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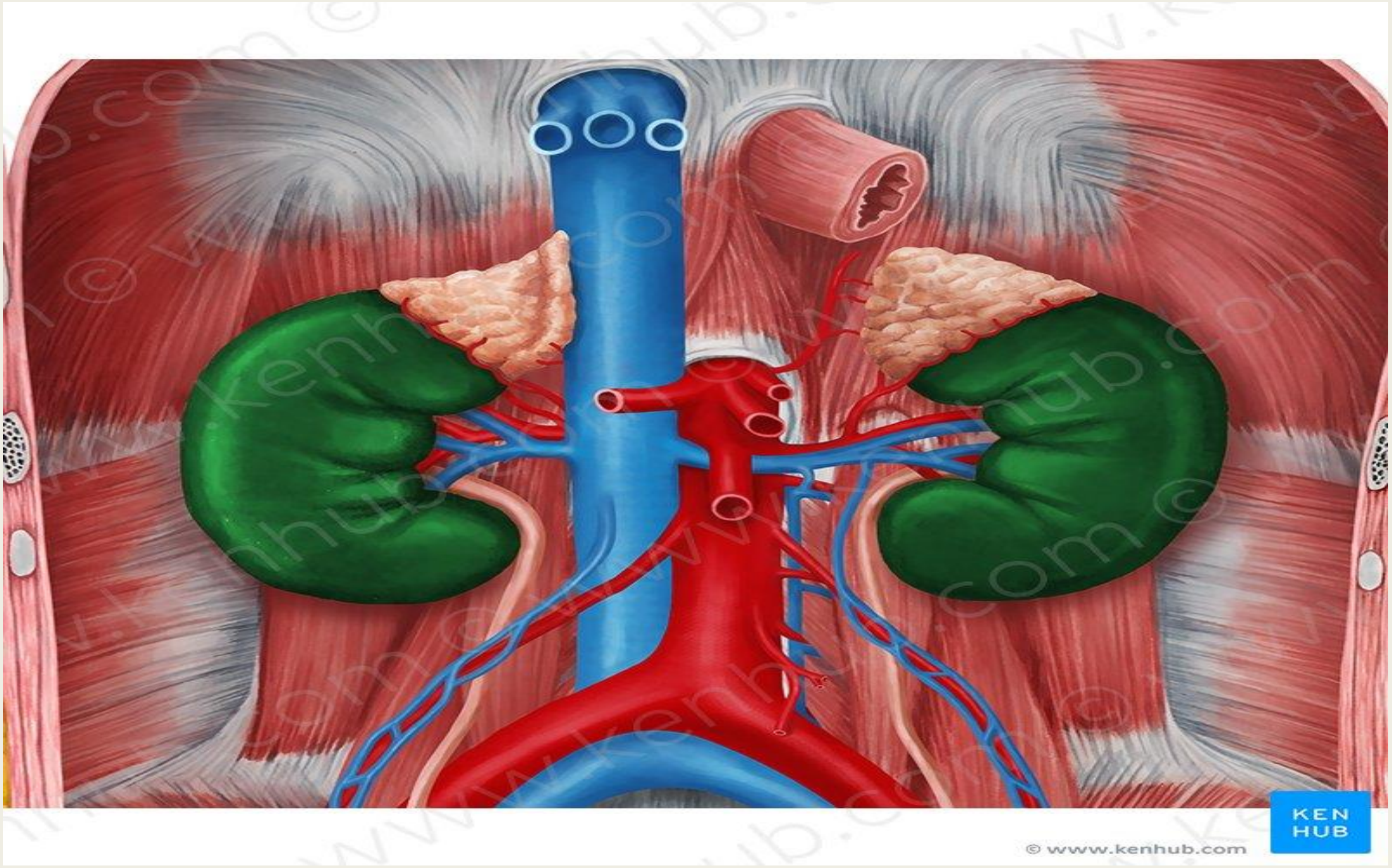
GROSS ANATOMY OF KIDNEY

DR. MAHVISH JAVED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KIDNEYS

- The kidneys are bilateral organs placed retroperitoneal in the upper left and right abdominal quadrants and are part of the urinary system. Their shape resembles a bean, where we can describe the superior and inferior poles, as well as the major convexity pointed laterally, and the minor concavity pointed medially.

KIDNEYS

- The main function of the kidney is to eliminate excess bodily fluid, salts and byproducts of metabolism – this makes kidneys key in the regulation of acid-base balance, blood pressure, and many other homeostatic parameters.

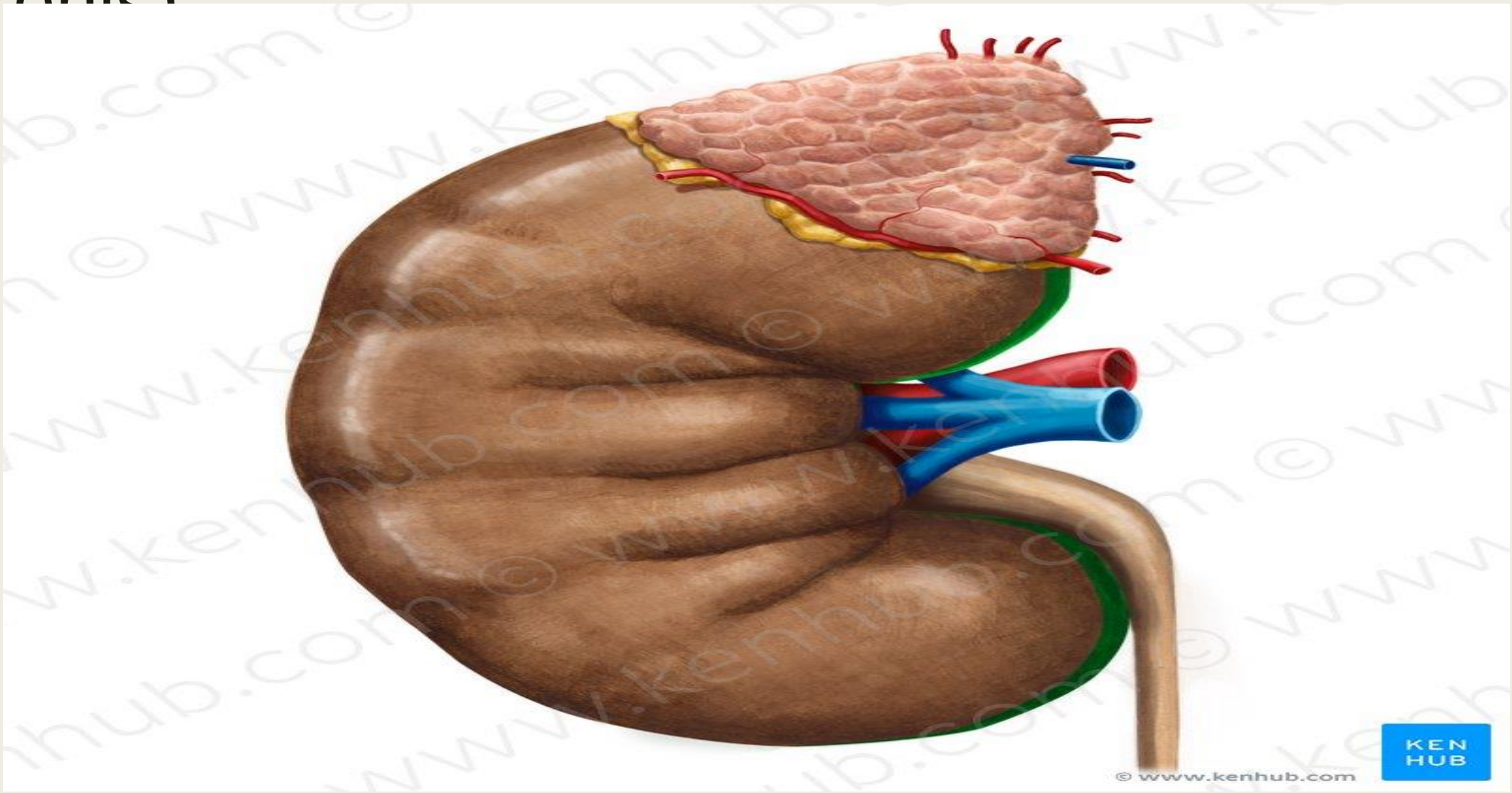
ANATOMY

The kidneys have their **anterior and posterior surfaces**. The anterior surface faces towards the anterior abdominal wall, whereas the posterior surface is facing the posterior abdominal wall.. The **media**l **borde**r is marked as the hilum of the kidney where the renal artery enters the kidney, and the renal vein and

Ureter leave the kidney.

The **lateral border** is convex outward.

Medial border of kidney (Margo medialis renis)



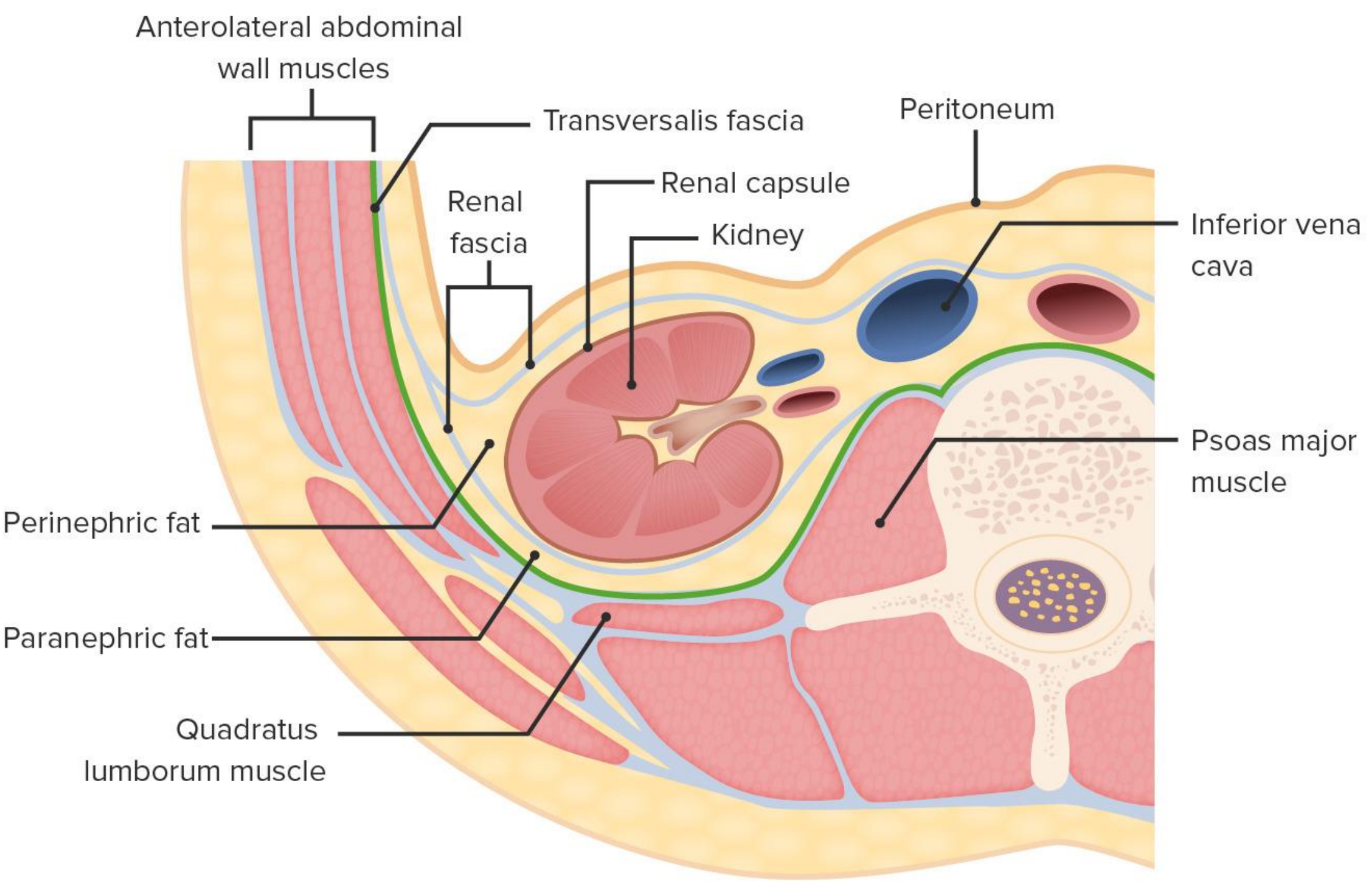
ANATOMY CONTD

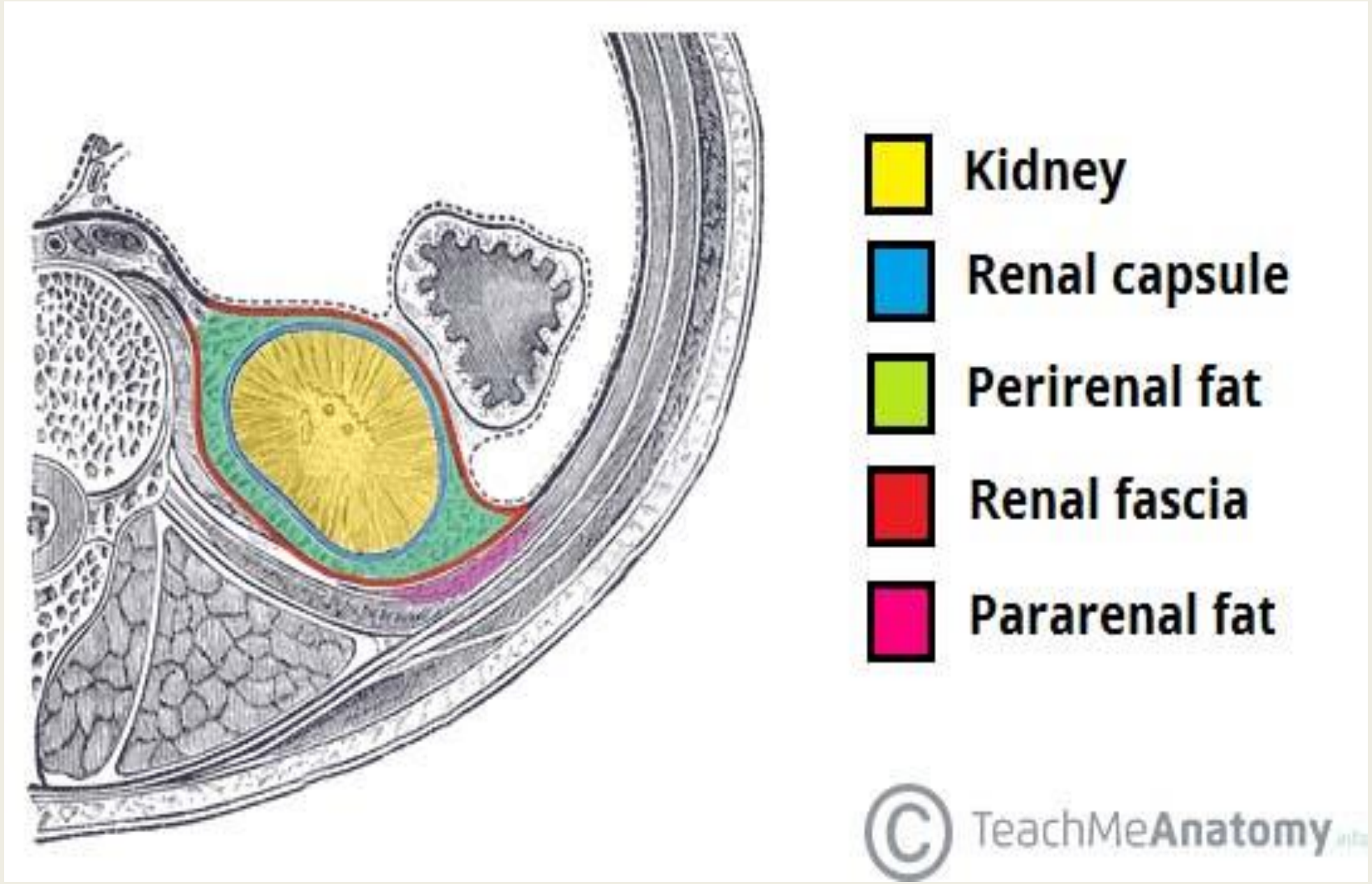
The kidneys are positioned retroperitoneally, meaning that they are not wrapped with the peritoneal layers the way most abdominal organs are, but rather are placed behind it. .

The kidney tissue is protected by three layers that entirely surround the kidney:

- The fibrous capsule (renal capsule)
- The perinephric fat (perirenal fat capsule)
- The renal fascia which besides the kidneys also encloses the suprarenal gland and its surrounding fat.

Outside the fascia is the most superficial layer – a layer of fat tissue called the perinephric fat. This layer sits posteriorly and posterolaterally to each kidney and separates it from the muscles of the abdominal wall.


Anterolateral abdominal wall muscles
Transversalis fascia
Peritoneum
Renal capsule
Renal fascia
Kidney
Inferior vena cava
Psoas major muscle
Perinephric fat
Paranephric fat
Quadratus lumborum muscle


Kidney
Renal capsule
Perirenal fat
Renal fascia
Pararenal fat
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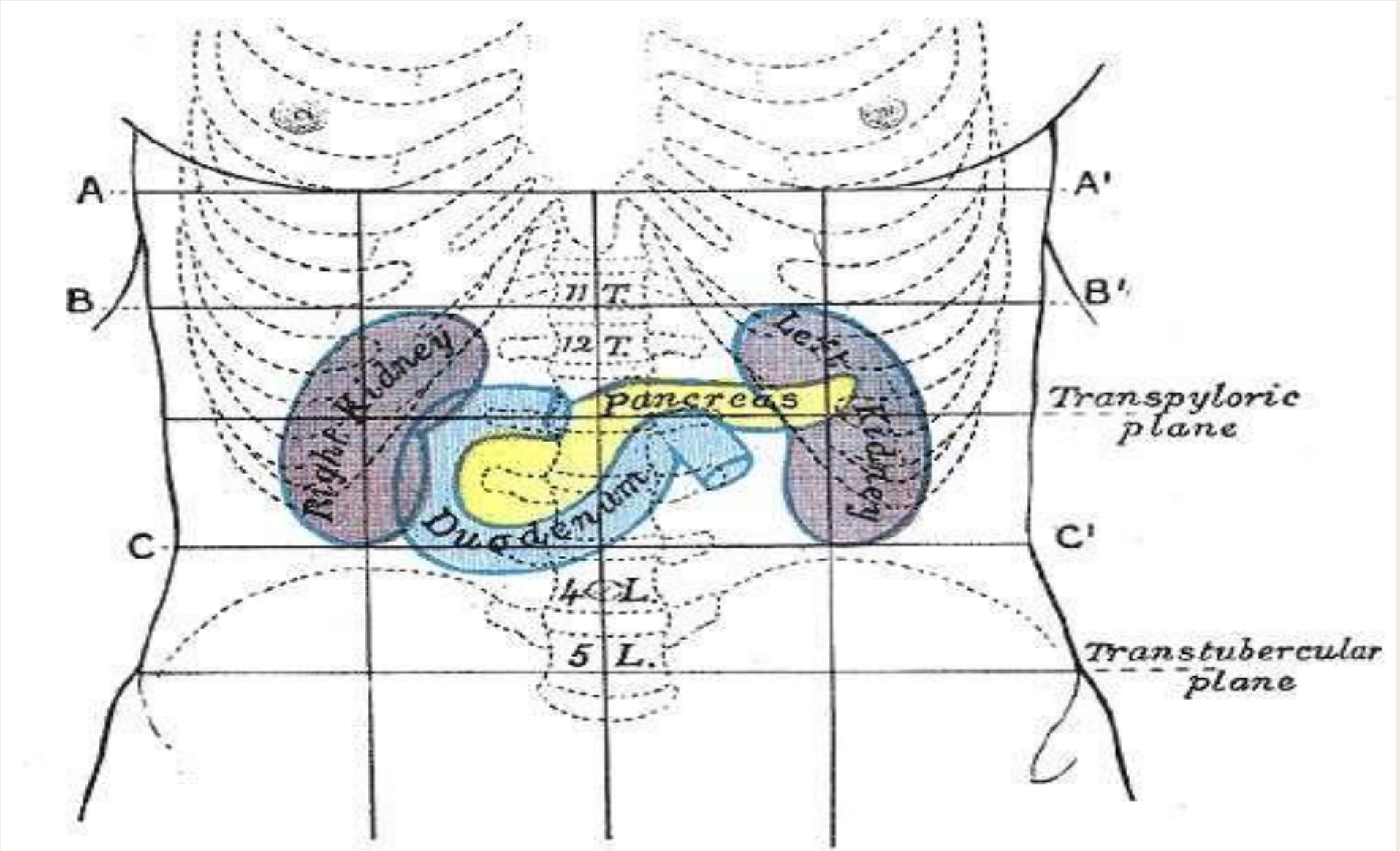
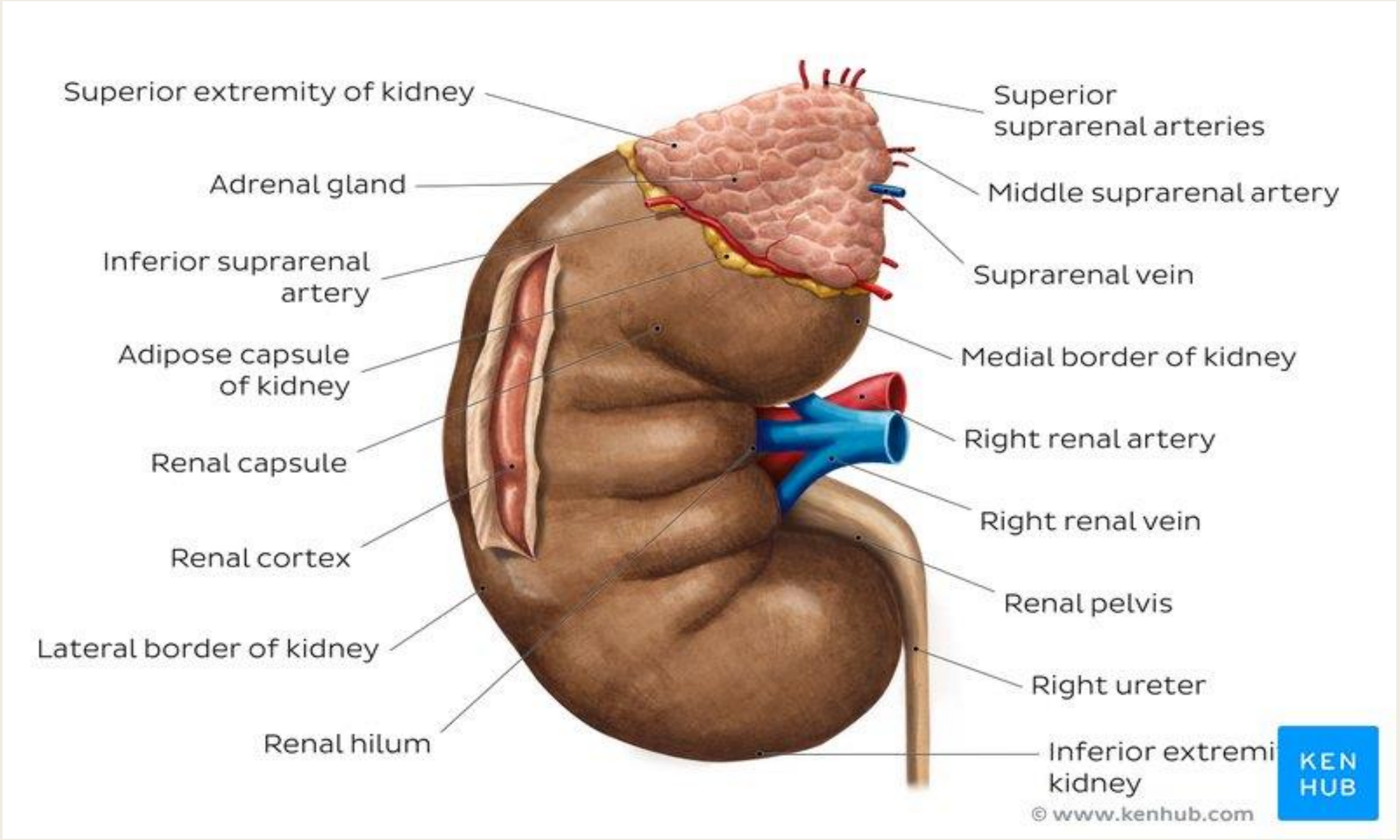
External Anatomy

- The kidneys are located between the transverse processes of T12-L3 vertebrae, with the left kidney typically positioned slightly more superiorly than the right. This is because the liver and the stomach offset the symmetry of the abdomen, with the liver forcing the right kidney a bit down, and the stomach forcing the left kidney a bit up.
- The superior poles (extremities) (T12) of both kidneys are more medially pointed towards the spine than the inferior poles (extremities) (L3). The hilum of the kidney usually projects at the level of the L2 vertebra. Thus, the ureter is seen paravertebrally starting from the L2 and going downwards.


A
A'
B
B'
11 T.
12 T.
Left Kidney
Right Kidney
Pancreas
Duodenum
Transpyloric plane
C
C'
4 L.
5 L.
Transtubercular plane


Superior extremity of kidney
Adrenal gland
Inferior suprarenal artery
Adipose capsule of kidney
Renal capsule
Renal cortex
Lateral border of kidney
Renal hilum
Superior suprarenal arteries
Middle suprarenal artery
Suprarenal vein
Medial border of kidney
Right renal artery
Right renal vein
Renal pelvis
Right ureter
Inferior extremi
kidney
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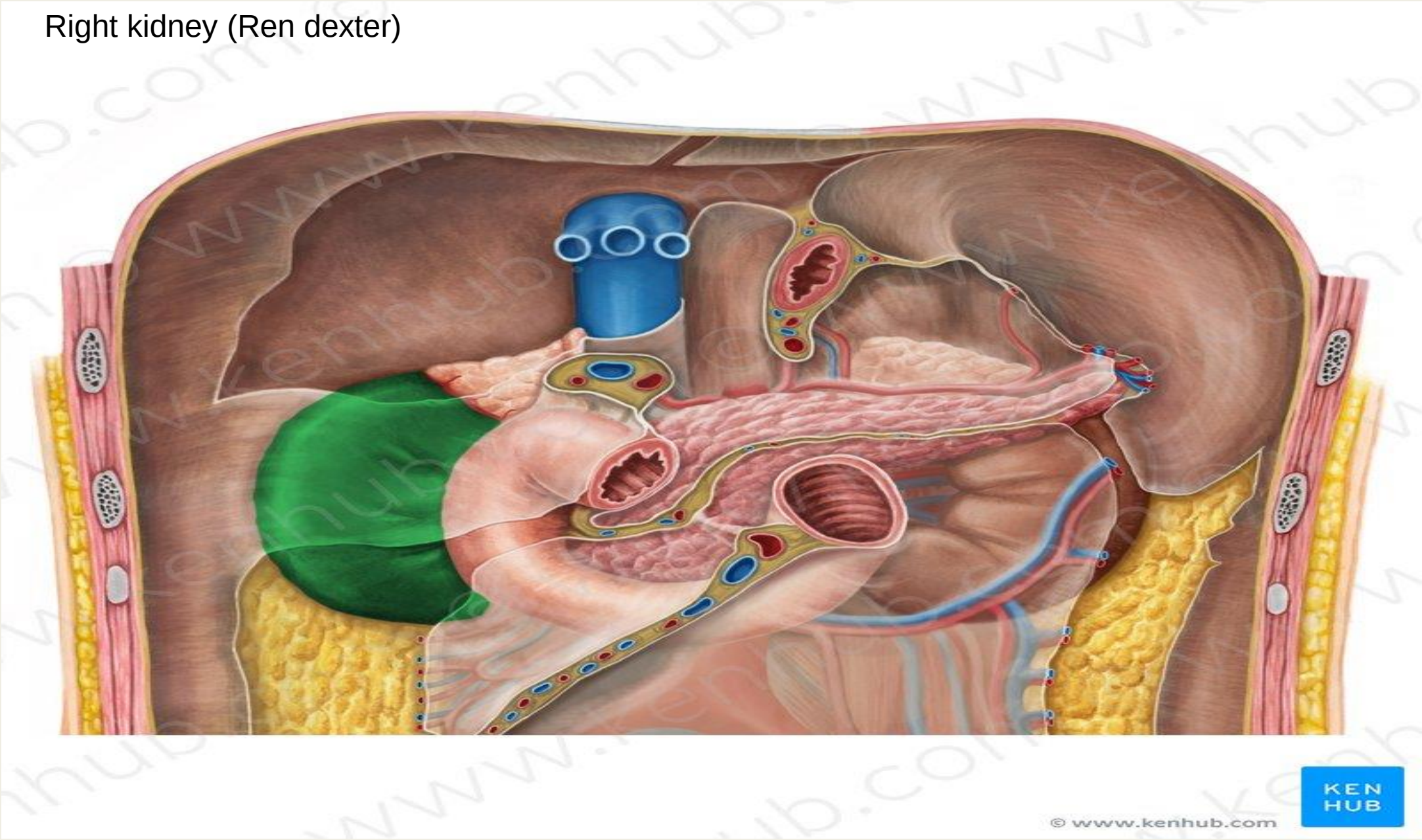
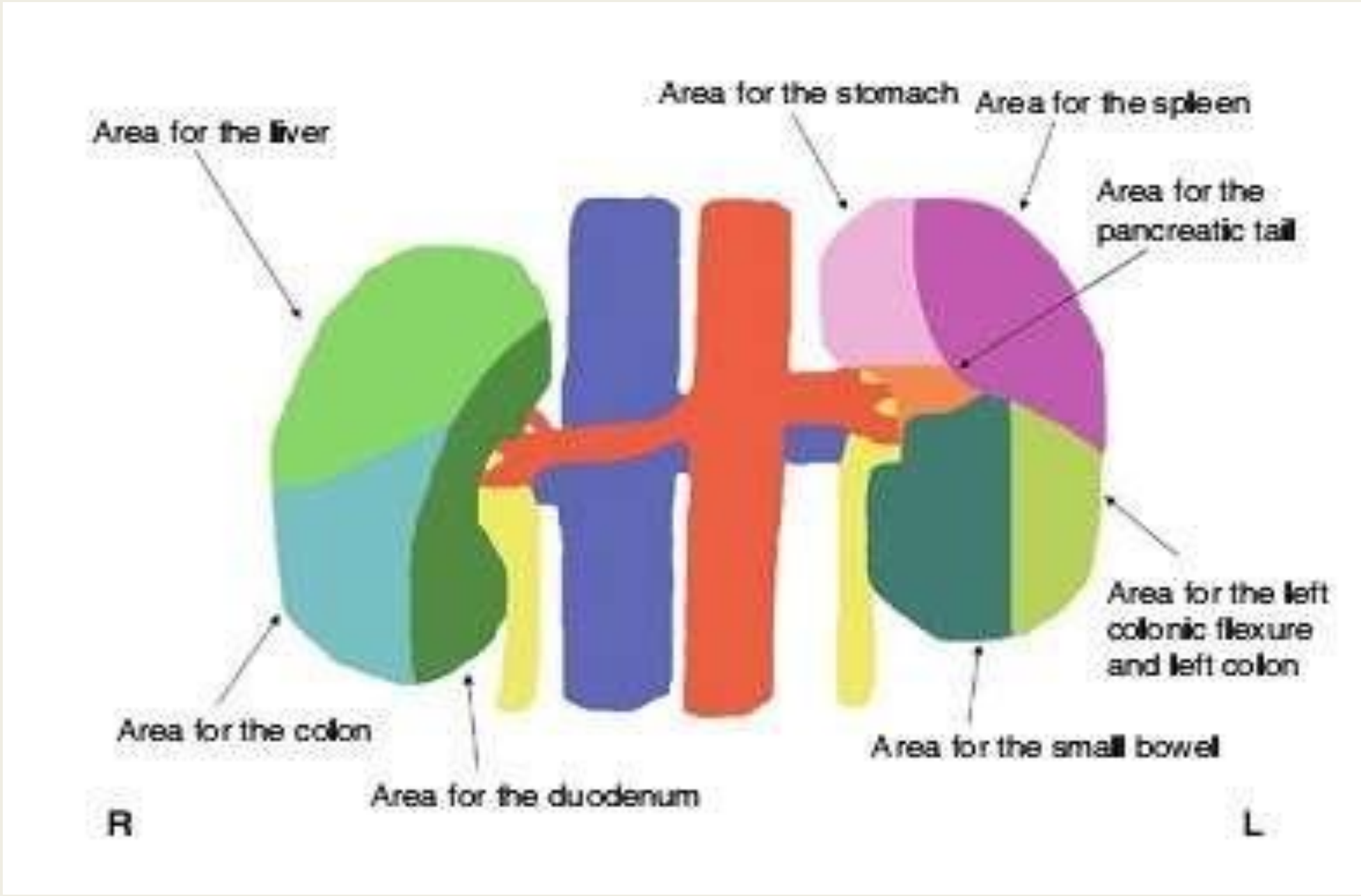
Right kidney (Ren dexter)

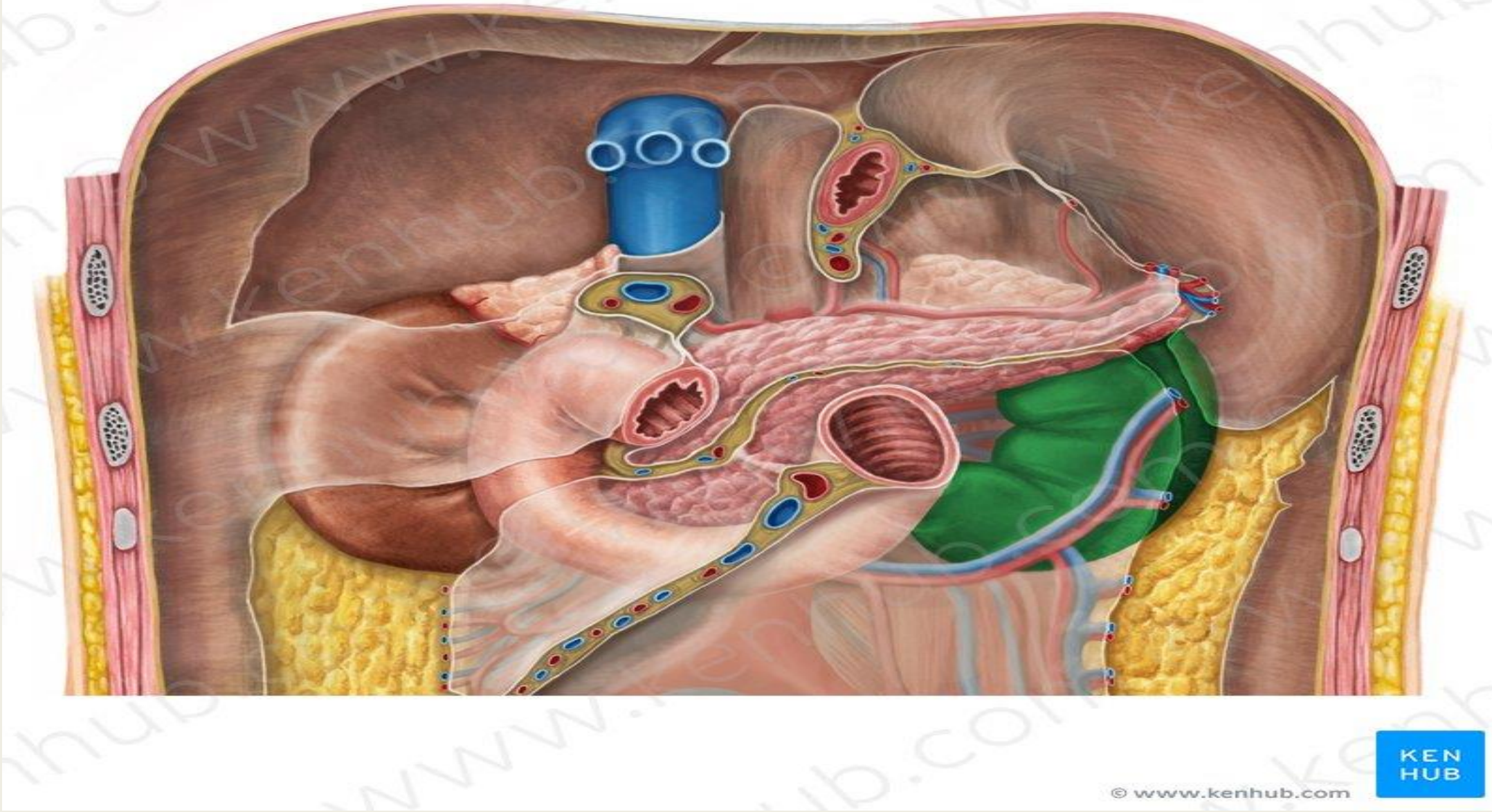


RIGHT KIDNEY ANTERIOR SURFACE

RIGHT KIDNEY	RELATIONS
Right suprarenal gland	Superior pole
Peritoneum	Superior one-half of anterior surface
Descending duodenum	Center of the anterior surface
Right colic flexure	Lateral part of inferior pole
Jejunum	Medial part of inferior pole


Area for the liver
Area for the stomach
Area for the spleen
Area for the pancreatic tail
Area for the left colonic flexure and left colon
Area for the small bowel
Area for the duodenum
Area for the colon
R
L

Left kidney (Ren dexter)



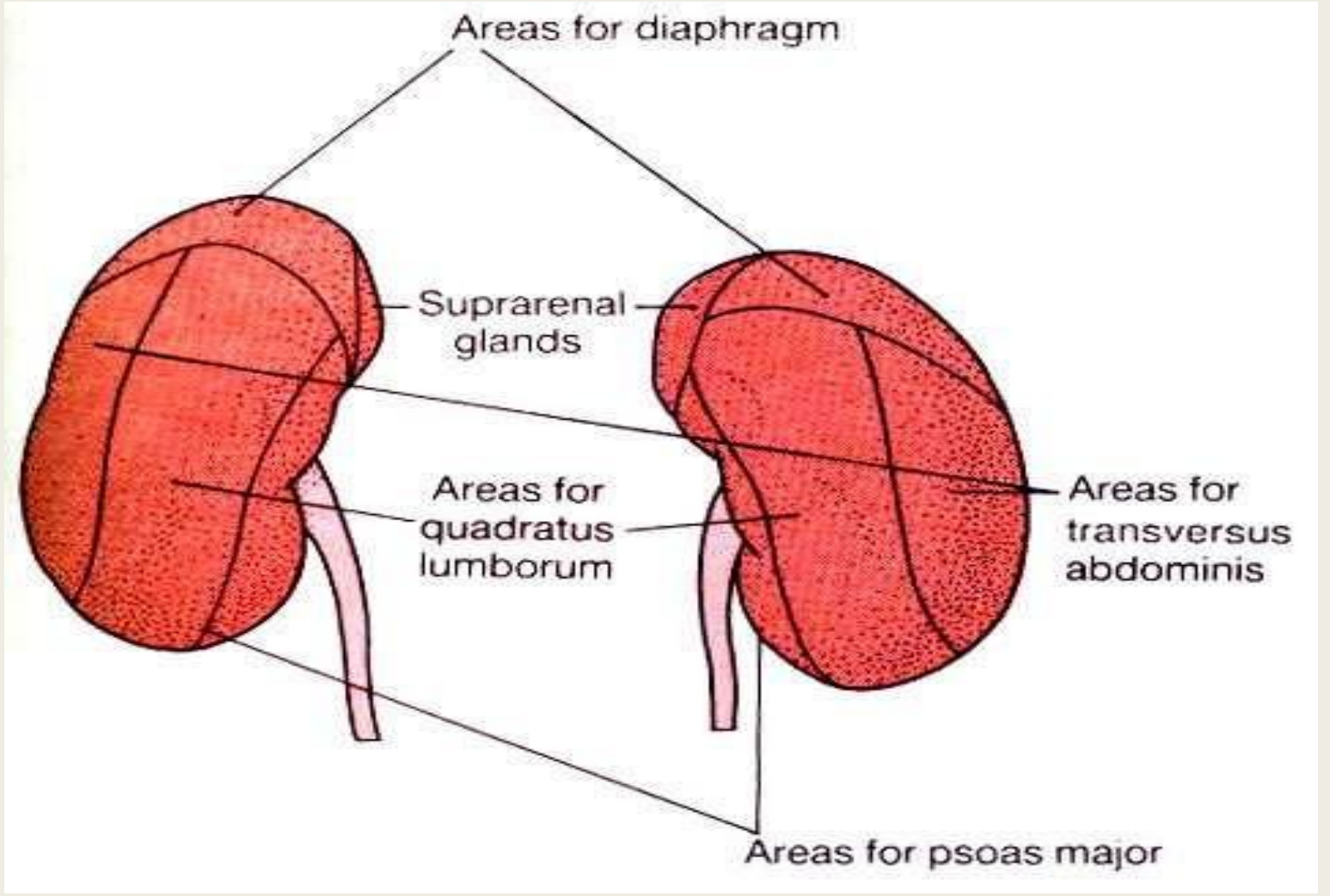
LEFT KIDNEY ANTERIOR SURFACE

KEY FACTS ABOUT THE LEFT KIDNEY RELATIONS	
Left suprarenal gland	Upper one half of superior pole
Stomach	Medial part of the lower half of superior pole
Spleen	Lateral part of the lower half of superior pole
Pancreas	Center of the anterior surface
Splenic flexure of descending colon	Lateral part of inferior half of anterior surface
Jejunum	Medial part of inferior half of anterior surface

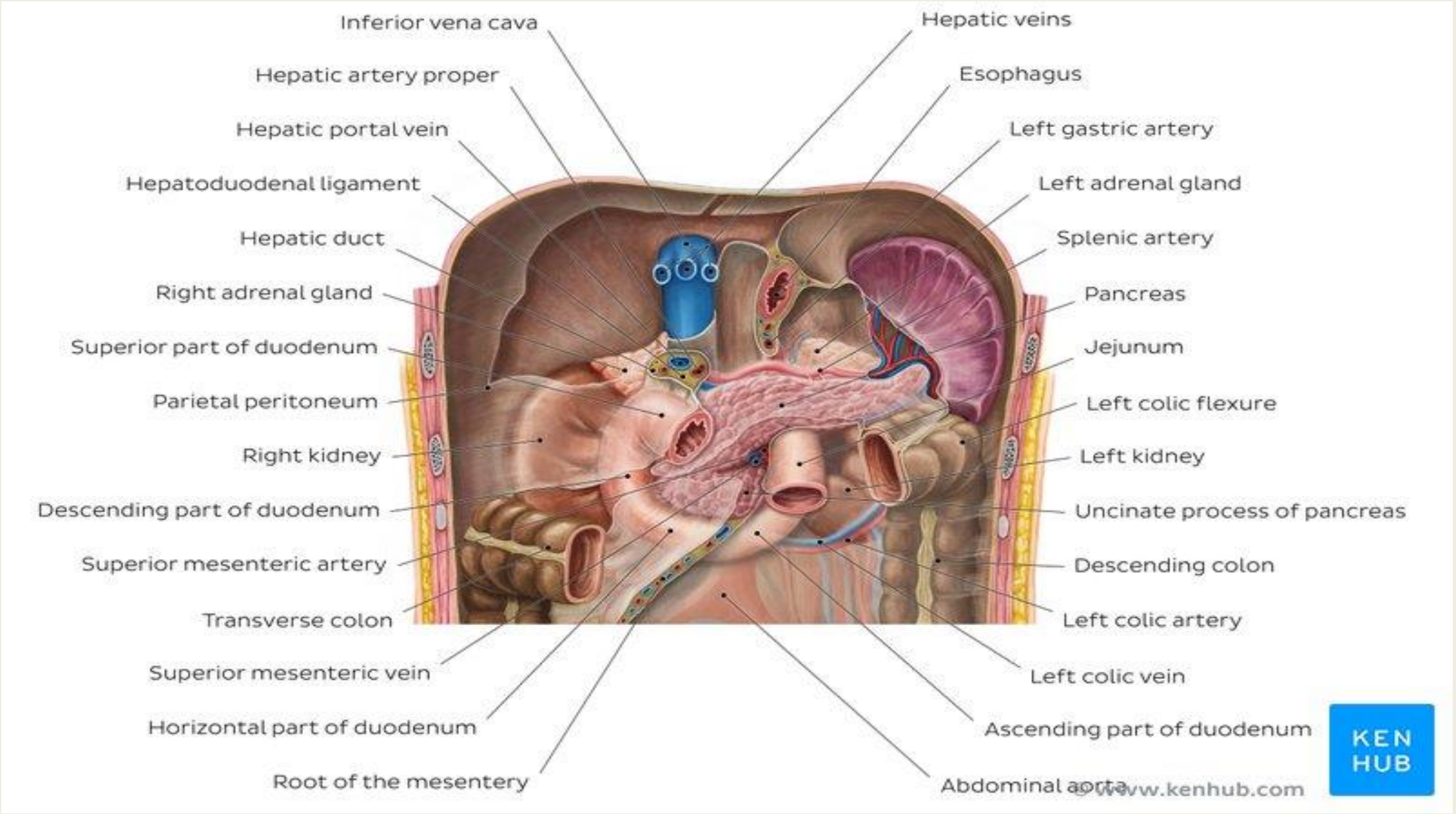
POSTERIOR SURFACE RELATIONS

KEY FACTS ABOUT POSTERIOR SURFACE RELATIONS	
Diaphragm	Superior half
Psoas major muscle	Medial third of lower half
Quadratus lumborum muscle	Middle third of lower half
Transversus abdominis muscle	Lateral third of lower half

- The superior half is covered by the diaphragm, which is why the kidneys move up and down during respiration
- The inferior half is easy to remember by dividing it into three vertical stripes, where the medial stripe represents the impression of the psoas major muscle, the central stripe the quadratus lumborum, and the lateral stripe the transversus abdominismuscle


Areas for diaphragm
Suprarenal glands
Areas for quadratus lumborum
Areas for transversus abdominis
Areas for psoas major

RELATIONS


Inferior vena cava
Hepatic veins
Hepatic artery proper
Esophagus
Hepatic portal vein
Left gastric artery
Hepatoduodenal ligament
Left adrenal gland
Hepatic duct
Splenic artery
Right adrenal gland
Pancreas
Superior part of duodenum
Jejunum
Parietal peritoneum
Left colic flexure
Right kidney
Left kidney
Descending part of duodenum
Uncinate process of pancreas
Superior mesenteric artery
Descending colon
Transverse colon
Left colic artery
Superior mesenteric vein
Left colic vein
Horizontal part of duodenum
Ascending part of duodenum
Root of the mesentery
Abdominal aorta
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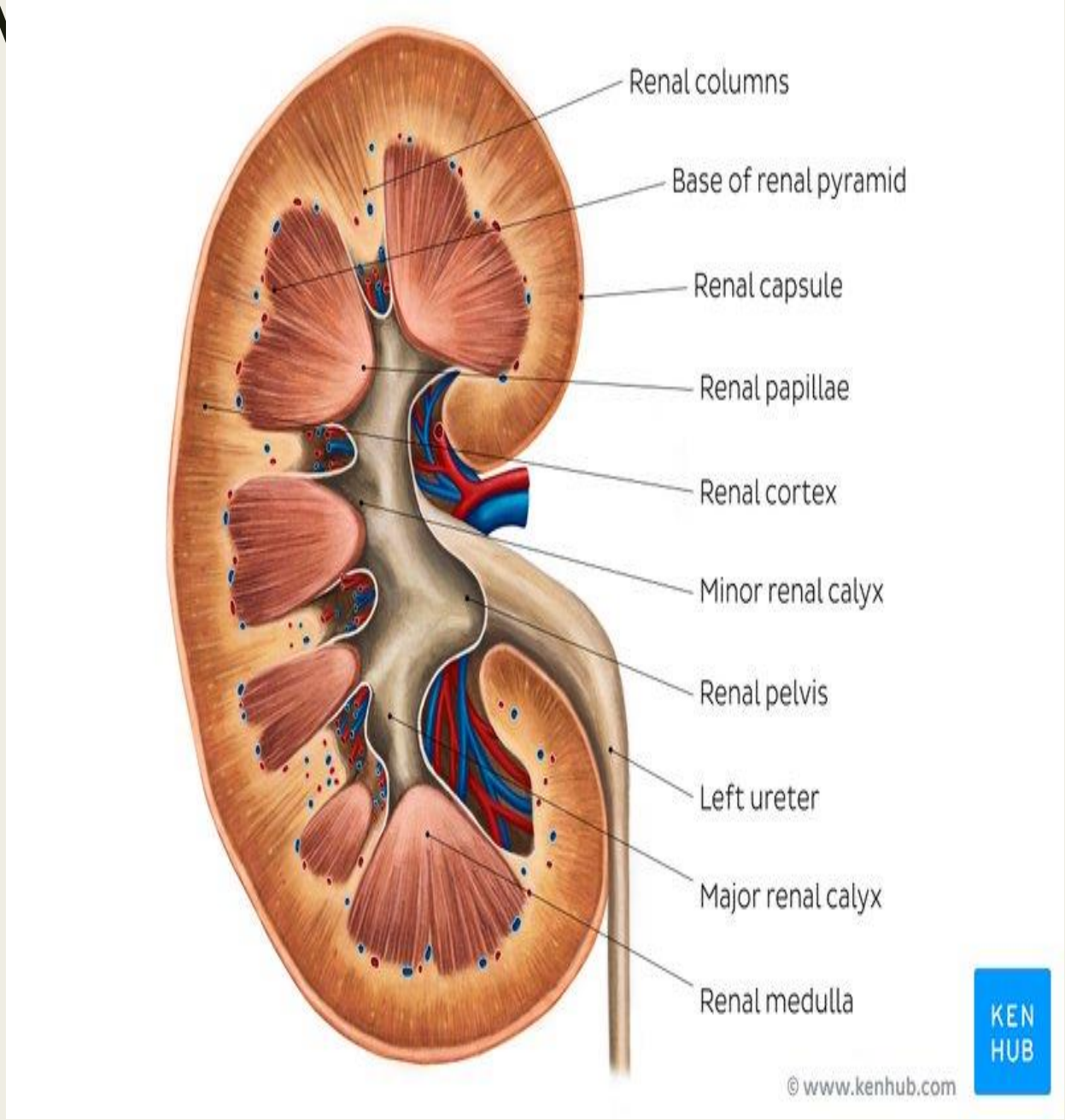
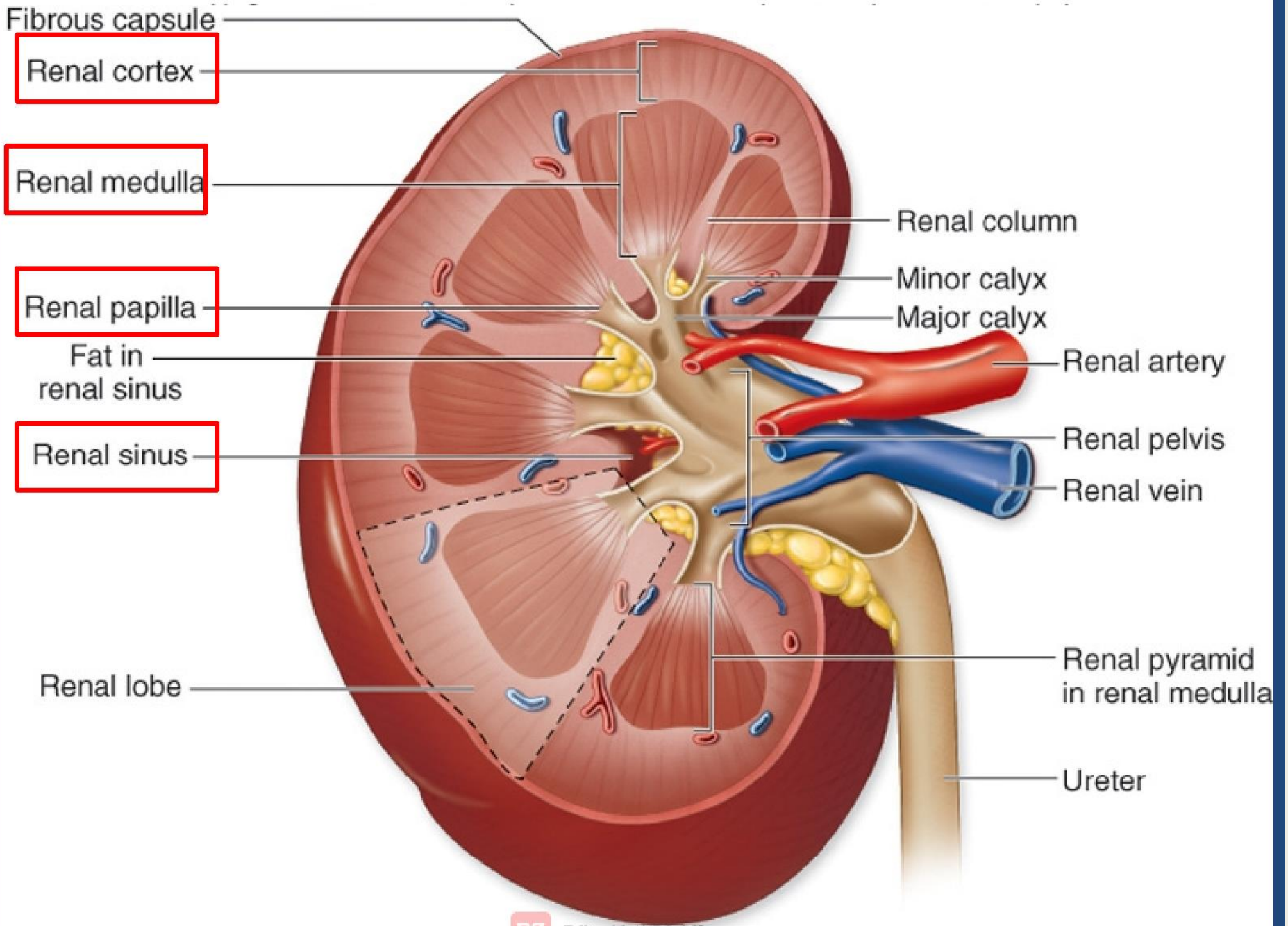
INTERNAL ANATOMY

The parenchyma of the kidney consists of the outer renal cortex, and inner renal medulla.





Right kidney, coronal section

- The main unit of the medulla is the renal pyramid. There are 8-18 renal pyramids in each kidney, that on the coronal section look like triangles lined next to each other with their bases directed toward the cortex and apex to the hilum.
- The apex of the pyramid projects medially toward the renal sinus. This apical projection is called the renal papilla and it opens to the minor calyx.
- The minor calyces unite to form a major calyx. Usually, there are two to three major calyces in the kidney (superior, middle, and inferior), which again unite to form the renal pelvis from which the ureter emerges and leaves the kidney through the hilum. The pyramids are separated by extensions of the cortex called the renal columns.

- The pyramids contain the functional units of the kidney, the nephrons, which filter blood in order to produce urine which then is transported through a system of the structures called calyces which then transport the urine to the ureter.
- So the pyramids represent the functional tissue that creates urine, whereas the calyces are the beginning of the ureter and transport the urine to it.

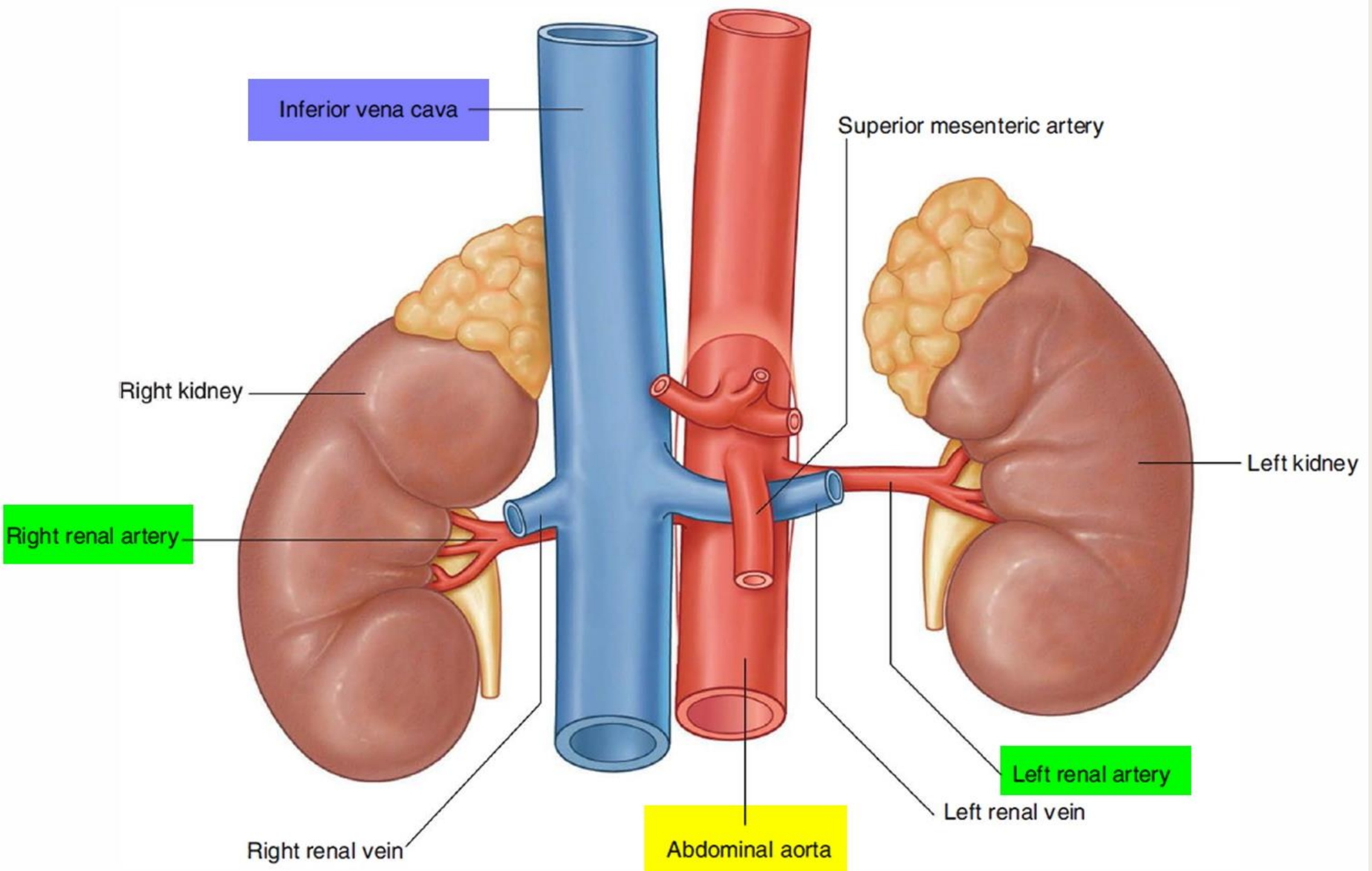
GLOMERULUS

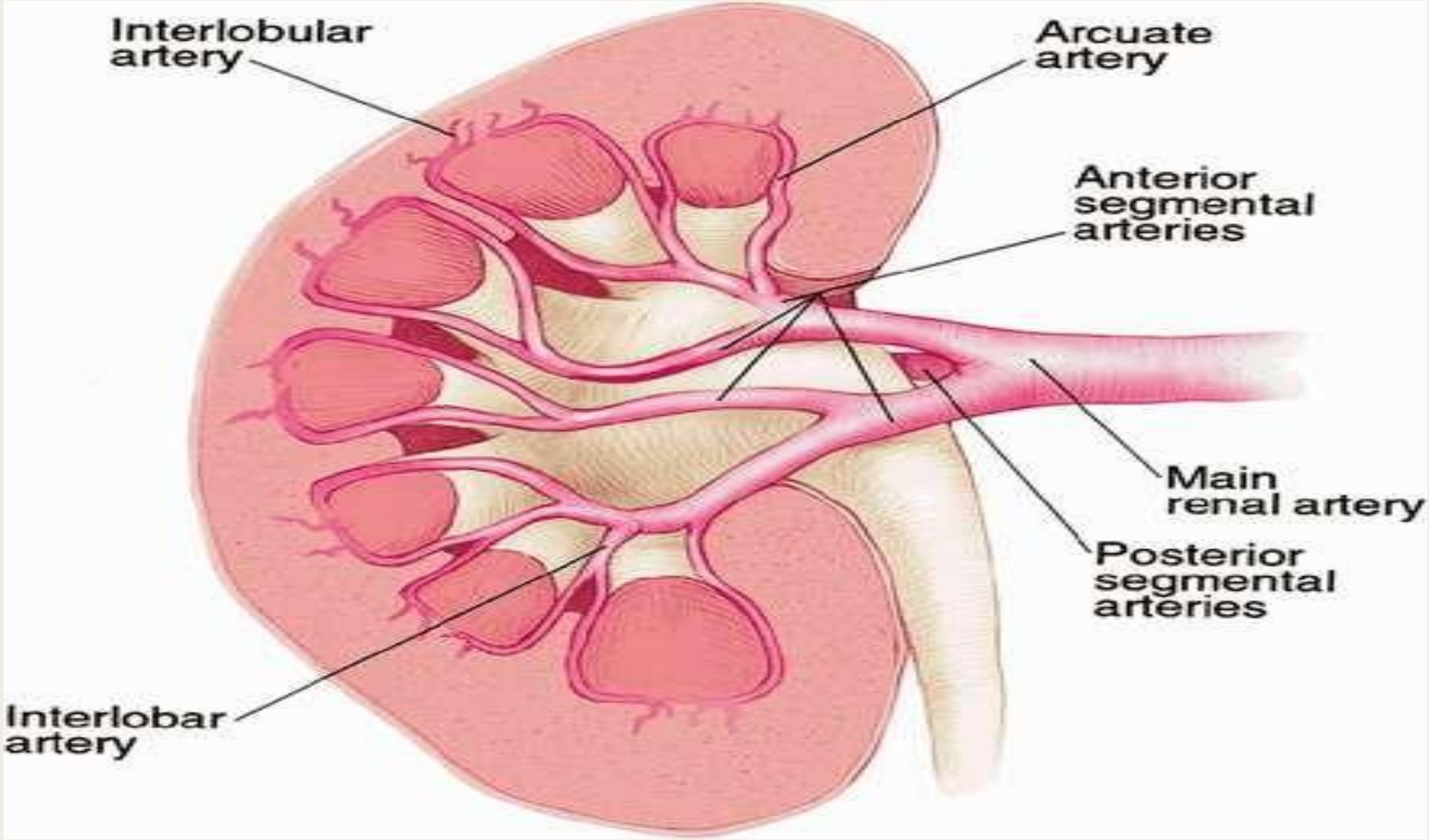
- The glomerulus is actually a web of arterioles and capillaries, with a special filter which filters the blood that runs through the capillaries, the glomerular membrane. The vessel which brings blood into the glomerulus is the afferent arteriole, whereas the vessel that carries the rest of the blood out that hasn’t been filtered out of the glomerulus is called the efferent arteriole.

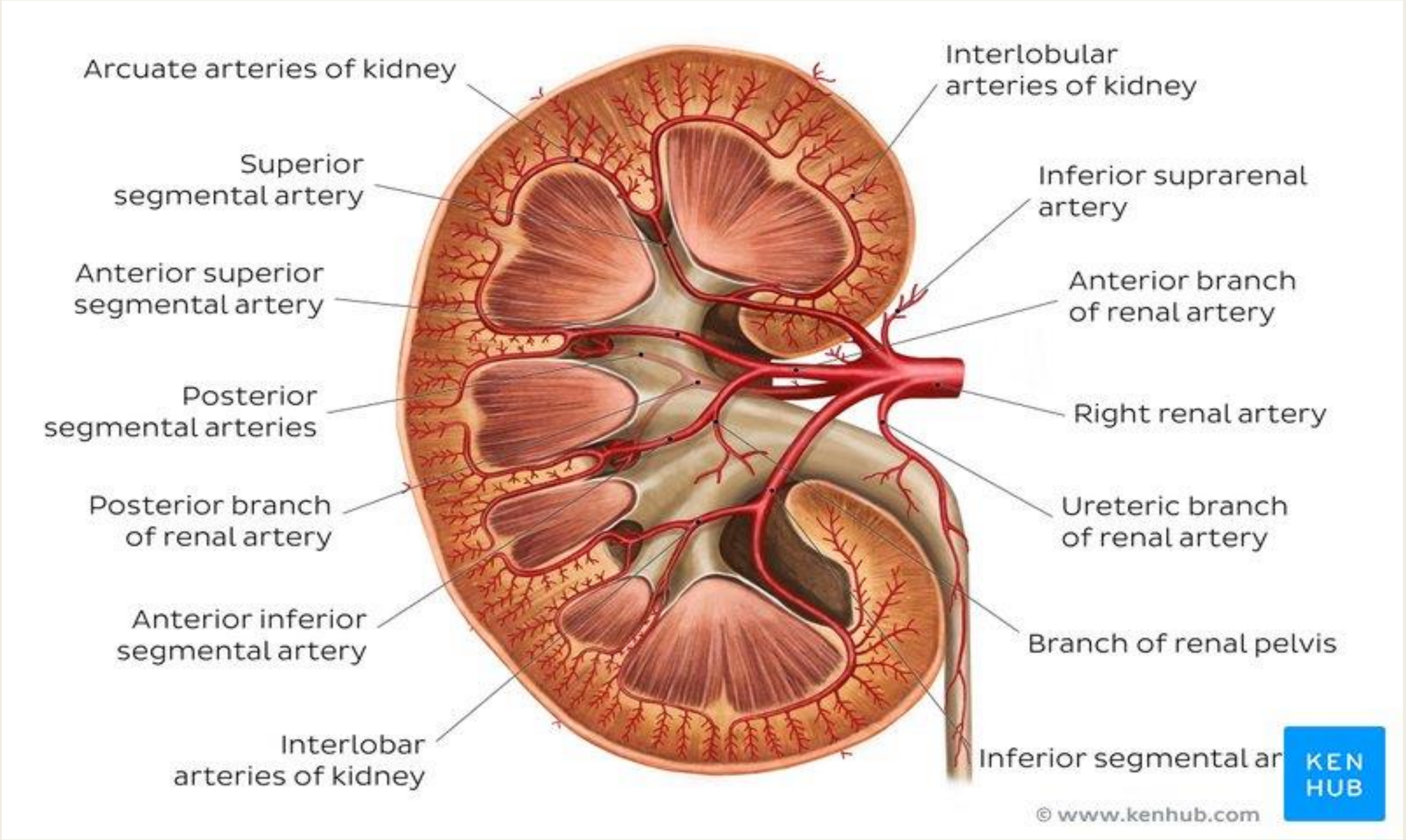
Vasculature and Lymphatic Drainage

ARTERIES

- Each kidney is supplied by a single renal artery, which is a direct lateral branch of the abdominal aorta. Both renal arteries, left and right, arise just below the superior mesenteric artery, between L1 and L2 with the left renal artery positioned slightly superiorly to the right one.
- The left artery has a short way to the left kidney, whereas the right has to go behind the inferior vena cava in order to reach the right kidney.
- In addition to the renal artery, accessory renal arteries are present too. They are branches of the abdominal aorta and all together are called the extra hilar renal arteries.


Inferior vena cava
Superior mesenteric artery
Right kidney
Left kidney
Right renal artery
Left renal artery
Left renal vein
Right renal vein
Abdominal aorta


Interlobular artery
Arcuate artery
Anterior segmental arteries
Main renal artery
Posterior segmental arteries
Interlobar artery


Arcuate arteries of kidney
Interlobular arteries of kidney
Superior segmental artery
Inferior suprarenal artery
Anterior superior segmental artery
Anterior branch of renal artery
Posterior segmental arteries
Right renal artery
Posterior branch of renal artery
Ureteric branch of renal artery
Anterior inferior segmental artery
Branch of renal pelvis
Interlobar arteries of kidney
Inferior segmental ar
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When the renal arteries enter the kidney through the hilum, they split into anterior and posterior branches.

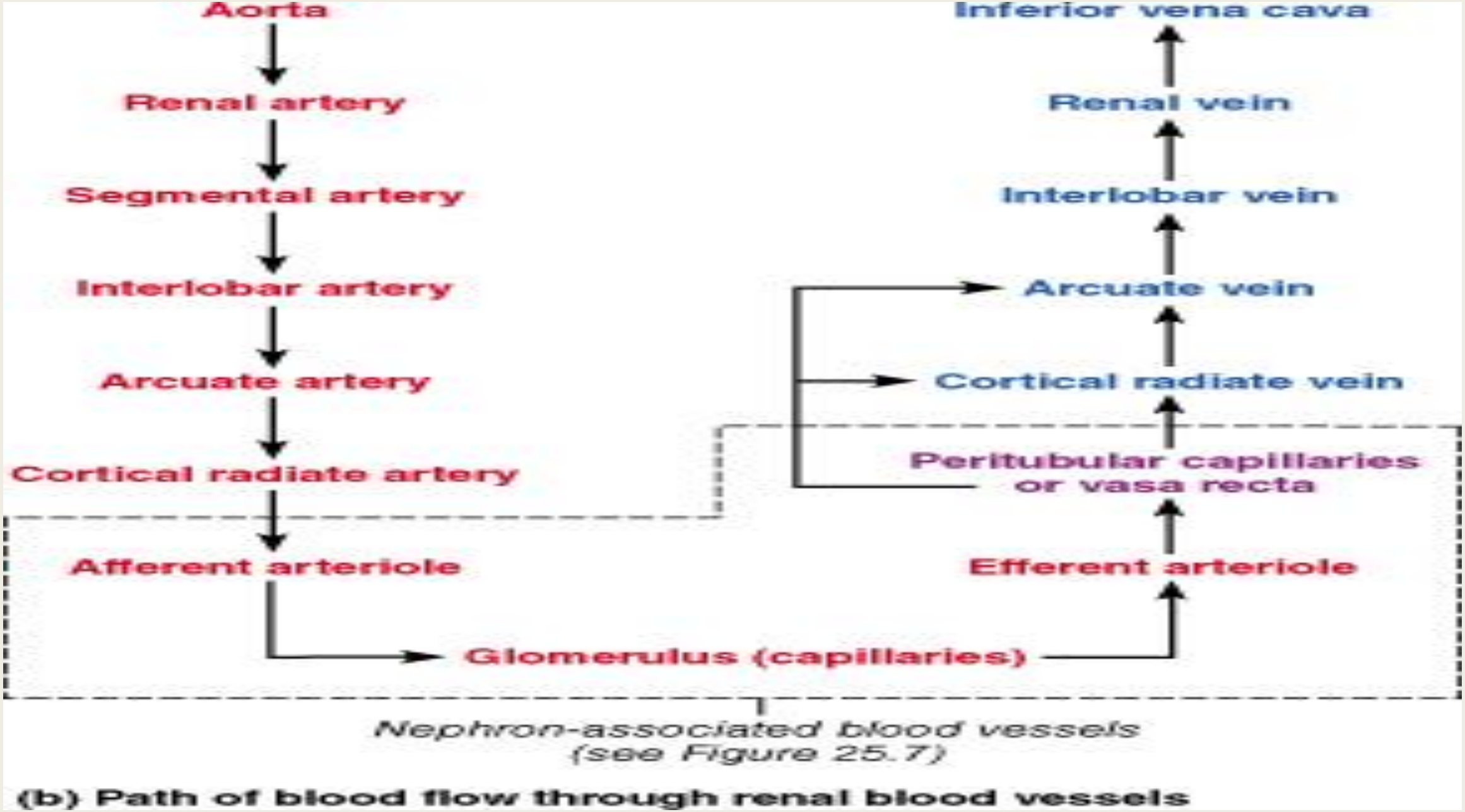
The posterior branch supplies the posterior part of the kidney, whereas the

anterior branch arborizes into five segmental arteries, each supplying a different renal segment.

The segmental arteries then branch into the interlobar arteries, which further branch into the arcuate arteries

Finally, the arcuate arteries branch into the interlobular arteries which branch off even further by giving afferent arterioles

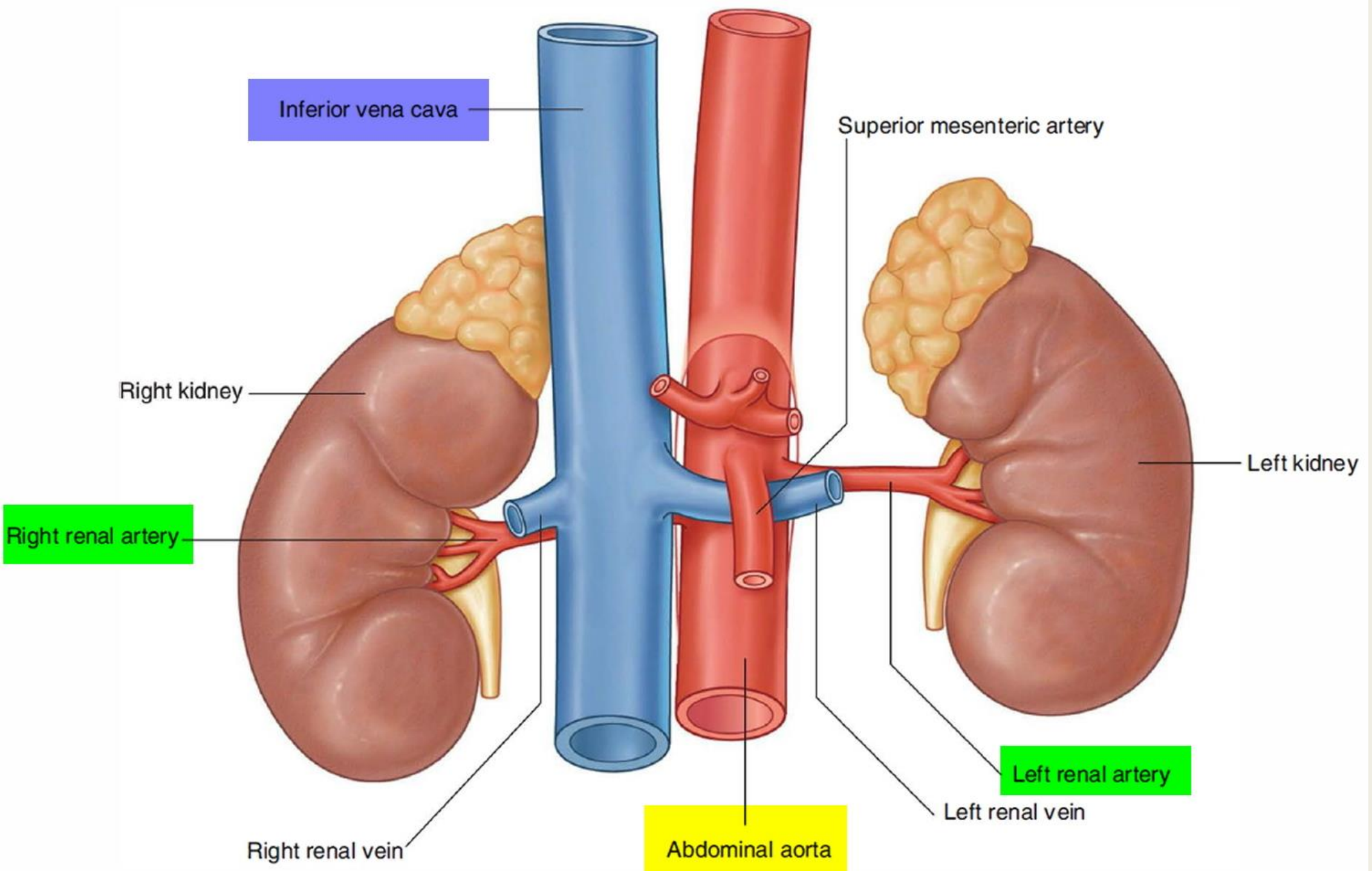
to run blood past the glomerulus for blood filtration. It is notable that the kidney has a very rich blood supply.



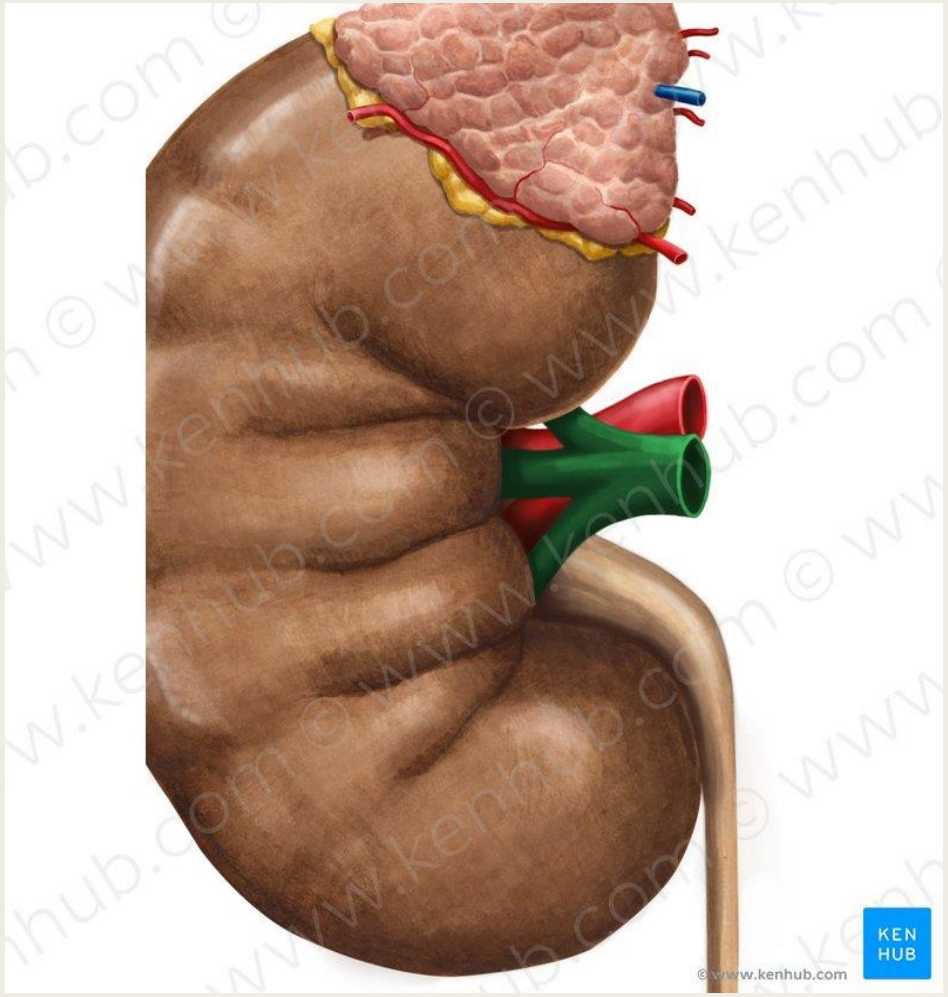
(b) Path of blood flow through renal blood vessels

VEINS AND LYMPHATICS

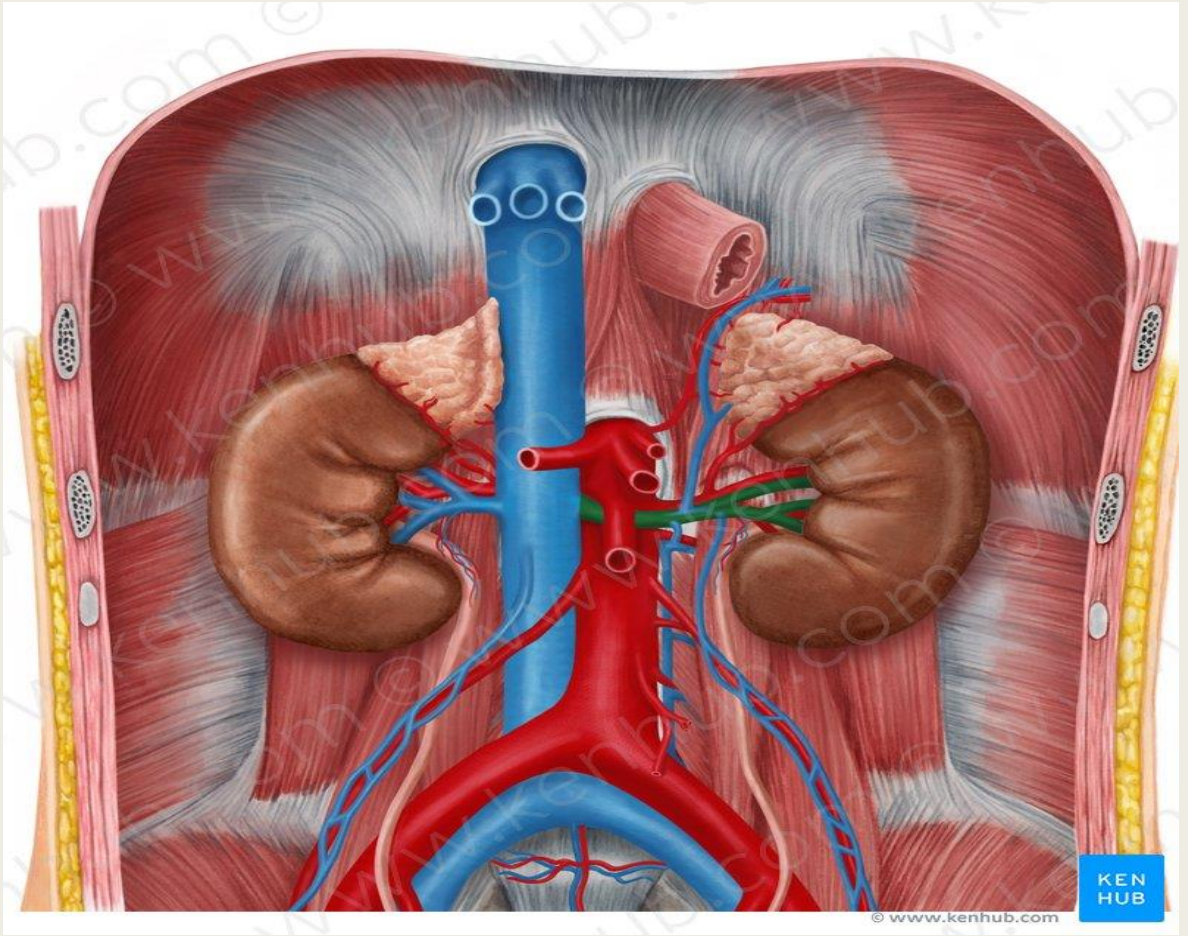
Each kidney has a single renal vein which conducts the blood out of the kidney and is positioned anterior to the artery. The renal veins empty to the inferior vena cava, so the right vein must be longer because the inferior vena cava is closer to the left kidney. The left renal vein passes anteriorly to the aorta just below the trunk of the superior mesenteric artery, which is risky because it can be compressed by one of those two. Concerning lymphatic drainage, each kidney drains into the lateral aortic (lumbar) lymph nodes, which are placed around the origin of the renal artery.


Inferior vena cava
Superior mesenteric artery
Right kidney
Left kidney
Right renal artery
Left renal artery
Left renal vein
Right renal vein
Abdominal aorta

RIGHT RENAL VEIN (VENA RENALIS DEXTRA)

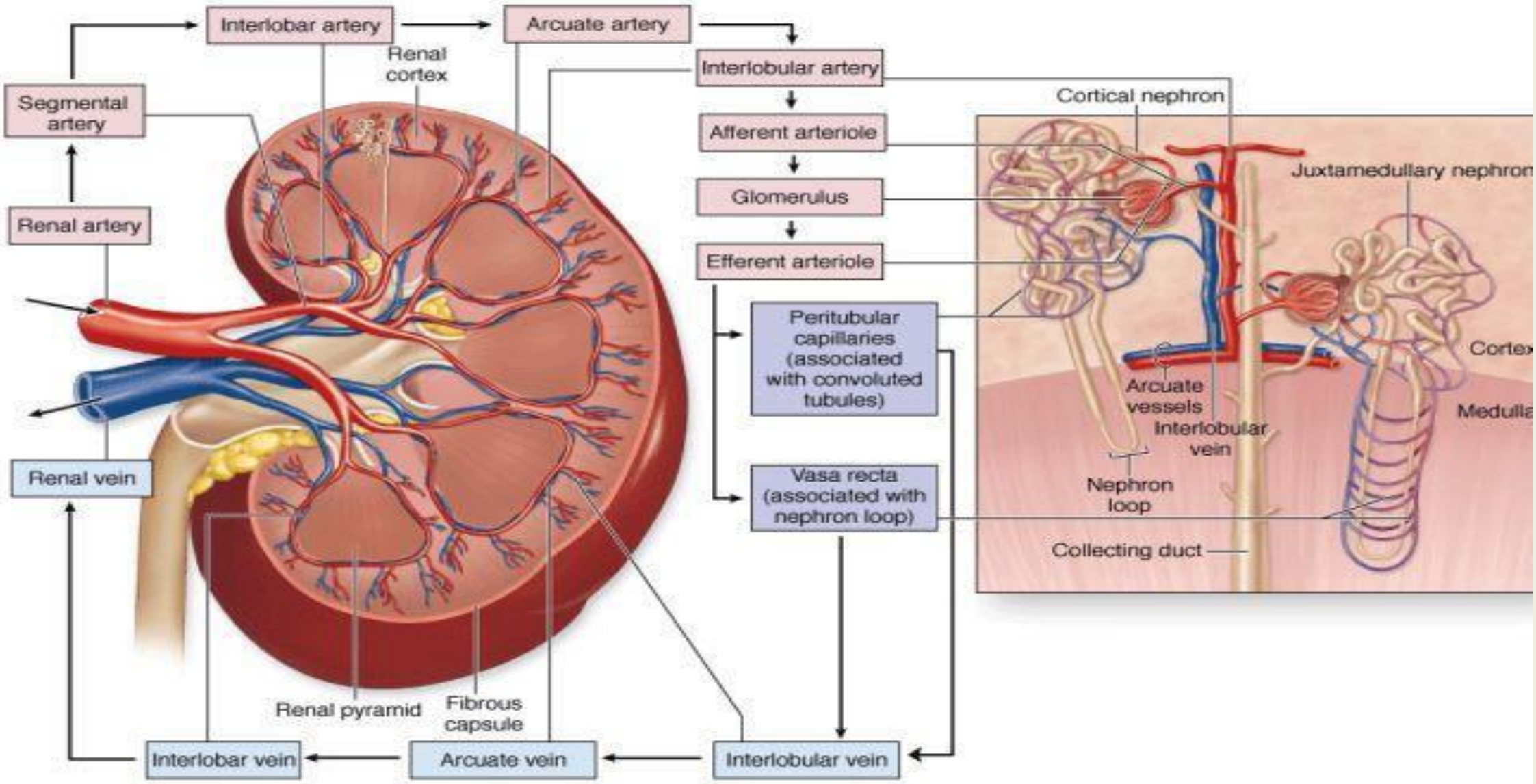


LEFT RENAL VEIN (VENA RENALIS SINISTRA)

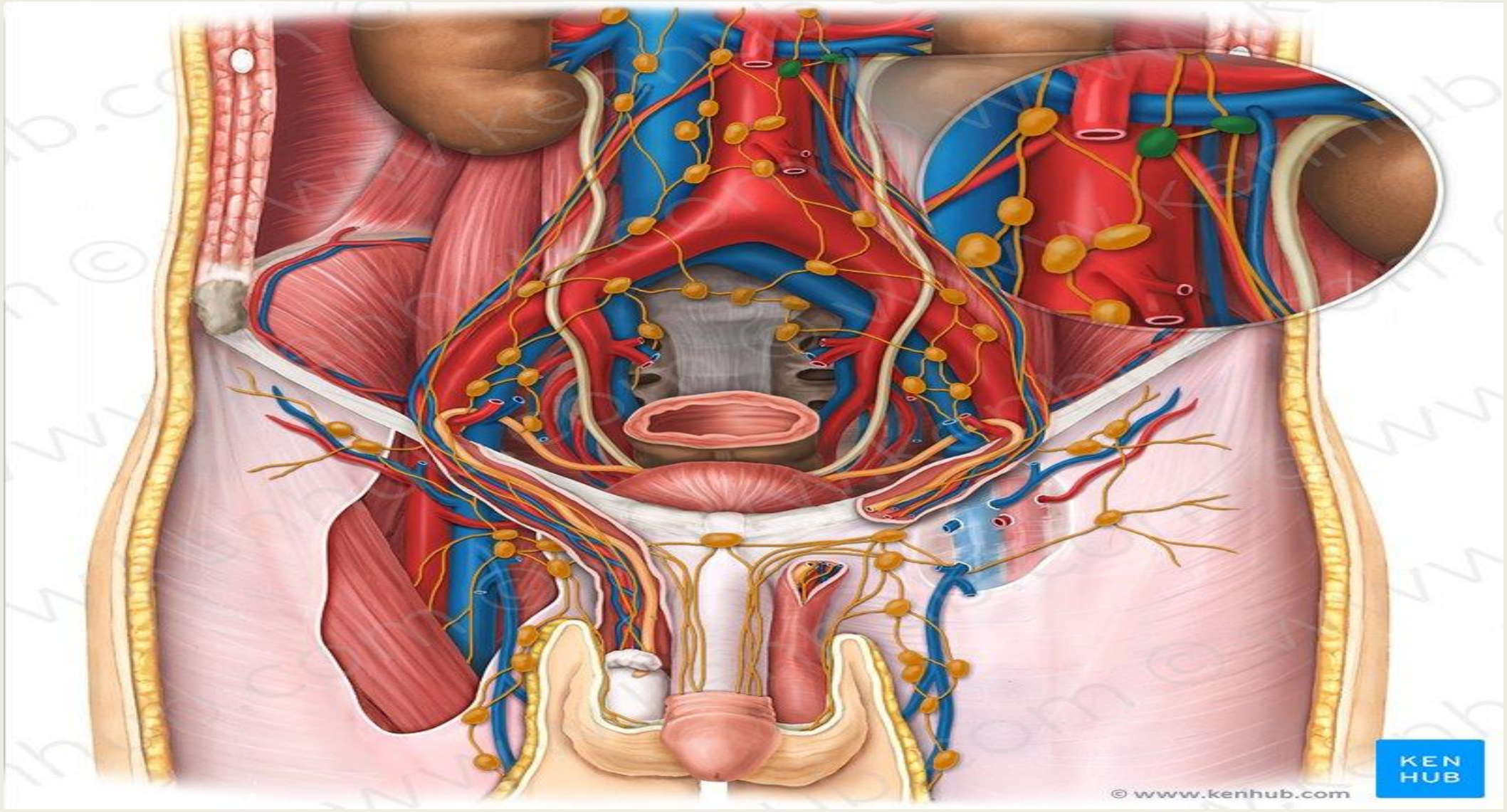


As expected for an organ specialized to process the blood, the anatomical organization of the kidney vasculature and its associations with nephron components are very important. Blood vessels of the kidney are named according to their precise locations or shapes (Figure 19–3).

Figure 19–3.

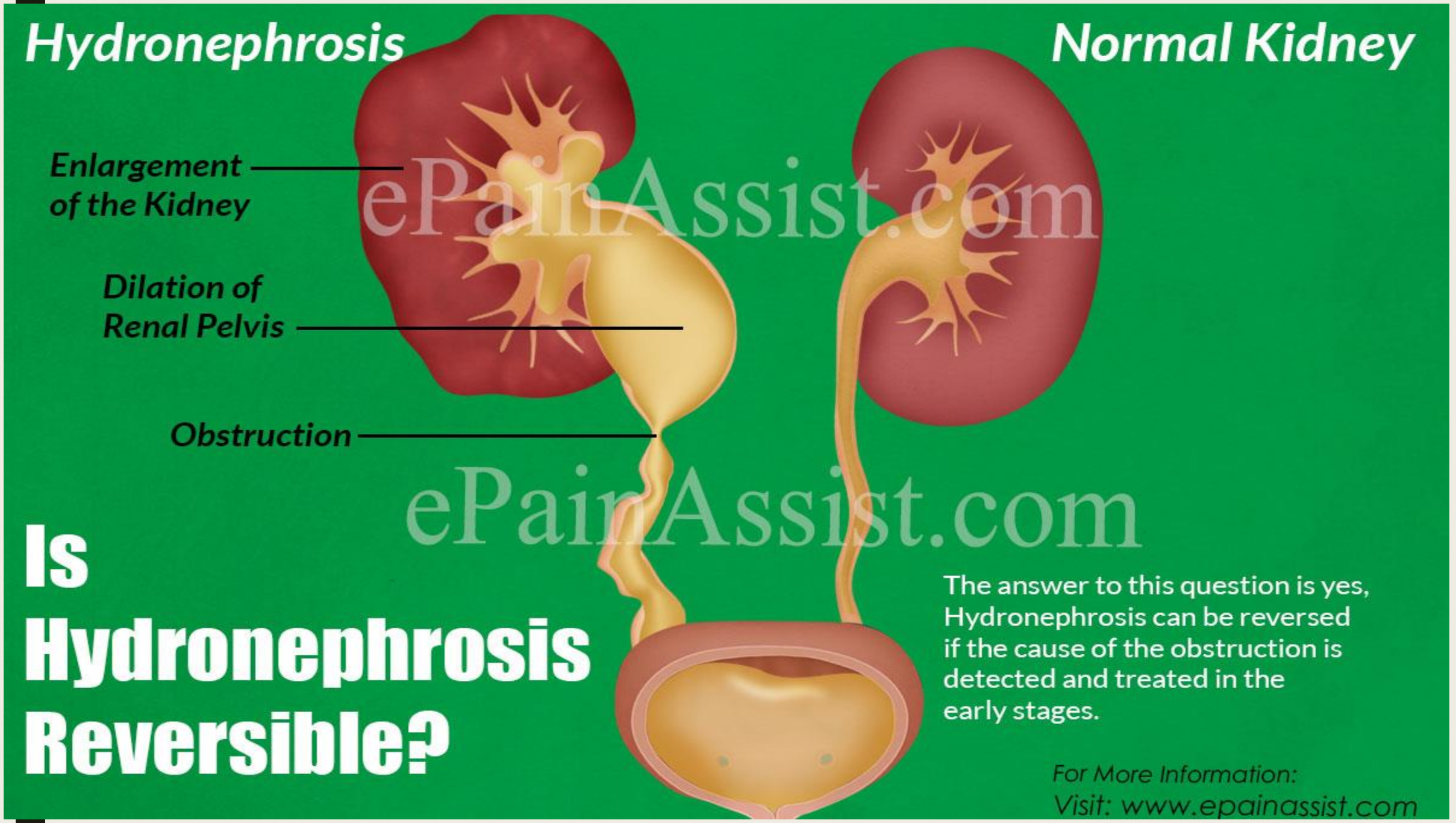


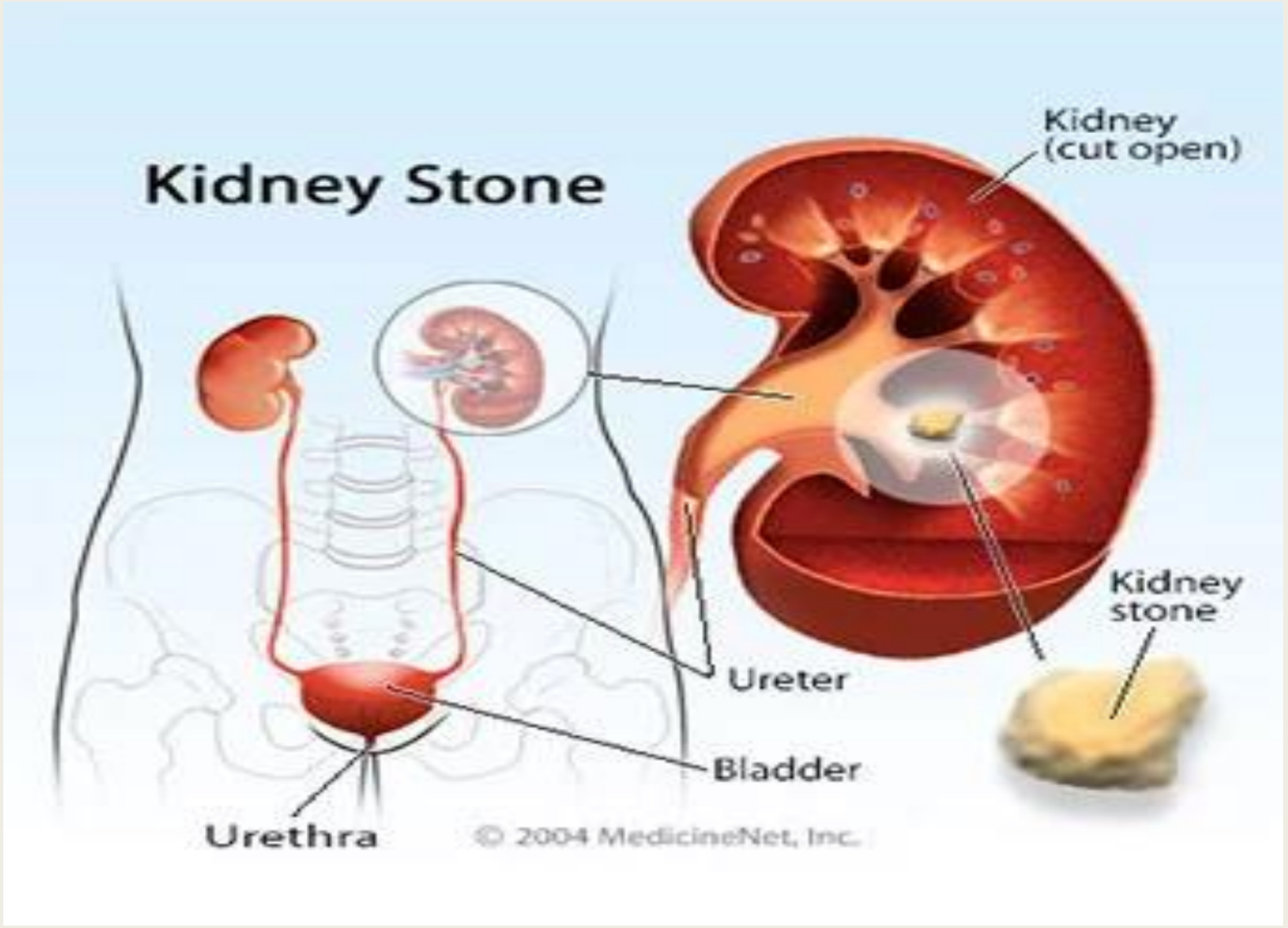
LATERAL AORTIC LYMPH NODES (NODI LYMPHOIDEI AORTICI LATERALES)



INNERVATION

- The kidneys are innervated by the renal plexus. This plexus provides input from:
- the sympathetic nervous system from the lower thoracic splanchnic nerves for the regulation of the vascular tone, and from
- the parasympathetic nervous system as well, through the vagus nerve.
- The sensory nerves from the kidney travel to the spinal cord at the levels T10-T11,T12 .


Hydronephrosis
Normal Kidney
Enlargement of the Kidney
Dilation of Renal Pelvis
Obstruction
ePainAssist.com
ePainAssist.com
Is Hydronephrosis Reversible?
The answer to this question is yes, Hydronephrosis can be reversed if the cause of the obstruction is detected and treated in the early stages.
For More Information:
Visit: www.epainassist.com


Kidney Stone
Kidney (cut open)
Kidney stone
Ureter
Bladder
Urethra
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Kidney Stones

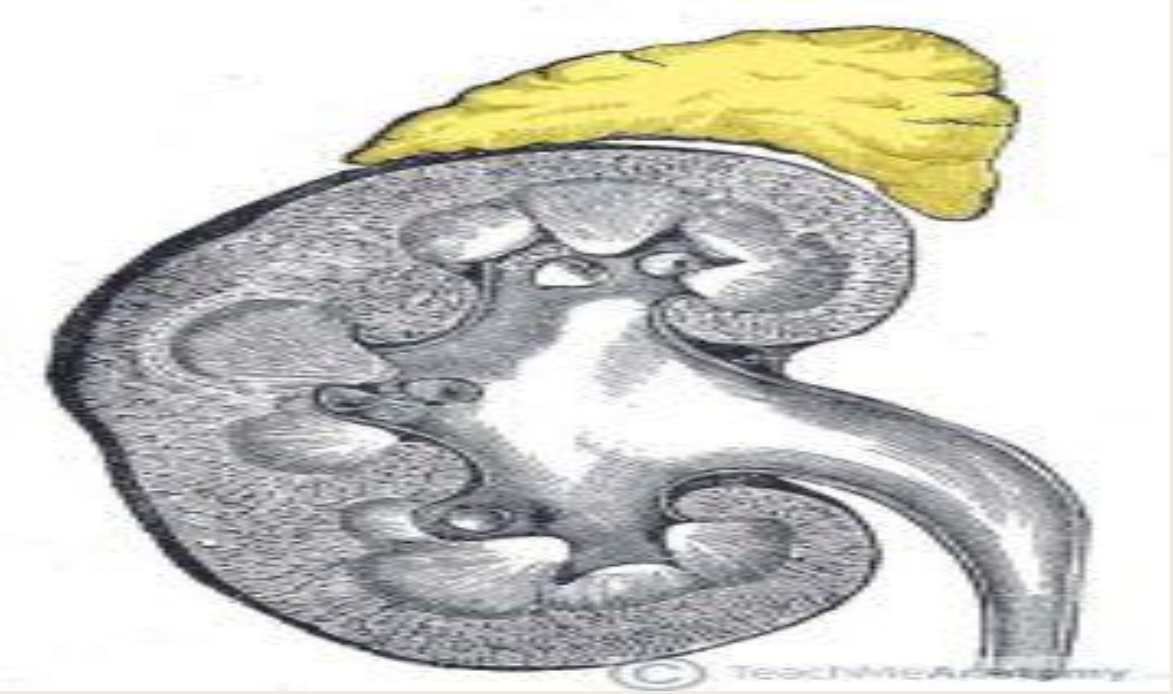
- Other common kidney conditions are acquired through life, and one of the most common is nephrolithiasis (kidney stones). This refers to the forming of the stones within the system of calyces because of too much calcium or uric acid into the filtrate. The calcium or uric acid will precipitate and form stones. The stones can move into the ureter and literally get stuck there because the lumen of the ureter is much smaller compared to the calyces, which is very painful for the patient. Kidney stones are most often treated by ultrasound shock therapy, during which high-frequency radio waves break the stone into smaller pieces that can be passed naturally into the urine. Other methods include classical surgical removal of the stone, either through the ureter or by open surgery.

Acute Kidney Failure

- Other malfunctions of the kidney are presented through acute kidney failure, a serious and urgent medical condition. It can be caused by a variety of factors, but most often arises because of the ischemia of the kidney and the toxic effect of some medications, resulting in the failure of all kidney functions. We’ve mentioned that the most important functions of the kidney are the regulation of the blood homeostasis and blood pressure, so acute kidney failure can lead to a quick fall of blood pressure which presents as a state of shock.

The Adrenal Glands

- The **adrenal** (or suprarenal) glands are paired endocrine glands situated over the medial aspect of the upper poles of each kidney.
- They secrete steroid and catecholamine **hormones** directly into the blood.

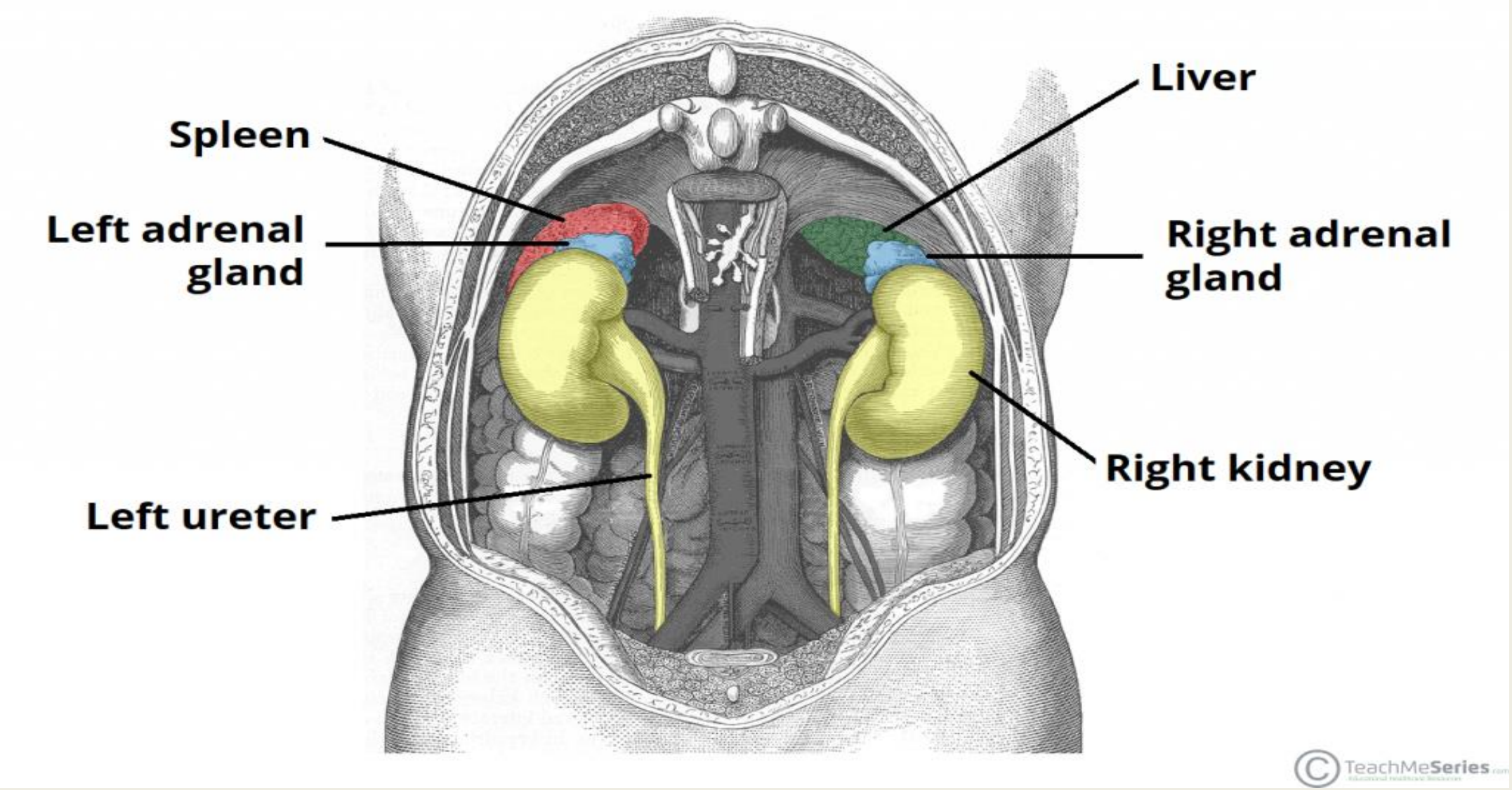


The right adrenal gland, situated over the medial aspect of the upper pole of the right

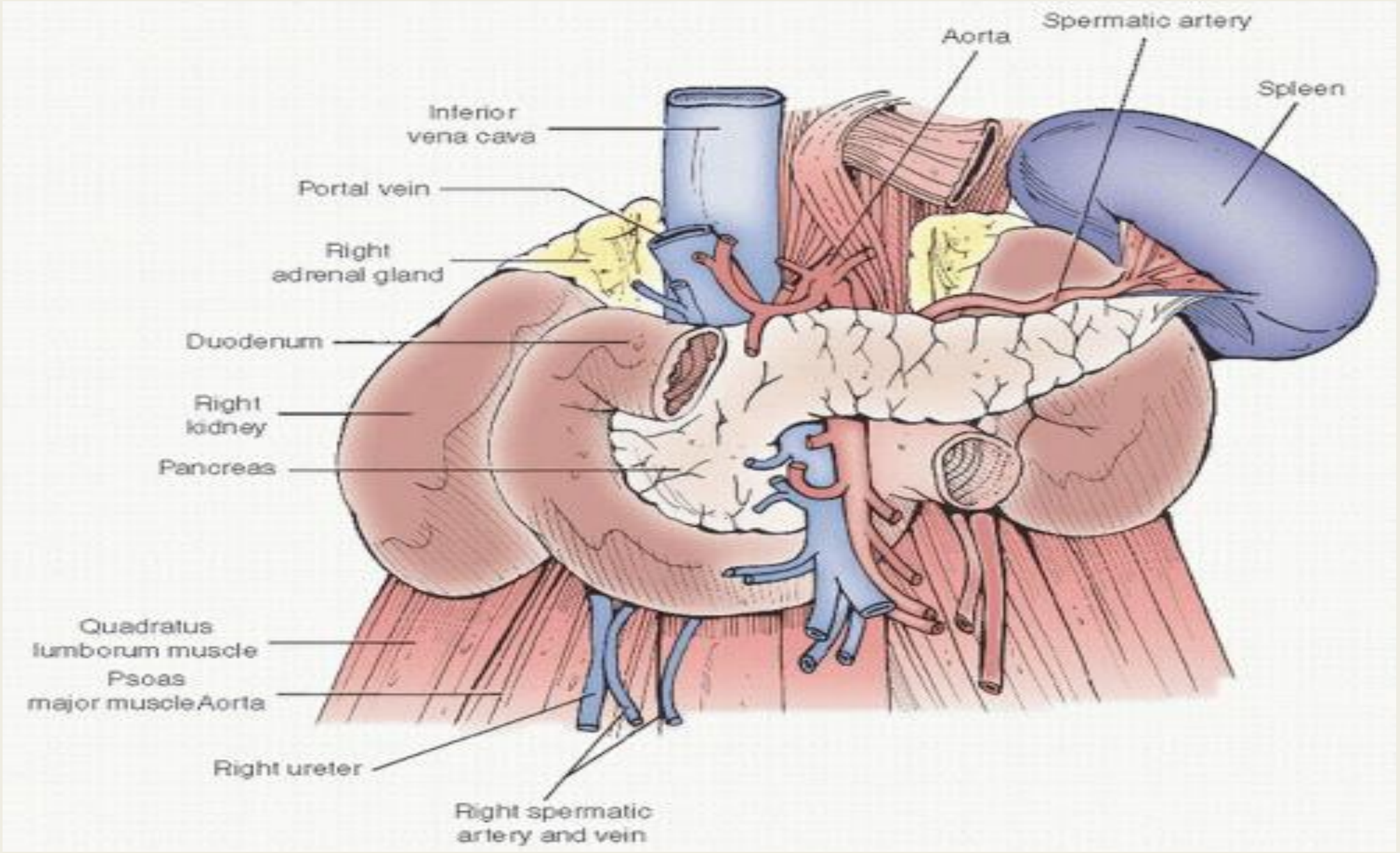
Anatomical Location and Relations

- The **adrenal glands** are located in the posterior abdomen, between the superomedial kidney and the diaphragm. They are retroperitoneal, with parietal peritoneum covering their anterior surface only.
- The right gland is **pyramidal** in shape, contrasting with the semi-lunar shape of the left gland.
- **Perinephric** (or renal) fascia encloses the adrenal glands and the kidneys. This fascia attaches the glands to the crura of the diaphragm. They are separated from the kidneys by the perirenal fat.
- The adrenal glands sit in close proximity to many other structures in the abdomen:

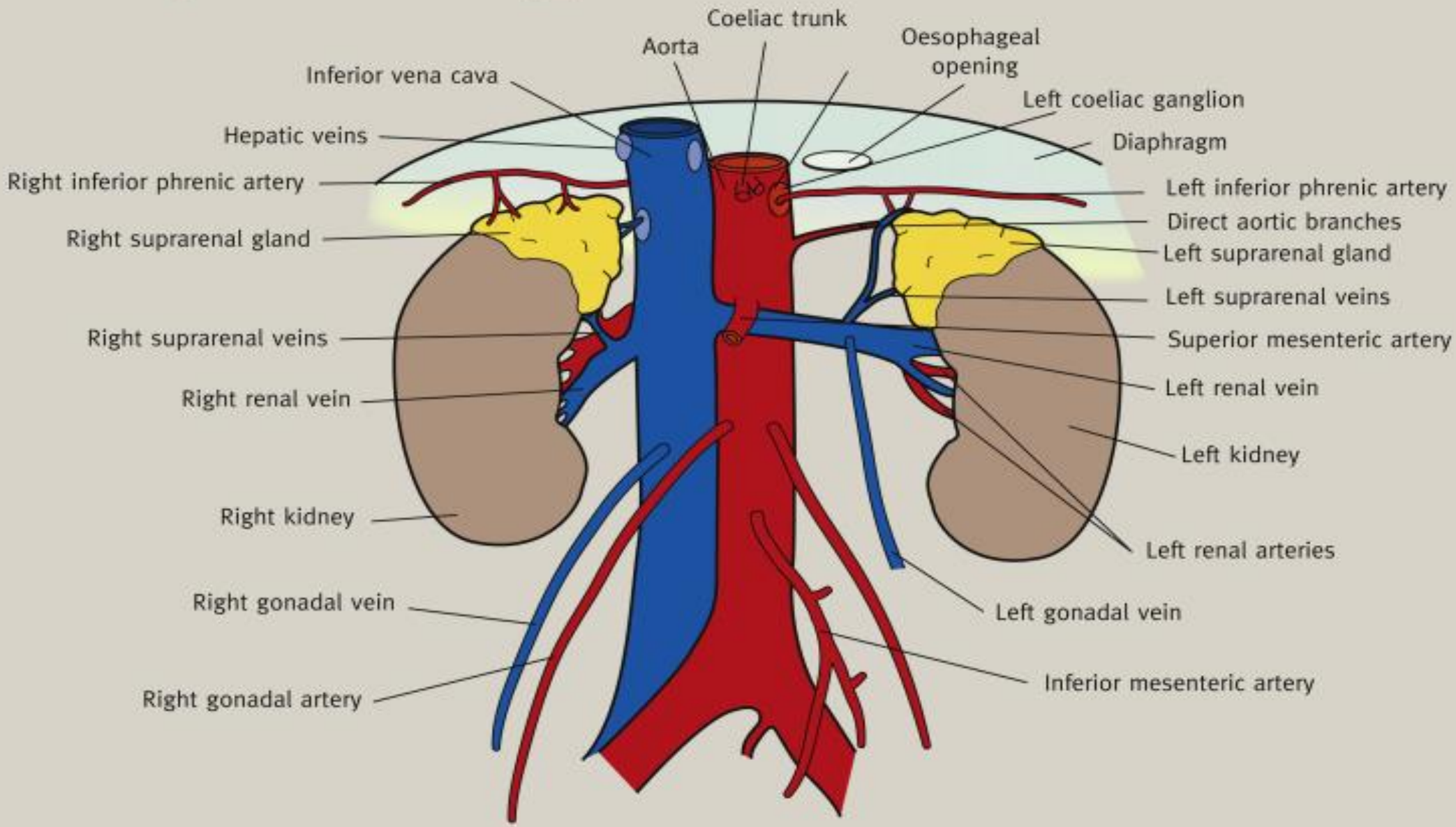
Right adrenal gland		Left adrenal gland	
Anterior	Posterior	Anterior	Posterior
•Inferior vena cava •Right lobe of the liver	•Right crus of the diaphragm	•Stomach •Pancreas •Spleen	•Left crus of the diaphragm



Posterior view of the abdomen, demonstrating the anatomical relations of the adrenal glands.

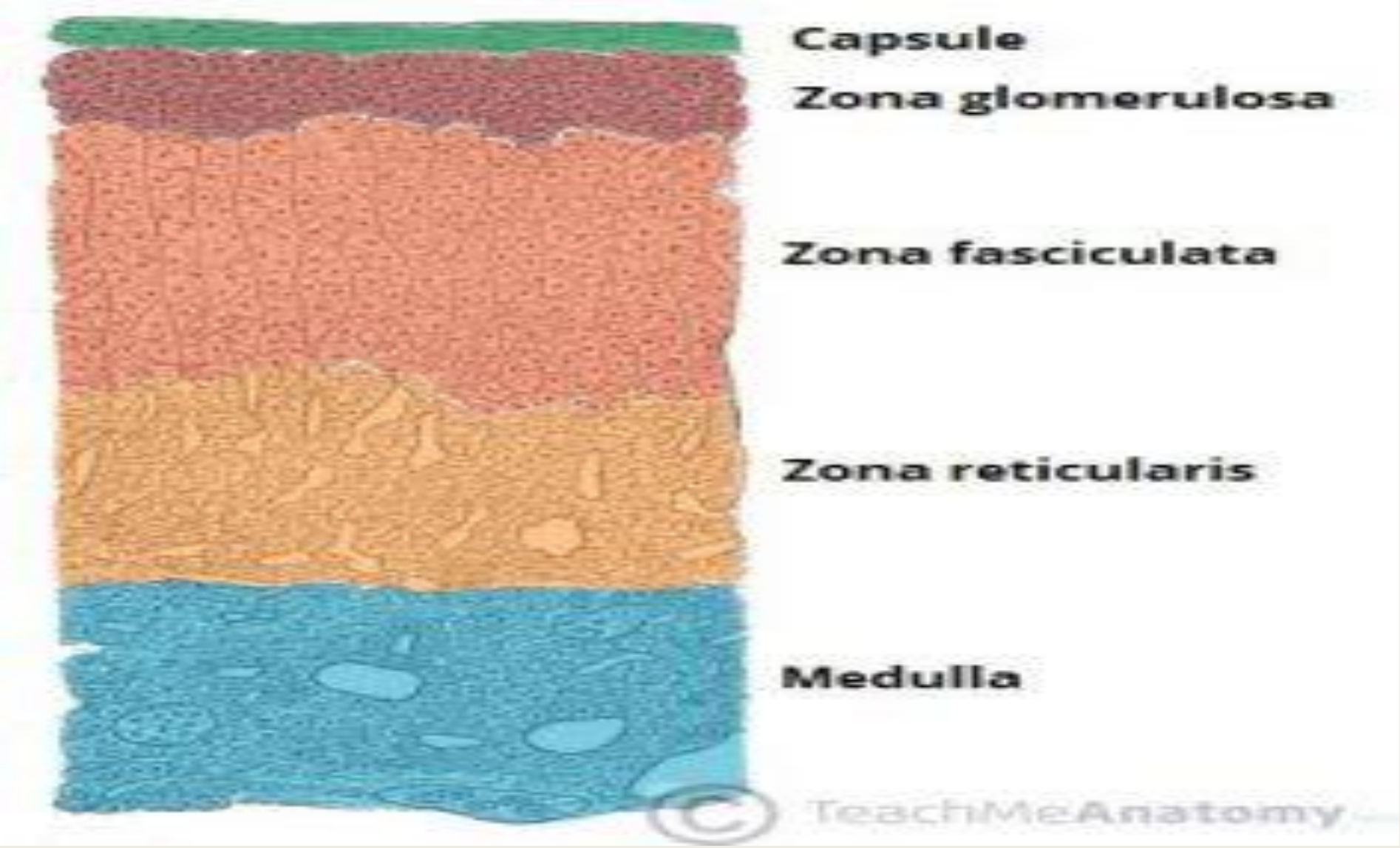

Aorta
Spermatic artery
Spleen
Inferior vena cava
Portal vein
Right adrenal gland
Duodenum
Right kidney
Pancreas
Quadratus lumborum muscle
Psoas major muscle
Aorta
Right ureter
Right spermatic artery and vein

The adrenal glands with their blood supply and anatomical relations



- **Anatomical Structure**
- The adrenal glands consist of an outer connective tissue **capsule**, a **cortex** and a **medulla**. Veins and lymphatics leave each gland via the **hilum**, but arteries and nerves enter the glands at numerous sites.
- The outer cortex and inner medulla are the functional portions of the gland. They are two separate endocrine glands, with different embryological origins:
- **Cortex** – derived from the embryonic mesoderm.
- **Medulla** – derived from the ectodermal neural crest cells.
- The cortex and medulla synthesise different hormones.

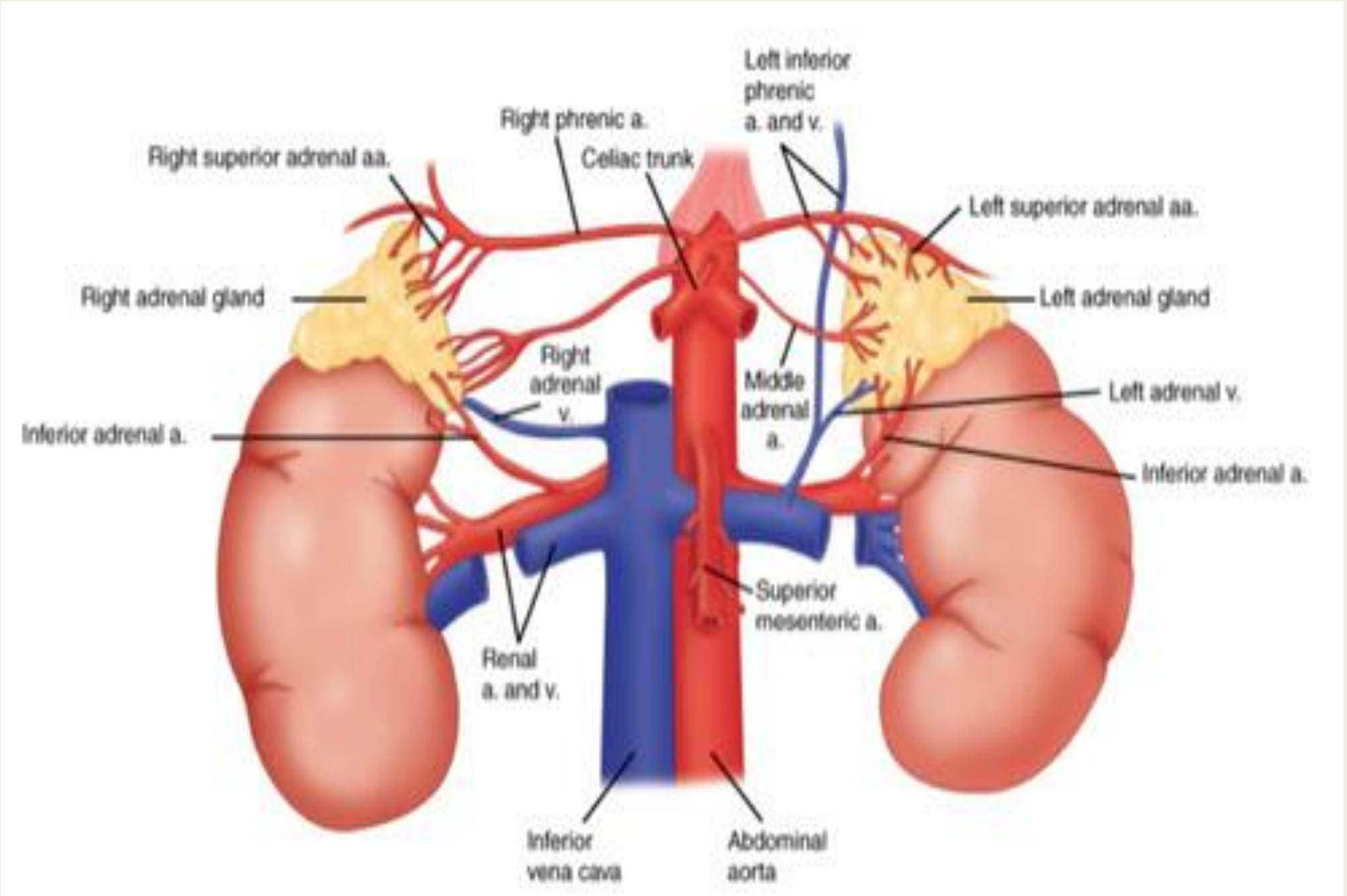
- **Cortex**
- The **cortex** is yellowish in colour. It secretes two cholesterol derived hormones – corticosteroids and androgens. Functionally, the cortex can be divided into three regions (superficial to deep):
- **Zona glomerulosa** – produces and secretes mineralocorticoids such as aldosterone.
- **Zona fasciculata** – produces and secretes corticosteroids such as cortisol. It also secretes a small amount of androgens.
- **Zona reticularis** – produces and secretes androgens such as dehydroepiandrosterone (DHES). It also secretes a small amount of corticosteroids.

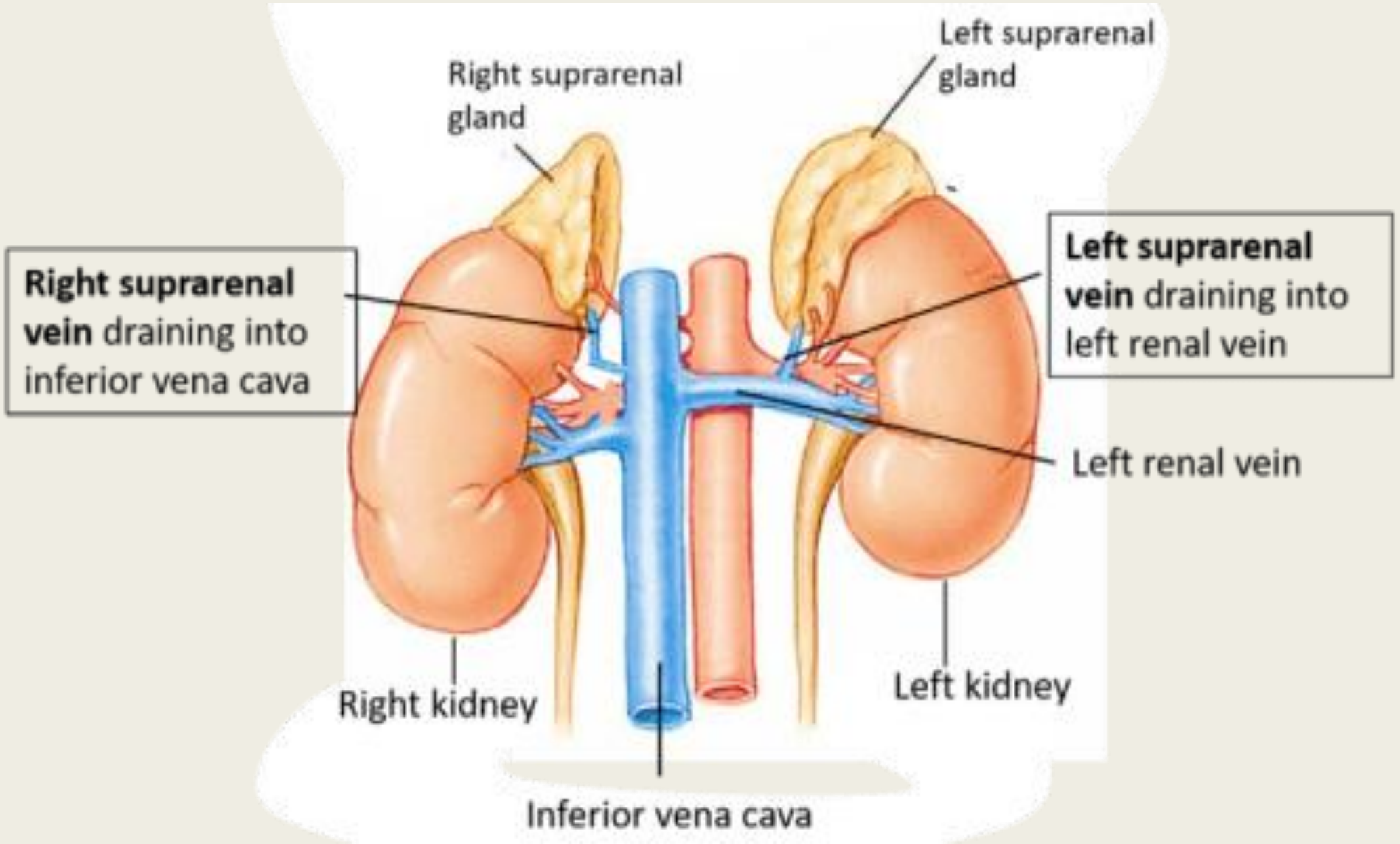


Histological appearance of the cortex and medulla of the adrenal gland.

- **Medulla**
- The medulla lies in the centre of the gland, and is dark brown in colour. It contains **chromaffin cells**, which secrete catecholamines (such as adrenaline) into the bloodstream in response to stress.
- These hormones produce a '**flight-or-fight**' response. Chromaffin cells also secrete enkephalins which function in pain control.

- **Vasculature**
- The adrenal glands have a rich blood supply via three main arteries:
- **Superior adrenal artery** – arises from the inferior phrenic artery
- **Middle adrenal artery** – arises from the abdominal aorta.
- **Inferior adrenal artery** – arises from the renal arteries.
- Right and left adrenal veins drain the glands. The right adrenal vein drains into the inferior vena cava, whereas the left adrenal vein drains into the **left renal vein**.


Left inferior phrenic a. and v.
Right phrenic a.
Right superior adrenal aa.
Celiac trunk
Left superior adrenal aa.
Right adrenal gland
Left adrenal gland
Right adrenal v.
Middle adrenal a.
Left adrenal v.
Inferior adrenal a.
Inferior adrenal a.
Superior mesenteric a.
Renal a. and v.
Inferior vena cava
Abdominal aorta


Right suprarenal gland
Left suprarenal gland
Right suprarenal vein draining into inferior vena cava
Left suprarenal vein draining into left renal vein
Left renal vein
Right kidney
Left kidney
Inferior vena cava

- **Innervation**
- The adrenal glands are innervated by the **coeliac plexus** and **greater splanchnic nerves**.
- Sympathetic innervation to the adrenal medulla is via myelinated pre-synaptic fibres, mainly from the T10 to L1 spinal cord segments.

LYMPHATICS

- Lymph drainage is to the **lumbar** lymph nodes by adrenal lymphatic vessels.

Thank You For Your Attention !