KIDNEYS

I. INTRODUCTION

The kidneys are paired symmetrical heterocrine glands. They are retroperitoneal situated in the lumbar fossa on each side of the dorsolumbar spine. They have an endocrine function but, mainly, an exocrine function that consists of glomerular filtration, urine secretion, hydro-electrolyte and acid-base homeostasis. The kidneys are subject to a number of anatomical variations.

II. DESCRIPTIVE ANATOMY

A- SITUATION

The kidneys lie high up on the posterior abdominal wall behind the peritoneum, largely under cover of the costal margin in the lumbar fossa at the level of T12 and L1 vertebra. Each kidney lies obliquely downwards and laterally parallel with the lateral border of psoas major. The hilum faces somewhat forwards as well as medially and the renal vascular pedicle lies well back in the paravertebral gutter. The upper pole of the left kidney may overlie the eleventh rib. The bulk of the right lobe of the liver accounts for the lower position of the right kidney.

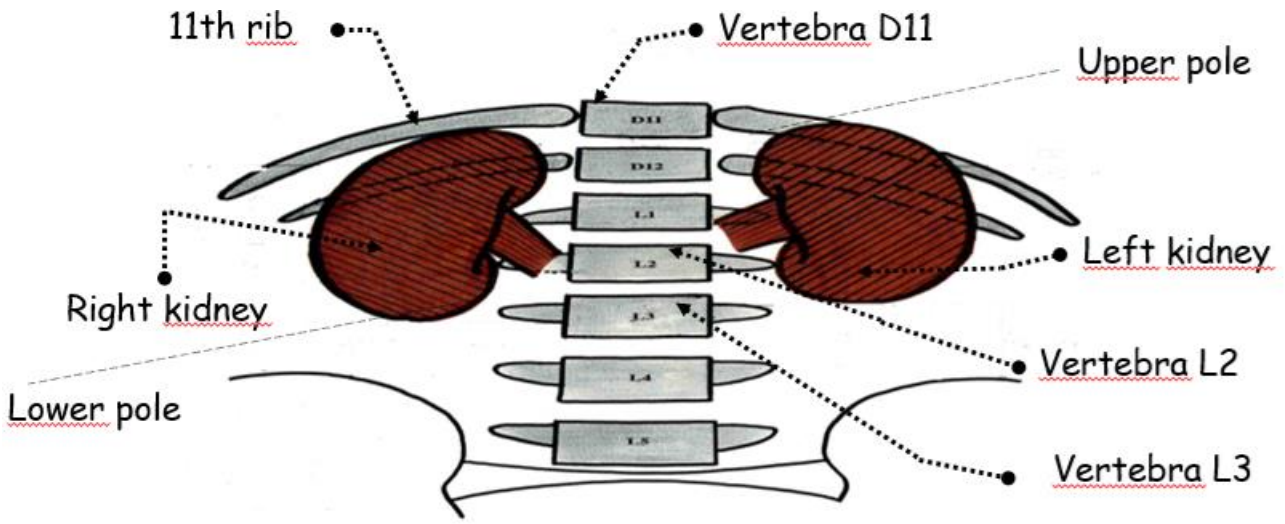

Figure 1: Anterior view of the kidneys showing their situation

B- SHAPE

The kidneys are shaped like a bean, flattened anteroposteriorly with a long oblique axis downwards and outwards parallel to the lateral border of psoas major. They have two faces, anterior and posterior convex, two borders, lateral convex, medial with a vertical slit-like depression, the hilum, transmitting the renal vessels and nerves and the renal pelvis and two poles, upper the floor of the suprarenal gland and lower. The kidney possesses a capsule which gives the fresh reddish-brown organ a glistening appearance. Its consistency is smooth with traces of lobulation pronounced in newborns.

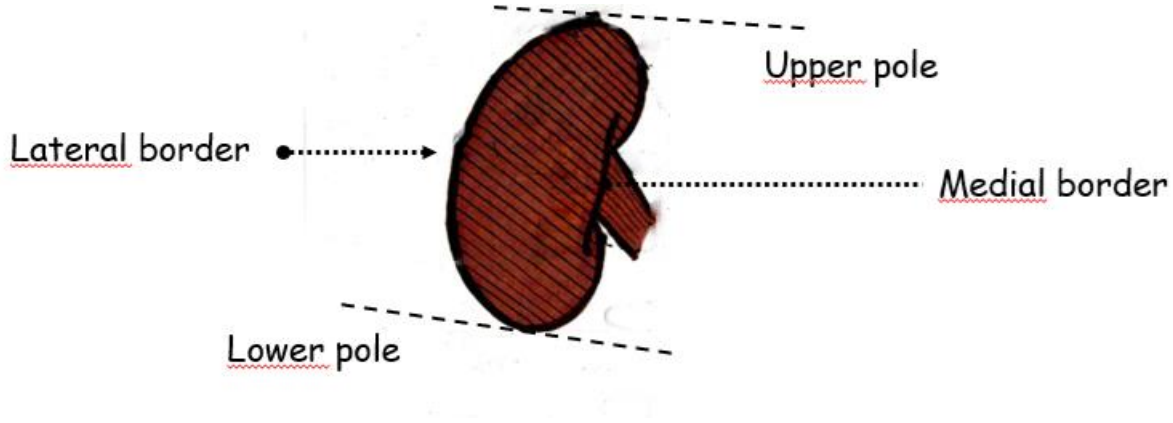

Figure 2: Anterior view of the right kidney

C- DIMENSIONS

The normal kidney is twelve centimetres long, six centimetres wide, three centimetres thick and weighs one hundred thirty grams.

Each kidney moves in a vertical range of two centimetres during full respiratory excursion of the diaphragm.

D- SUPPORTS

The perinephric fat lies outside the renal capsule. It is a more solid consistency fat than the general body fat and has the shape of an inverted cone. The perinephric fat fills the funnel-shaped hollow of the suprailiac part of the paravertebral gutter and plays a part in retaining the kidney in position.

The renal fascia of Gerota surrounds the perinephric fat and separates the kidney from the suprarenal gland. It is a condensation of the areolar tissue between the parietal peritoneum

and the posterior abdominal wall attached to the renal vessels and the ureter at the hilum extending until the sheath of the aorta and inferior vena cava. It ascends as a dome between the upper pole of the kidney and the suprarenal and to the diaphragmatic fascia and is complete though weak downwards. Posteriorly, it is separated from the fascia of psoas and quadratus lumborum by the pararenal fat.

The renal fascia sends fibrous strands to the renal capsule partitioning the perinephric fat.

E- CALYCES

The minor calyces are nine to twelve one-centimetre-long membranous funnels. Each of them moulds to one renal papilla. They constitute the commencement of major calyx.

The major calyces are three medium funnels, superior, middle and inferior. Each major calyx drains a renal pole and constitutes the projection of three to four minor calyces and the commencement of renal pelvis.

F- RENAL PELVIS

The renal pelvis is flattened and funnel-shaped muscular duct. It constitutes the most posterior of the three main structures of the hilum. Its upper and lower extremities receive two or three major calyces. Its summit is outside the hilum and constitutes the commencement of the ureter. The average capacity of the pelvis is less than five millimetres and its base measures two centimetres and half.

III. STRUCTURE

A- RENAL CAPSULE

The renal capsule reflects to line the renal pelvis and is continuous with minor calyces. It is made of smooth muscle and elastic connective tissue.

B- CORTEX

The cortex is the part of the renal parenchyma beneath the capsule. It is dark reddish and extends towards the pelvis across the medulla as the renal columns. Three different zones of the cortex can be distinguished. From the outer to the inner zone, the peripheral cortex contains glomeruli and convoluted tubes. The juxta-medullary cortex contains juxta-medullary glomeruli and their convoluted tubes, collecting ducts and arched vessels. The renal columns contain interlobar vessels.

C- MEDULLA

The medulla is the part of the renal parenchyma made of five to eleven triangular striated areas prolonged in the cortex, the pyramids of the medulla separated by the renal columns of the cortex. The bases of the pyramids are external, and the apices are internal and open together into a renal papilla, each of which projects into a minor calyx. They contain the loops of Henle, the collecting ducts and the right vessels. The kidney can, thus, be divided into five to eleven lobes. Each lobe is made up of one pyramid and the part of the cortex towards it.

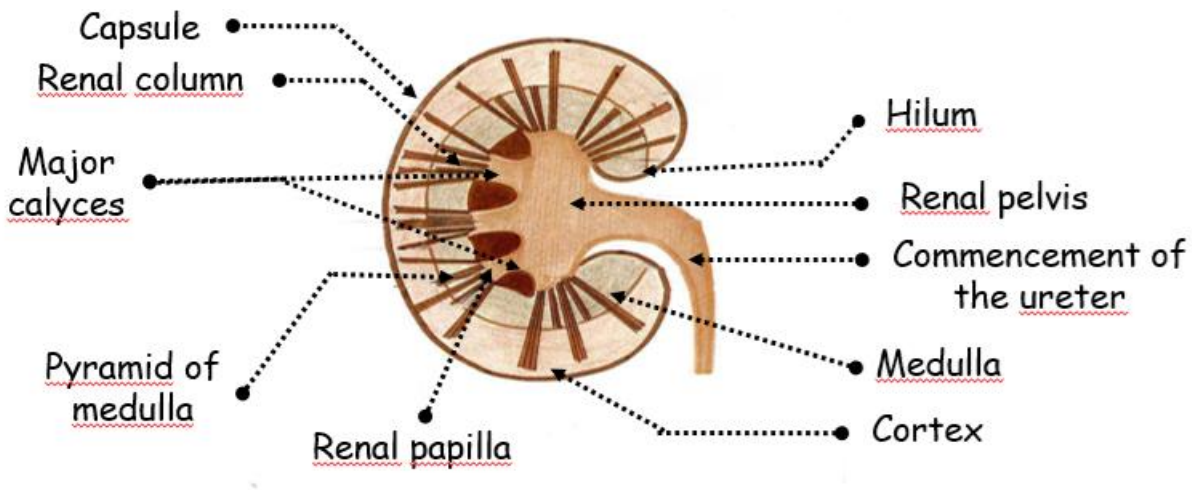

Figure 3: Coronal section showing the structure of kidney

D- NEPHRON

The nephron is the histological and functional unit of the kidney. There are about one million in each kidney. Each nephron consists of a glomerulus and a tubule system.

The glomerulus is a tuft of capillaries surrounded by very thin epithelial cells, the podocytes, continuous with the ones forming the boundary of Bowman's capsule and the ones of the tubule system. The capillaries' wall is made of endothelium and glomerular basement membrane. It is supplied by an afferent arteriole and leaving them is an efferent arteriole which breaks up into peritubular capillaries surrounding the proximal and distal convoluted tubules. The glomeruli ensure glomerular filtration producing the primary urine that accumulates in the glomerular space.

The part of the tubule adjacent to Bowman's capsule is the proximal convoluted tubule and is a centimetre and half long sinuous tubule lined by a simple columnar epithelium.

It leads into the thin-walled loop of Henle, U-shaped and lined with a pavement epithelium, and so to the distal convoluted tubule, sinuous and half a centimetre long lined by a thin simple columnar epithelium, and finally to the collecting tubule and collecting duct. The collecting ducts unite with one another, and the largest open at the tip of a renal papilla in a minor calyx. The tubule system ensures the modification of the primary urine by selective absorption and secretion to form the definitive urine.

The juxtaglomerular apparatus is formed by certain arteriolar cells and distal convoluted tubule cells. The arteriolar juxtaglomerular cells of the tunica media secrete renin.

The calyx and renal pelvis walls are made three layers. The mucous membrane is lined by a transitional epithelium. The muscle of the calyx and pelvis is longitudinal and circular. The adventitia is made of a lax connective tissue continuous with the fat of the hilum and the perinephric fat.

IV. ANATOMICAL RELATIONS

A- POSTERIOR RELATIONS

The posterior relations of the right and left kidneys are similar and arranged in two levels.

At the thoracic level, the kidneys are applied against the fibres of the diaphragm which arise from the lateral and medial arcuate ligaments in front of the costodiaphragmatic recess of the pleura and overlied by the eleventh and twelfth ribs and the subcostal vein, artery and nerve beneath the lateral arcuate ligament.

At the lumbar level, the kidneys lie on, from inside to outside, psoas major muscle and the iliohypogastric and ilioinguinal nerves as they emerge from its lateral border, quadratus lumborum muscle and the upper lumbar arteries and veins behind it and transversus abdominis muscle.

B- ANTERIOR RELATIONS

The anterior relations of the kidneys are more symmetrical than appears at first sight. These relations are established through the peritoneum of the posterior abdominal wall.

The right kidney lies behind the under surface of the liver and the hepatorenal pouch at its upper part, the second part of the duodenum and jejunal coils towards the hilum, the hepatic flexure, phrenicocolic ligament and ascending branch of right colic artery at its lower pole.

The left kidney lies behind the tail of pancreas towards the middle part, the splenic flexure, jejunal coils and the ascending branch of left colic artery at its lower part and the spleen, lesser sac with lienorenal ligament and stomach towards its upper part.

C- HILUM

The hilum lies over psoas muscle. On the right, it is next to the inferior vena cava and the ureter. On the left, it is overlied by the left suprarenal gland next to the aorta and the vena cava behind the lesser sac.

D- LATERAL BORDER

The lateral border is surrounded by the aponeurosis of origin of transversus abdominis muscle.

E- UPPER POLE

The upper pole is overlied by the suprarenal gland. On the right, it is in contact with the inferior vena cava and the bare area of the liver forwards. On the left, it is in contact with the spleen.

F- LOWER POLE

The lower pole of the kidney is three centimetres above the iliac crest on the right and five centimetres above on the left.

G- RENAL PELVIS

The renal pelvis is surrounded by the anterior division of the renal artery forwards and the posterior division backwards. The other relations are the same as of the hilum.

V. BLOOD SUPPLY; LYMPH DRAINAGE AND NERVE SUPPLY

A- ARTERIES

The kidneys are supplied by the renal arteries. They are large vessels arising at right angles from the aorta at the level of L2 vertebra.

The left artery is shorter than the right. It crosses the left crus of diaphragm and psoas behind and above the left renal vein. It is covered by the tail of the pancreas and the splenic vessels.

The right artery is longer. It crosses the right crus and psoas behind the inferior vena cava, the short right renal vein, the head of pancreas, bile duct and the second part of the duodenum.

In the region of the hilum the artery typically gives rise to an anterior and a posterior division.

The posterior division supplies the posterior segment.

The anterior division gives branches, the segmental arteries, that supply the apical, upper, middle and lower segments. Based on its blood supply, each kidney possesses five segments. The standard pattern is frequently modified by the way the vessels branch. There are always five segments with no collateral circulation between them. The segmental arteries give rise to, interlobar arteries, the latter give rise to the arched arteries that project towards the base of the pyramids of the medulla giving rise to the interlobular arteries in the cortex. The interlobular arteries define renal lobules.

The arteries of the renal capsule may be provided by the renal artery, the genital artery or colic arteries.

Polar arteries may rise from the renal artery or the aorta and can be superior, inferior, or both, respectively by frequency.

B- VEINS

The veins from the renal segments communicate with one another profusely, unlike the arteries. They form five or six vessels that unite at the hilum to form the single renal vein.

Upstream, the veins correspond to the arteries.

The renal veins lie in front of the renal arteries and behind the pancreas. In length and in territory drained the two veins are very different.

The left vein is three times as long as the right, seven centimetres and half long. It crosses in front of the aorta, receives the left suprarenal vein, the left gonadal vein, the left inferior phrenic vein and is connected with the left ascending lumbar and lumbar azygos veins and hence with azygos and vertebral systems. The right vein drains only its own kidney.

C- LYMPH DRAINAGE

The lymphatics of the kidneys drain to para-aortic nodes at the level of origin of the renal arteries. The surface of the upper pole may drain through the diaphragm into nodes in the posterior mediastinum. They are arranged into two plexuses, intrarenal and capsular.

D- NERVES

Renal nerves are derived from both parts of the autonomic system. The sympathetic preganglionic cells lie in the spinal cord from T12 to LI segments and they send preganglionic fibres to the thoracic and lumbar splanchnic nerves. The postganglionic cells are in the coeliac,

renal and superior hypogastric plexuses and, for the least splanchnic nerve, in the renal ganglion in the hilum of the kidney. They are vasomotor in function. Afferent fibres, including those subserving pain, accompany the sympathetic nerves as for most other viscera. Thus, the pathway for the pain of renal colic from a stone in the calyces or renal pelvis may run along blood vessels to the coeliac plexus and thence by the splanchnic nerves to the sympathetic trunk and via white rami communicantes to T12–L1 spinal nerves and so into the spinal cord by the posterior nerve roots. The pain may radiate from the back and lumbar region to the anterior abdominal wall and down to the external genitalia. There is some parasympathetic supply from the vagus, of uncertain function, but it is possible that some afferents run with the vagal fibres, and this may explain the nausea and vomiting that may accompany renal pain.

VI. SURGICAL APPROACH

For many operations on the kidney including removal, nephrectomy, and removal of stones, nephrolithotomy, a lumbar approach is used. The incision extends below the twelfth rib from the lateral border of erector spinae towards the anterior superior iliac spine. Latissimus dorsi and external oblique are incised and their cut edges retracted so that the internal oblique and transversus merging with the lumbar fascia can also be incised. The subcostal nerve deep to internal oblique should be preserved but the vessels can be ligated. The transversalis fascia and extraperitoneal fat in the posterior part of the incision are separated to expose the renal fascia. The peritoneal cavity is not entered. Proper identification of the twelfth rib especially when short) is essential, to avoid entering the pleural cavity.

The renal fascia and perirenal fat are incised to expose the kidney, whose upper pole is freed leaving the suprarenal gland within its own compartment of the fascia. The overlying peritoneum is pushed away forwards and medially. The renal vessels can then be exposed and ligated, the artery before the vein, to mobilize the organ further and transect the ureter. On the right a diseased kidney may adhere to the colon, ureter, duodenum, inferior vena cava or suprarenal gland, and on the left to the colon, ureter, spleen, pancreas and suprarenal. The right renal vein is only two centimetres and half long, so the inferior vena cava is very near the operation area.

For percutaneous renal biopsy, the lower pole of the kidney is entered by an approach two centimetres and half below the twelfth rib and at a distance from the midline determined radiologically. Damage to a renal vessel or calyx is a potential hazard, and the needle is only advanced while the patient is holding the breath so that the kidney is not torn by respiratory movement.

For transplantation, the donor kidney is placed retroperitoneally in the iliac fossa with the hilum parallel to the external iliac vessels. The renal artery is anastomosed to the internal or external iliac artery and the renal vein to external iliac vein. The ureter is implanted into the anterior surface of the bladder.

VII. CONCLUSION

The kidneys are paired heterocrine glands, retroperitoneal and paravertebral, important to life.

They are made of cortex and medulla that secrete different hormones.

They have several anatomical relations and a rich terminal blood supply.

Nerves are mainly provided from the splanchnic nerves and lymph drainage is ensured by the para-aortic nodes.