-43(A), upper calyx (right)



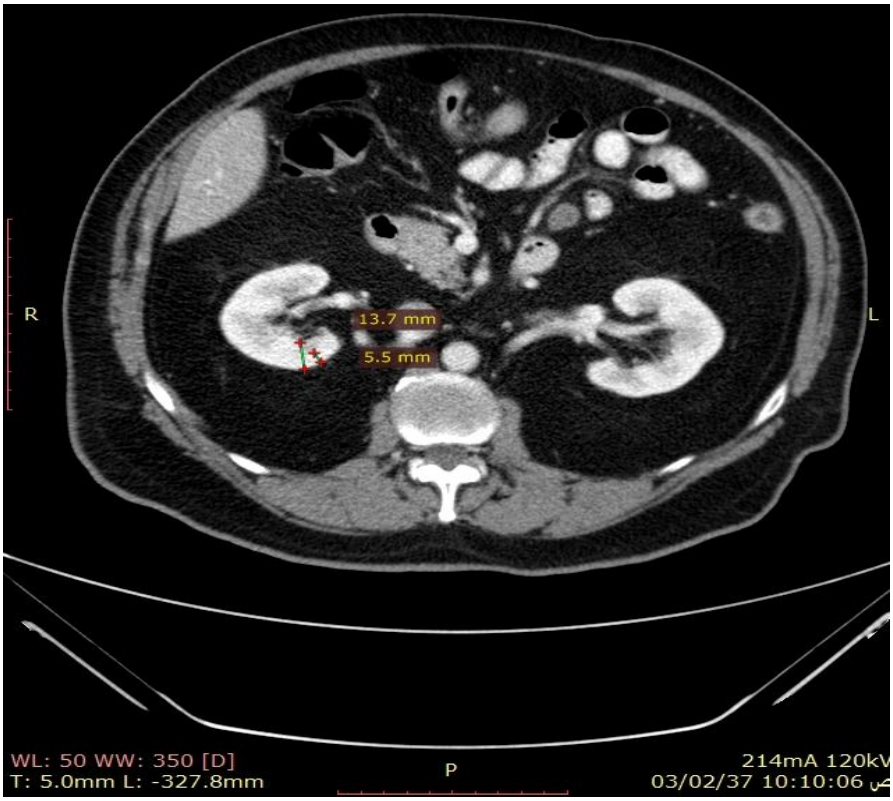
5-44(B), renal pelvis



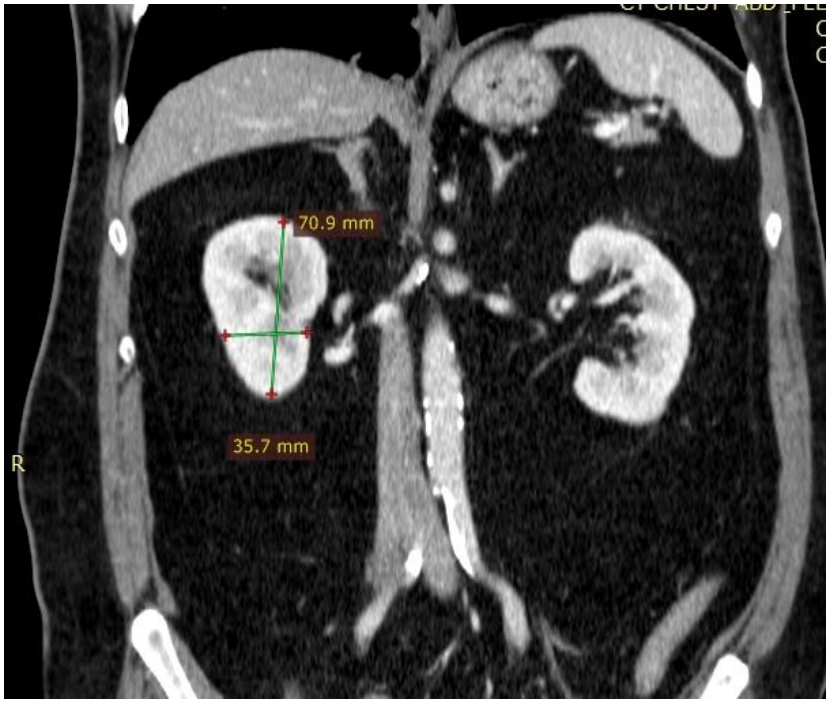
5-45(C), lower calyx



5-46(D) L1



5-47Cortex and Medulla (axial)



Length and width of right
5-48kidney (coronal)

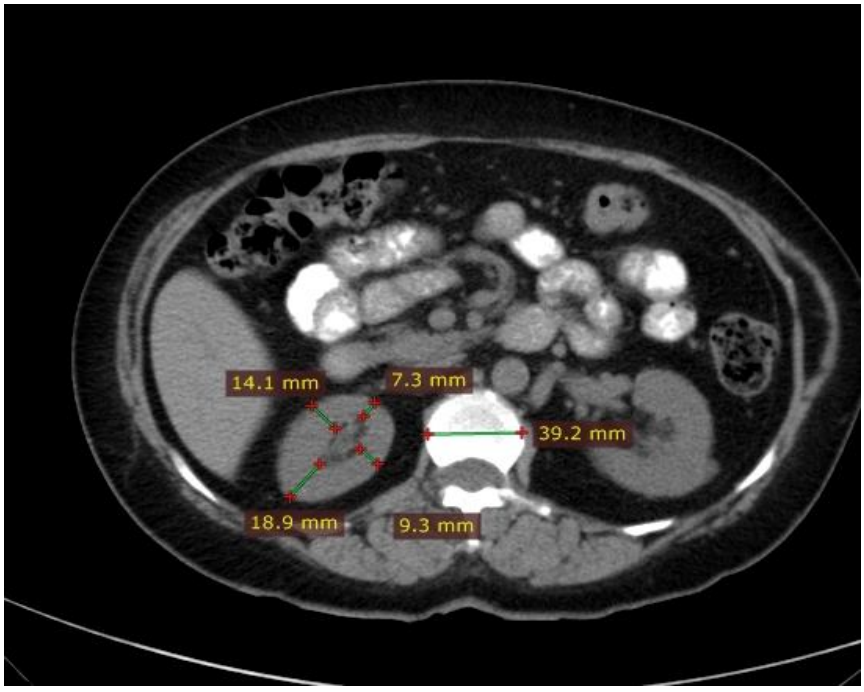
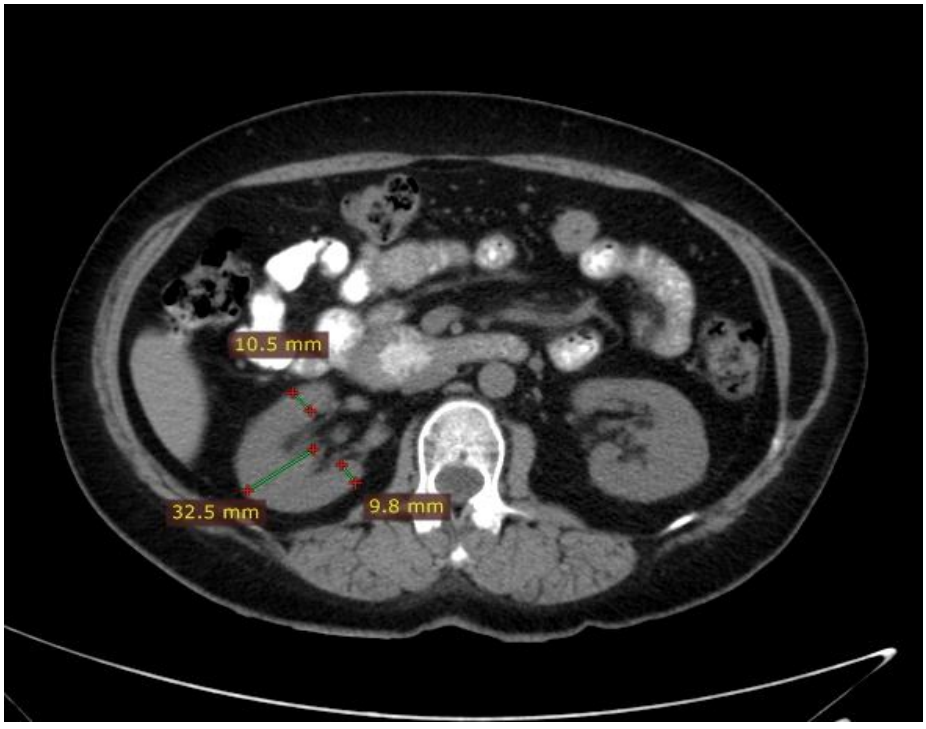
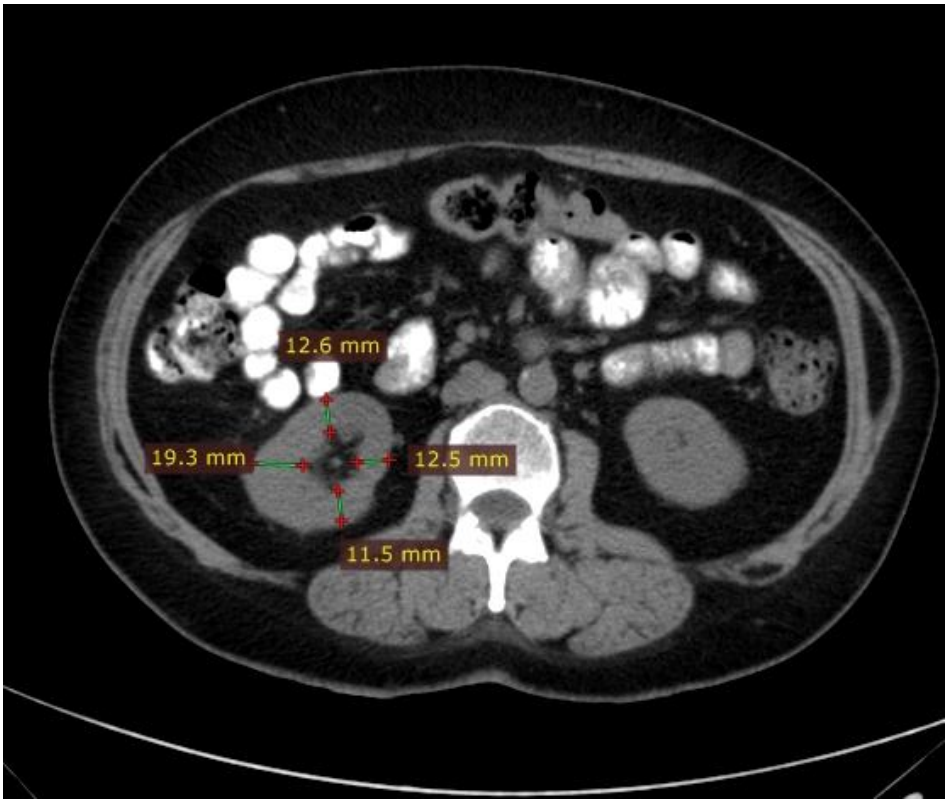


Fig. (A-1): axial view, of right kidney in a 53-year old female patient with Diabetes.

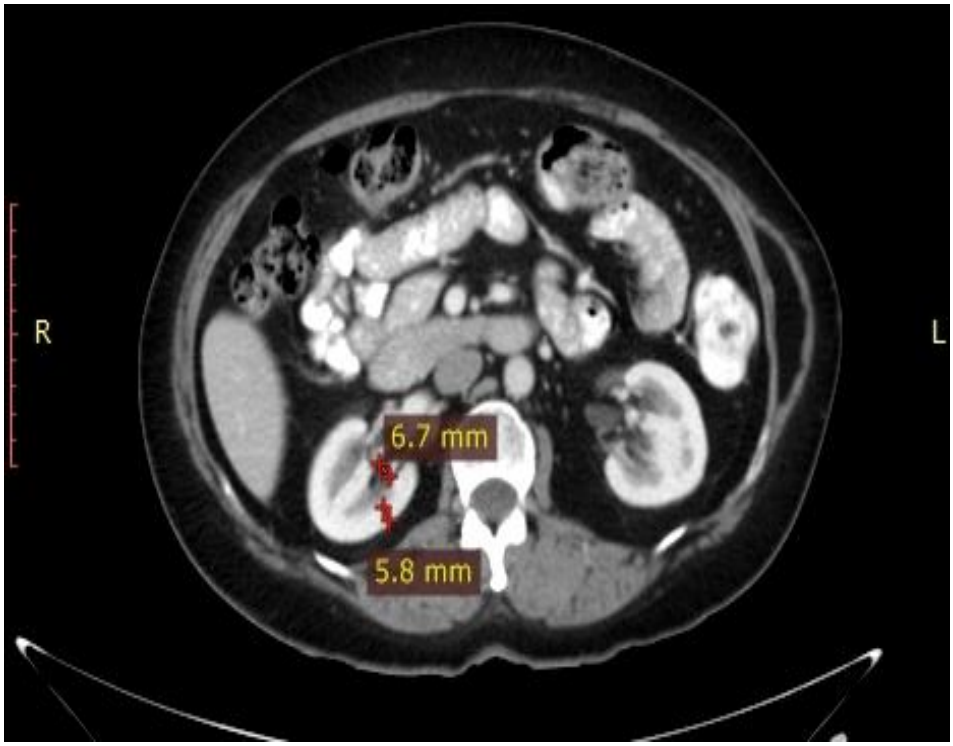
5-49(A-1), upper calyx (right) and (D) L1



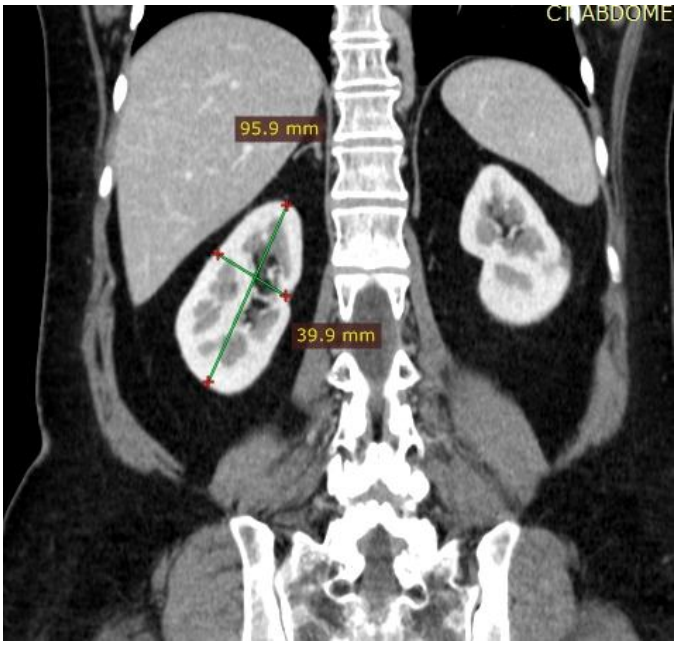
5-50(B-1), renal pelvis



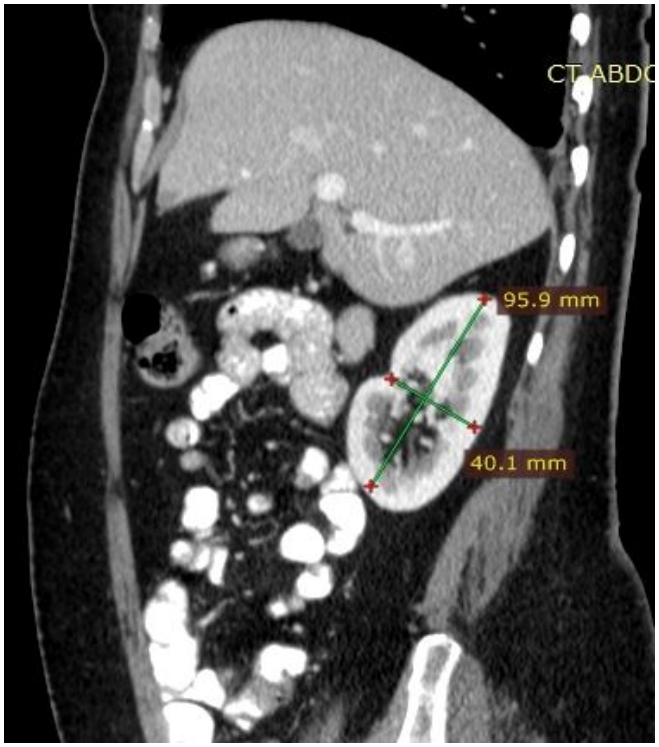
5-51(C-1), lower calyx



5-52Cortex and Medulla (axial)



Length and width of right
5-53kidney (coronal)



Length and width of right
5-54kidney (Sagittal)

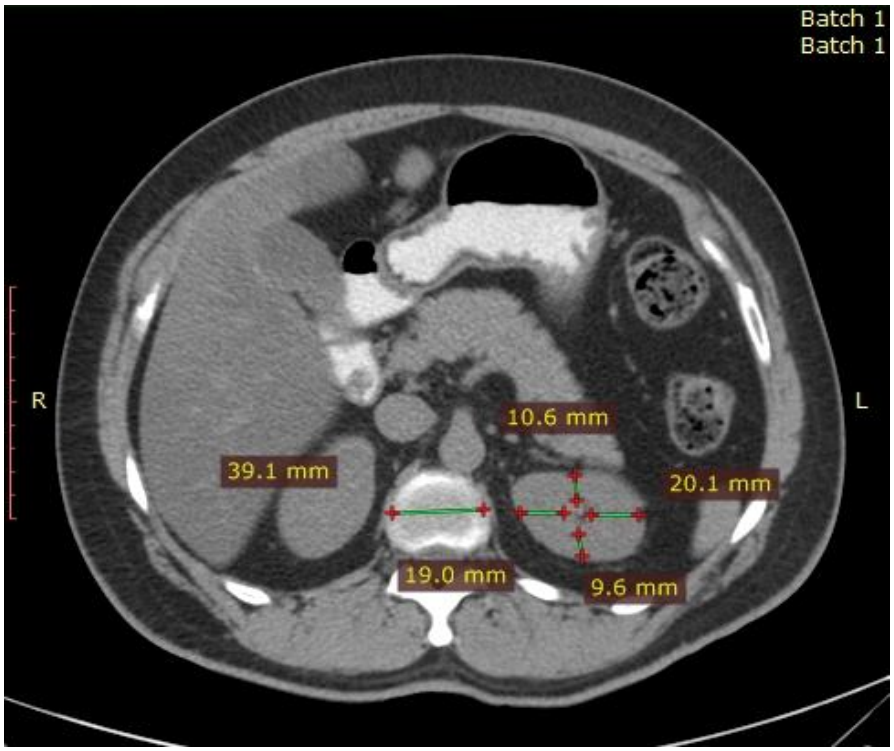
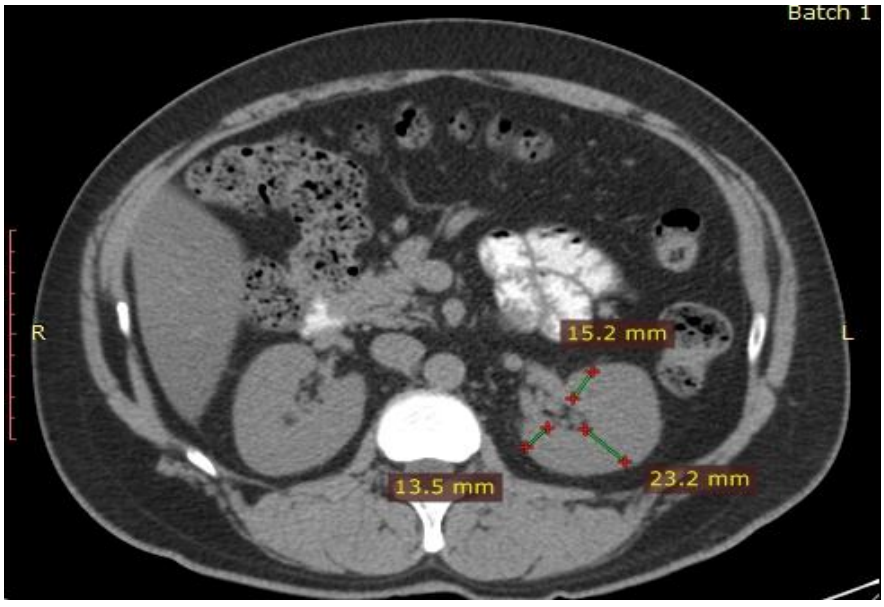
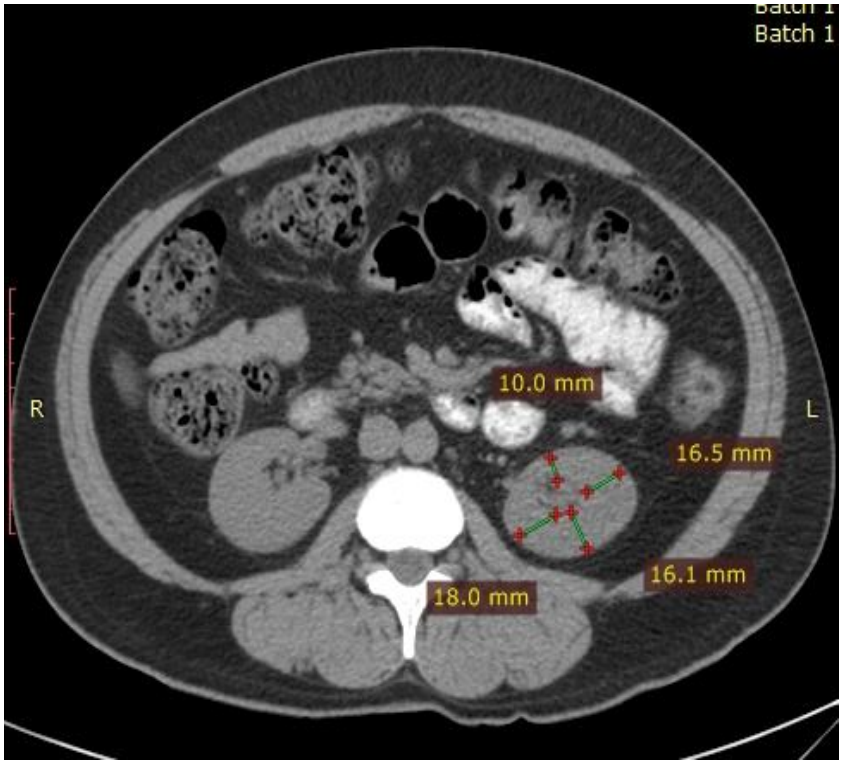


Fig. (A-2): axial view of left kidney in a 46 -year old male patient with up normal finding

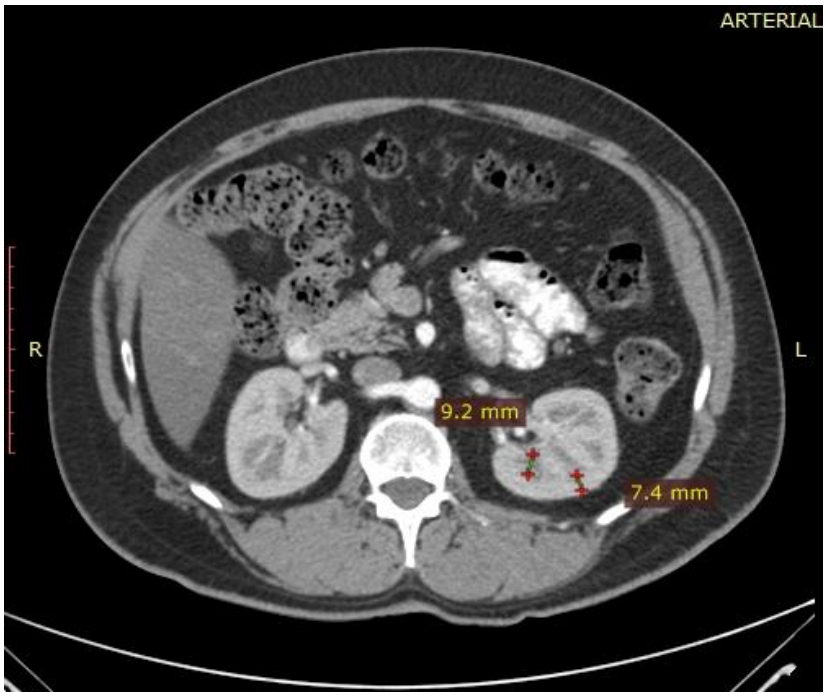
5-55(A-2), upper calyx (left) and (D) L1



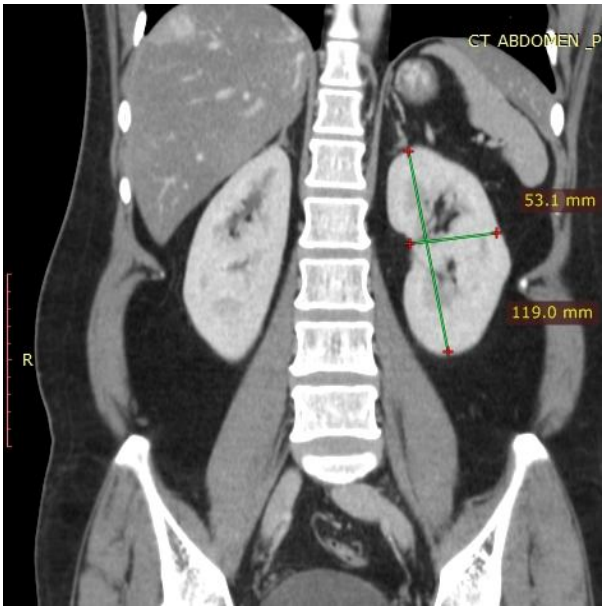
5-56(B-2), renal pelvis



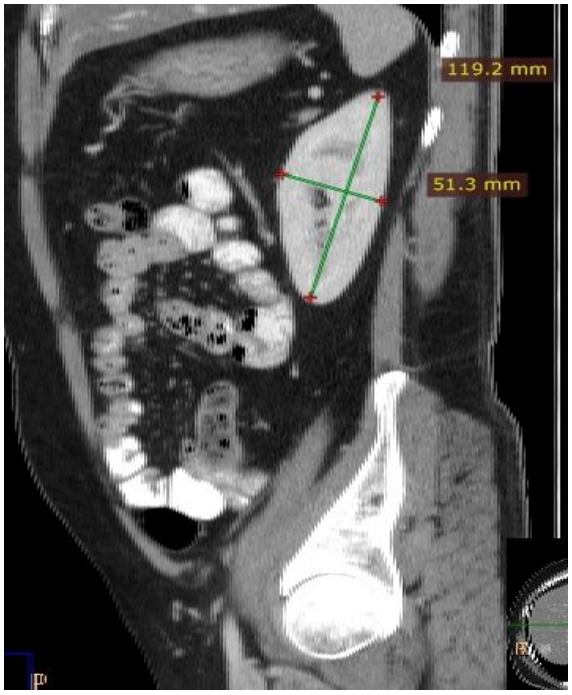
5-57(C-2), lower calyx



5-58Cortex and Medulla (axial)



Length and width of left
5-59kidney (coronal)



Length and width of left
5-60kidney (Sagittal)

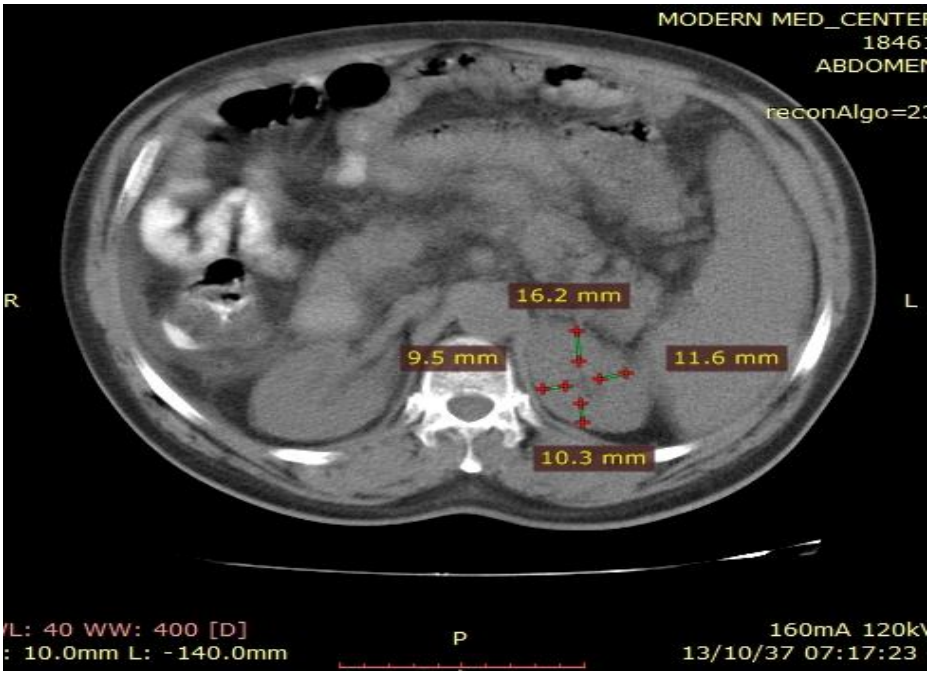
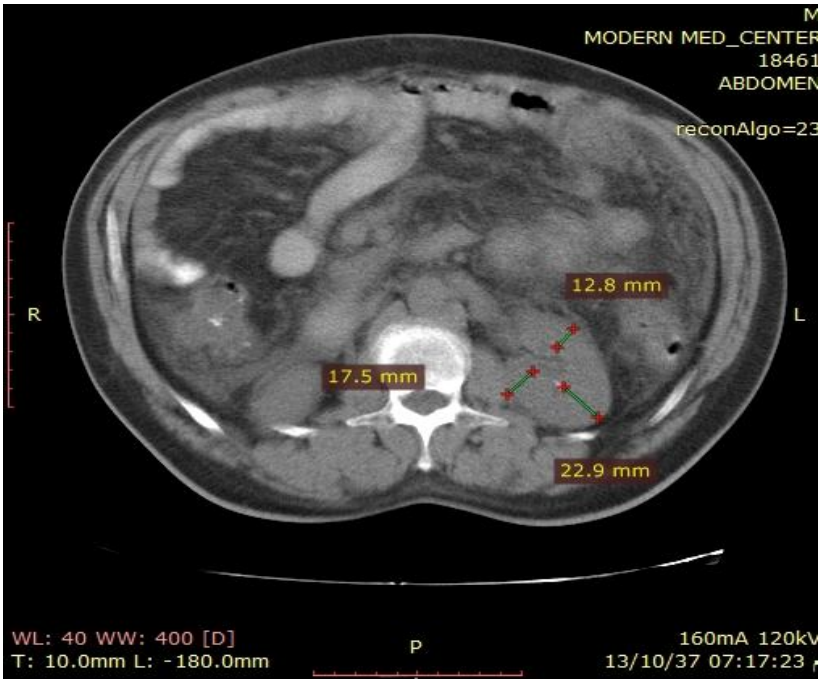


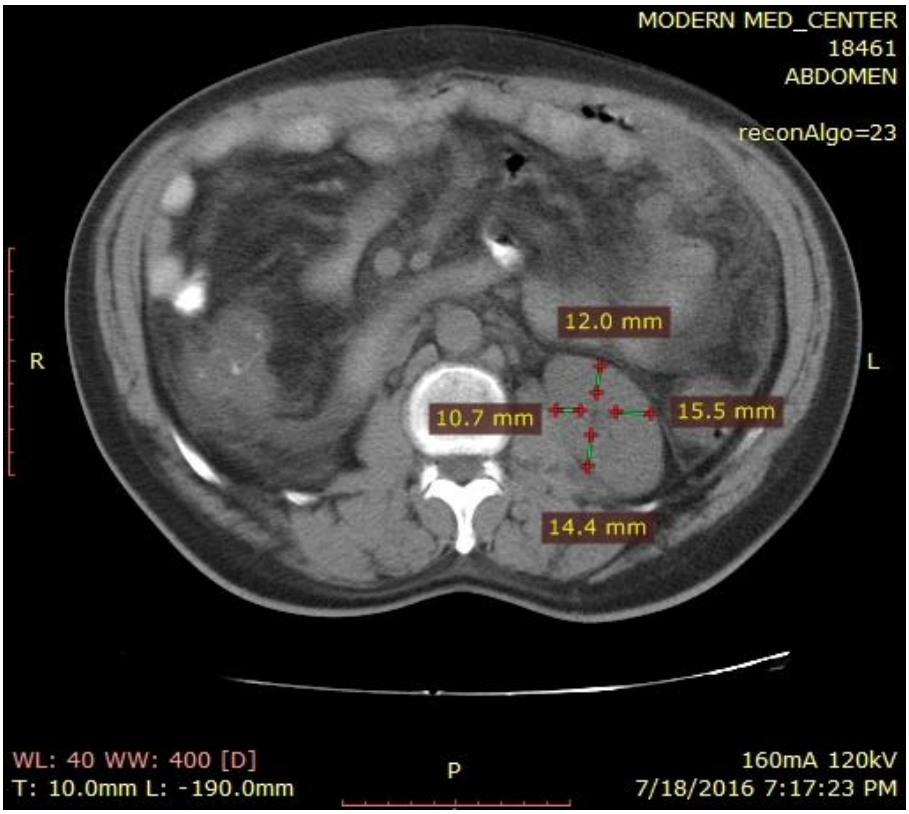
Fig. (A-3): axial view of left kidney in a 56 -year old male patient with Diabetes.

Upper calyx (left)

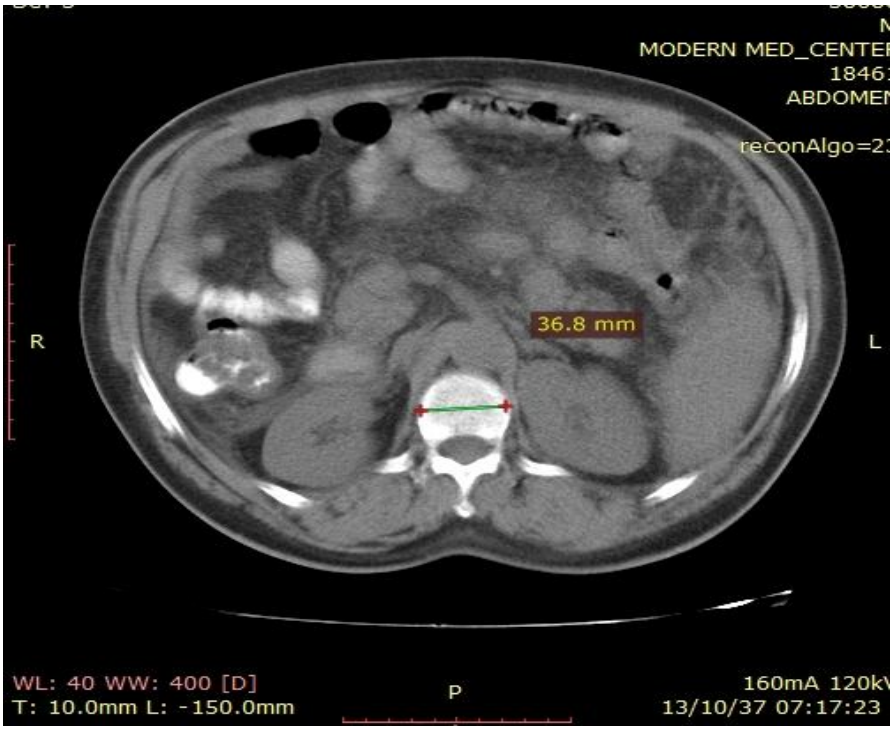
5-61(A-3),



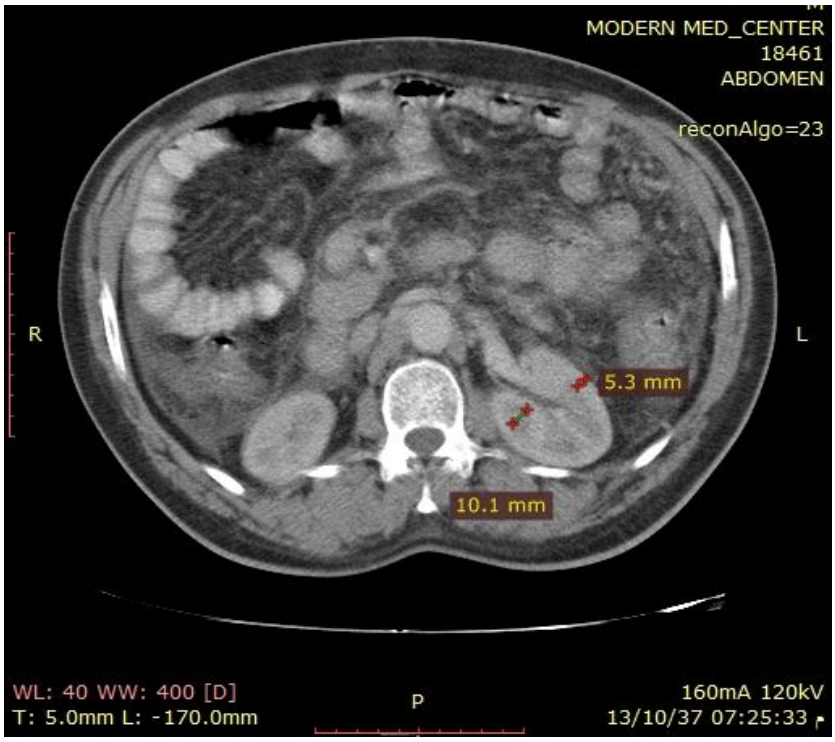
5-62(B-3), renal pelvis



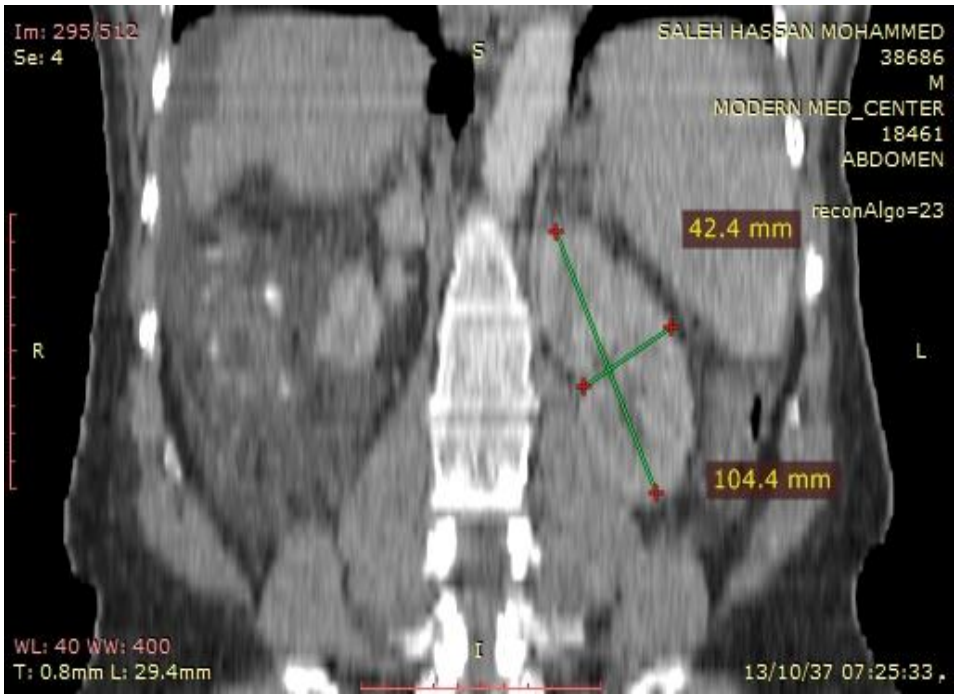
5-63(C-3), lower calyx



5-64(D-3) L1



5-65Cortex and Medulla (axial)



Length and width of left
5-66kidney (coronal)

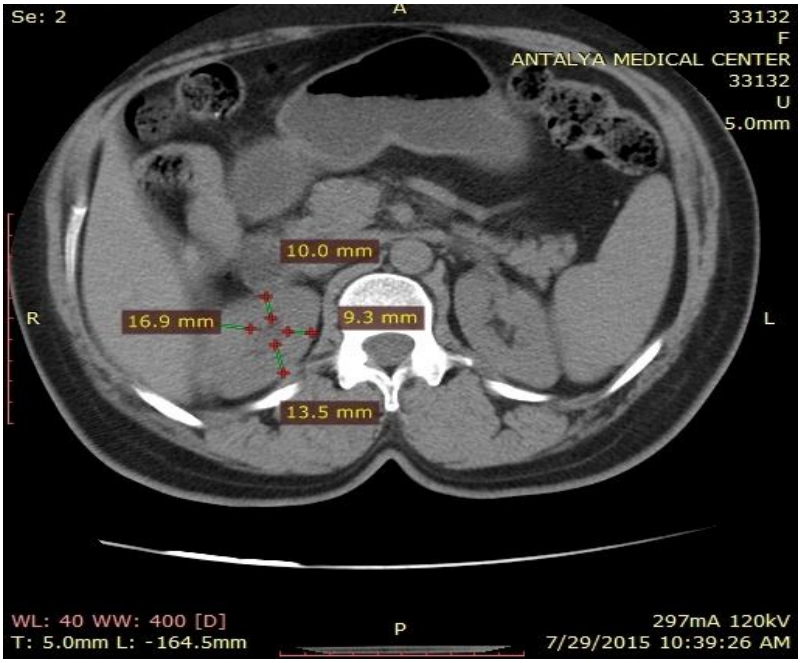
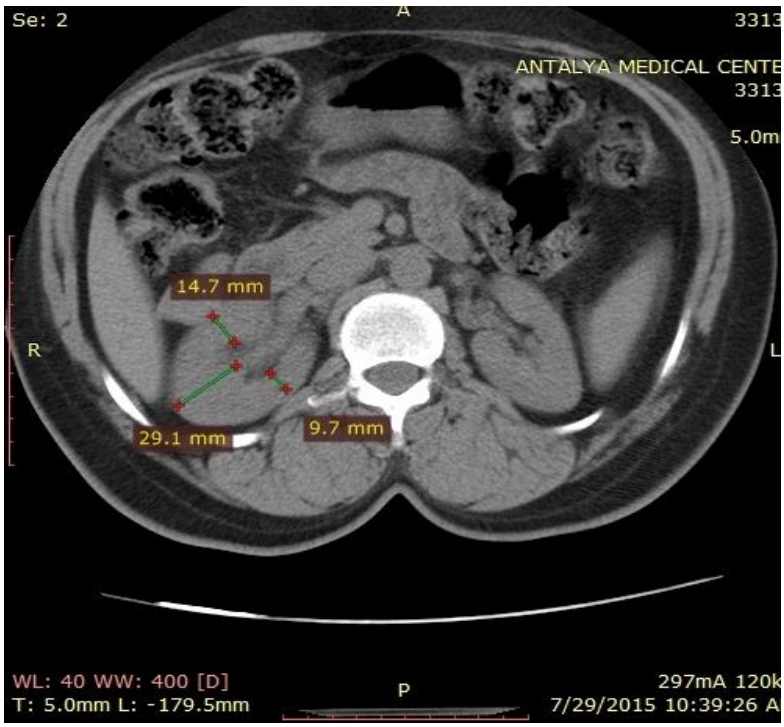
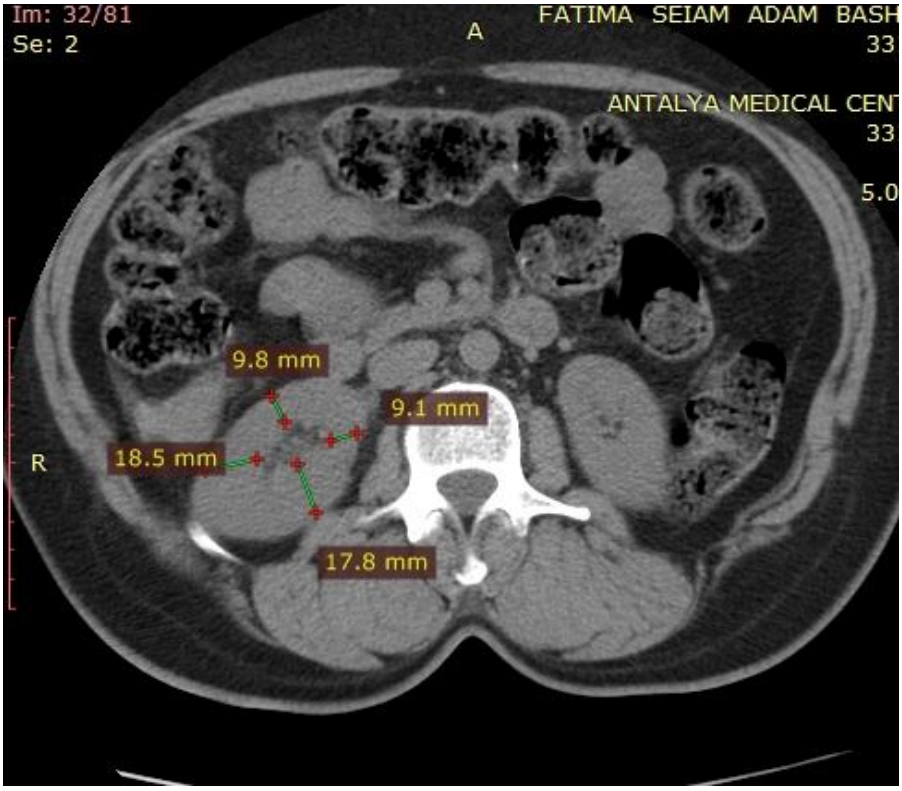


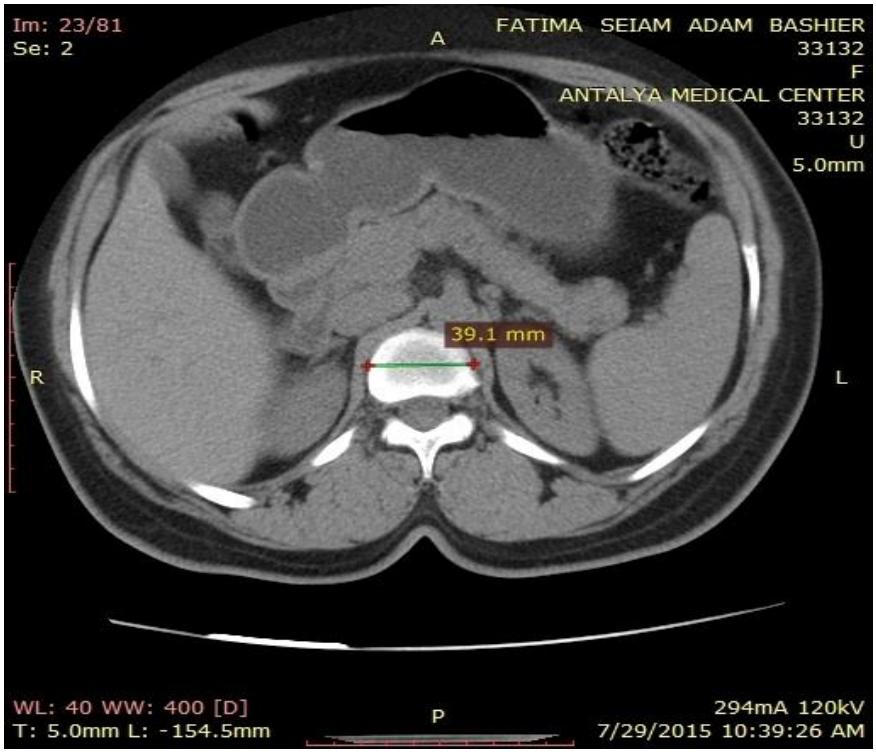
Fig. (A-4): axial view of right kidney in a 56 -year old male patient with Diabetes. 5-67(A-4), upper calyx (right)



5-68(B-4), renal pelvis

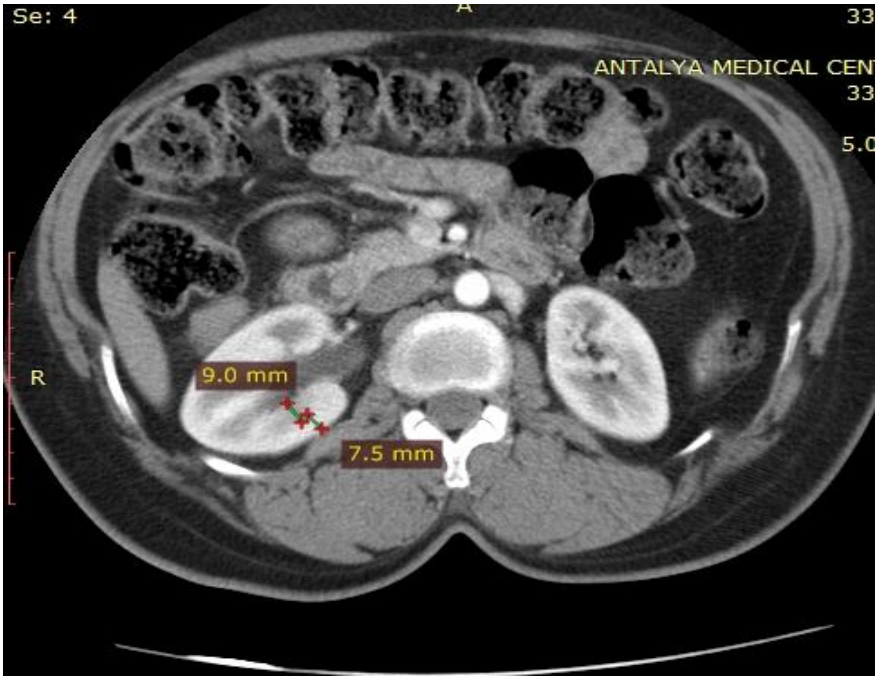


5-69(C-4), lower calyx

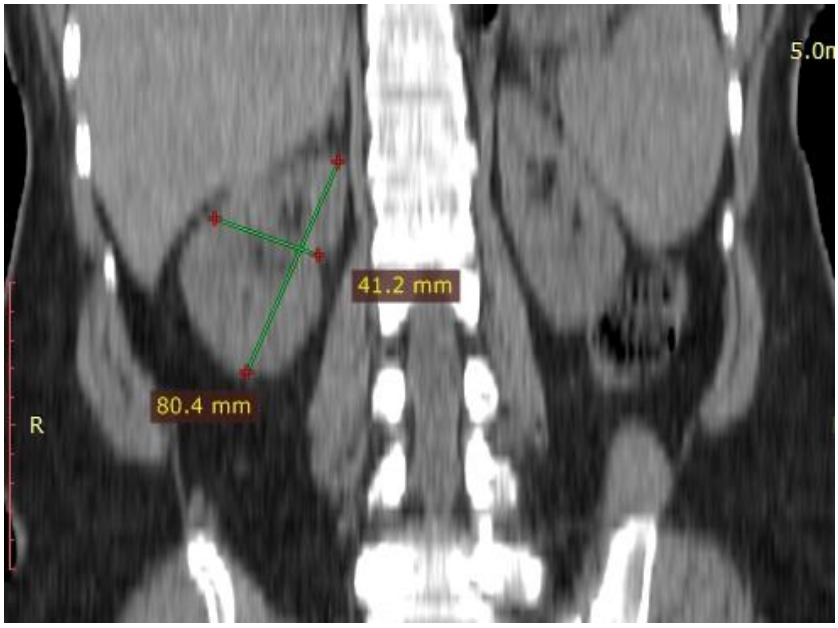


5-70(D-4) L1

5-71Cortex and Medulla (axial)



5-71Cortex and Medulla (axial)



5-72Length and width of right kidney (coronal)

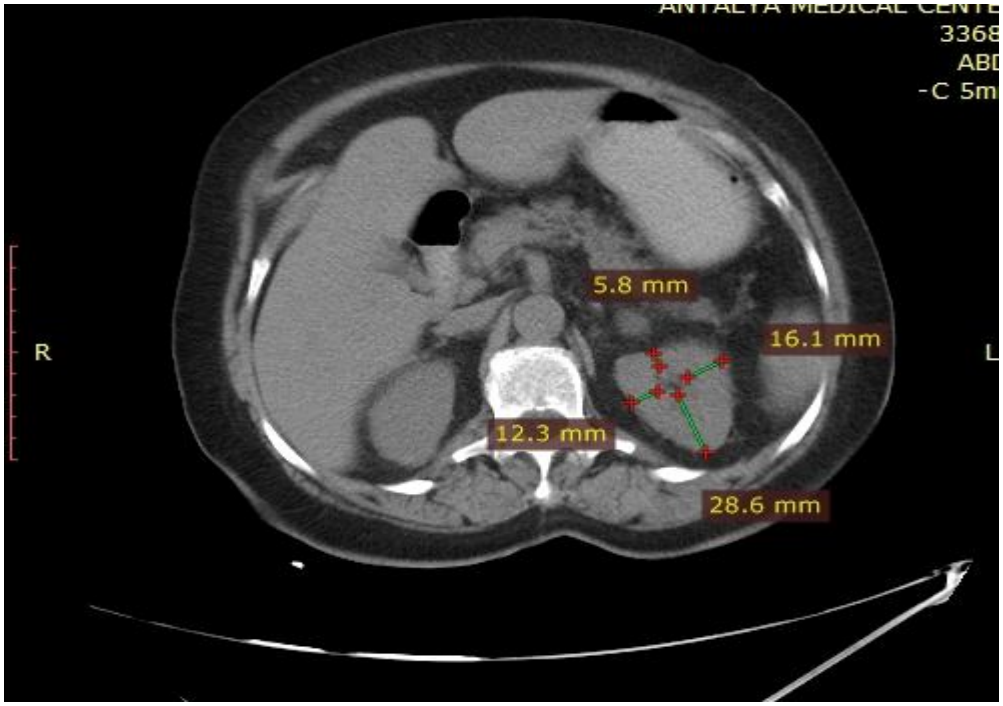
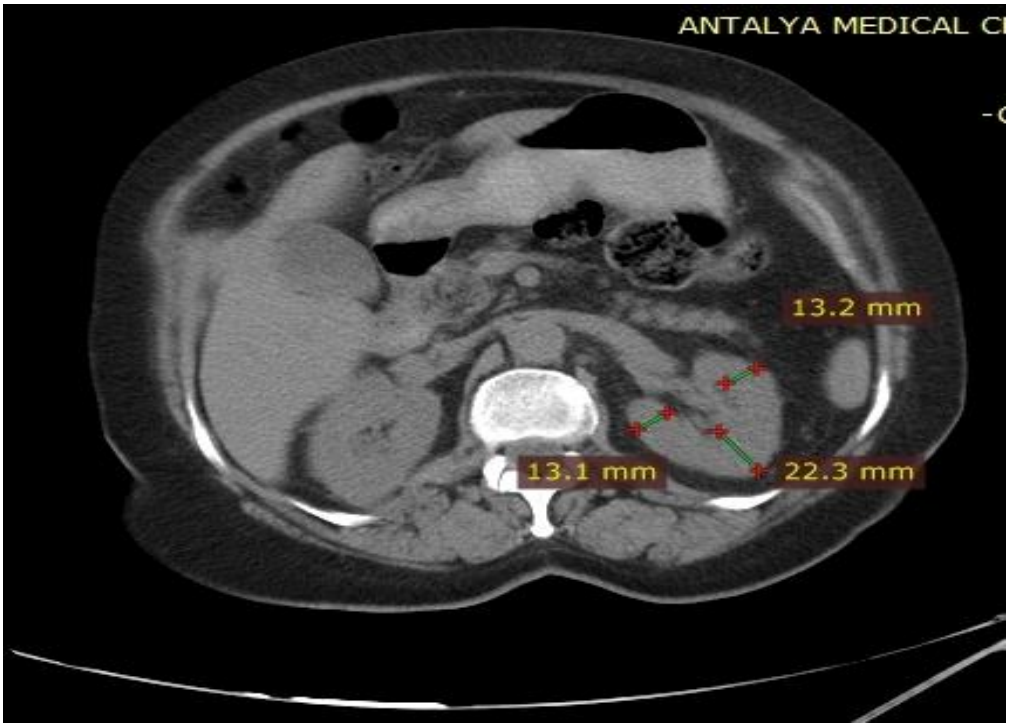
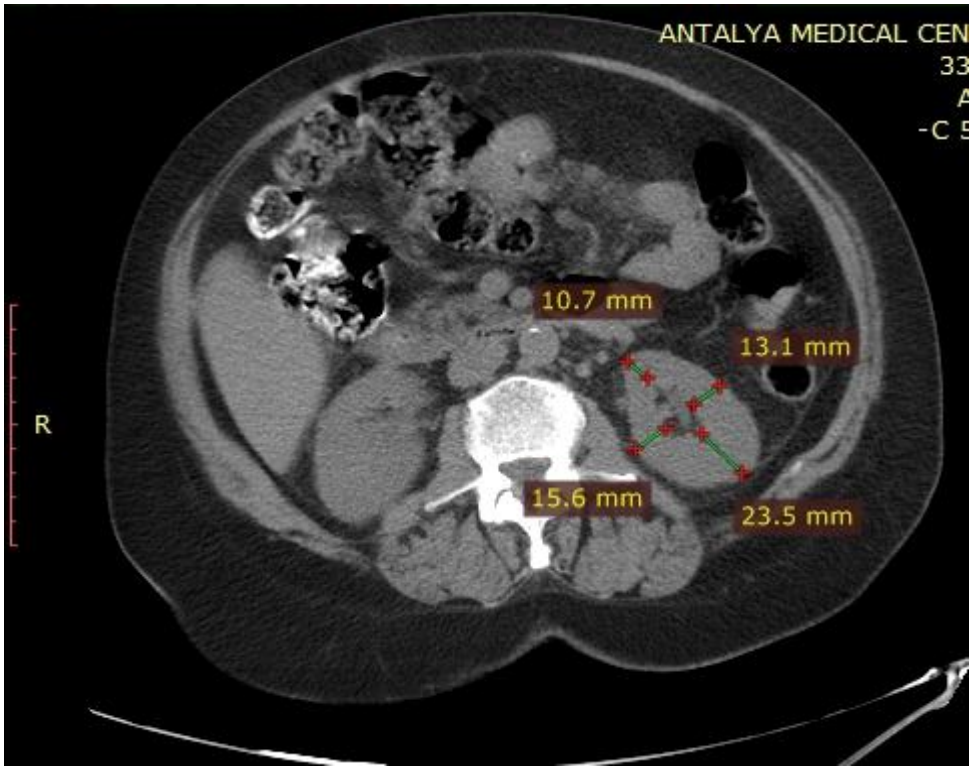


Fig. (A-5): axial view of left kidney in a 65 -year old female patient with Diabetes.

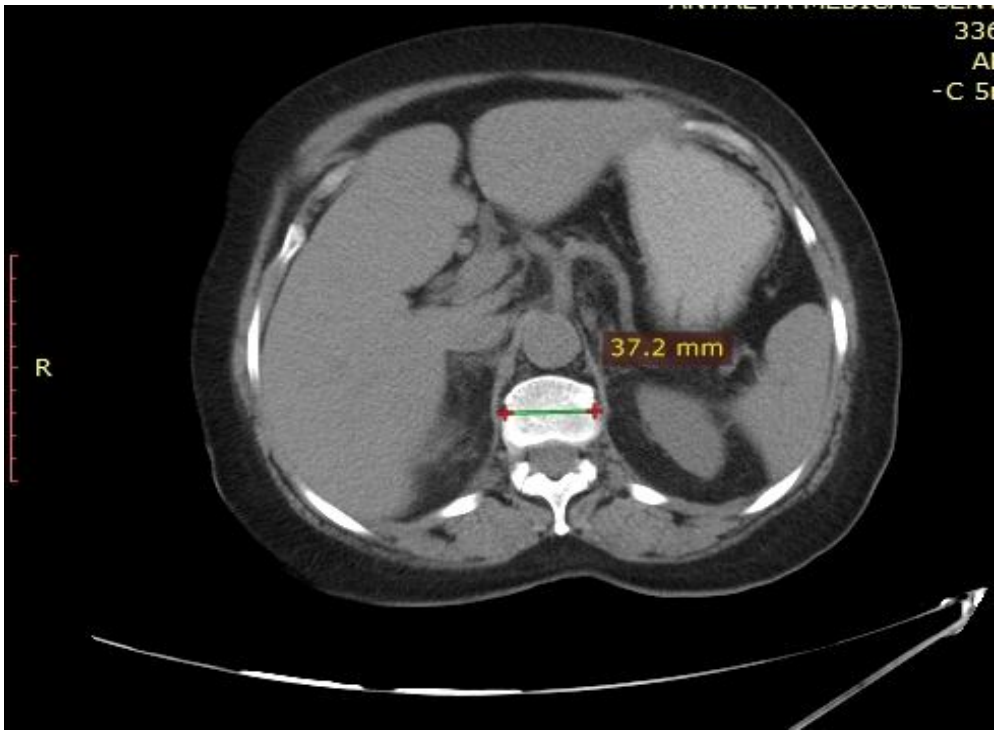
5-73(A-5), upper calyx (left)



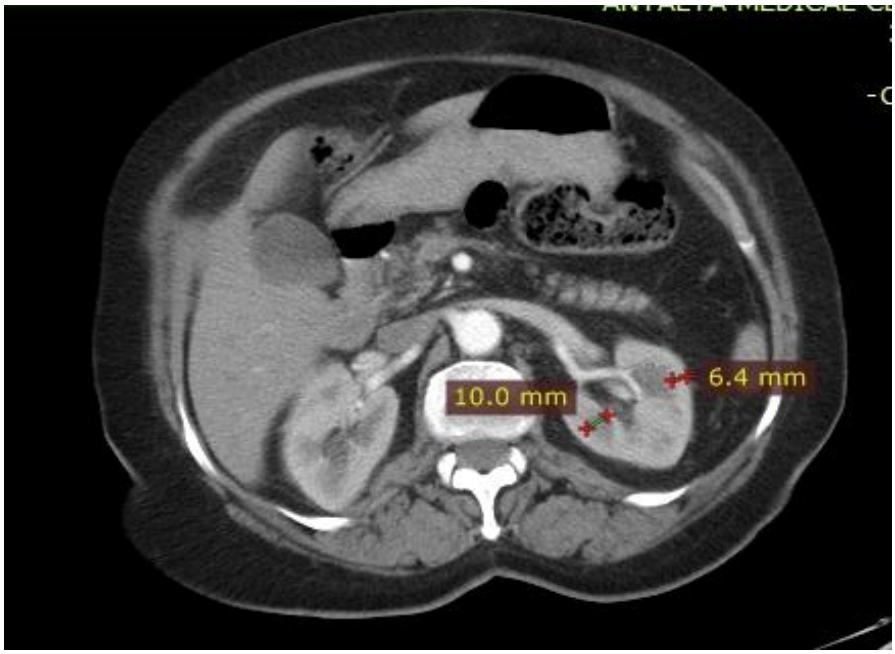
5-74(B-5), renal pelvis



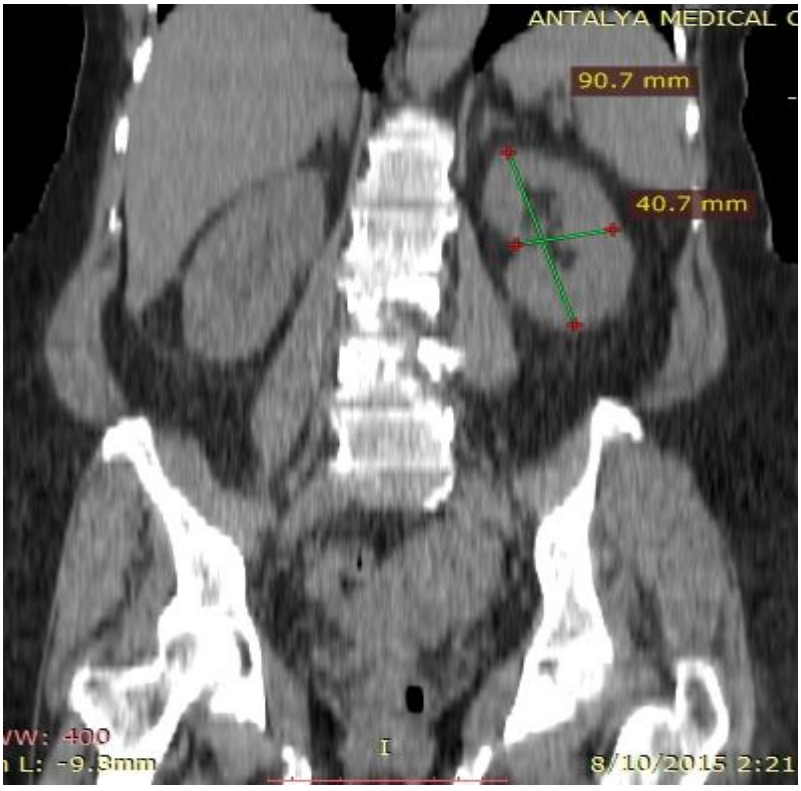
5-75 (C-5), lower calyx



5-77(D-5) L1



5-77 Cortex and Medulla (axial)



Length and width of left
5-78 kidney (coronal)