

Renal System Anatomy

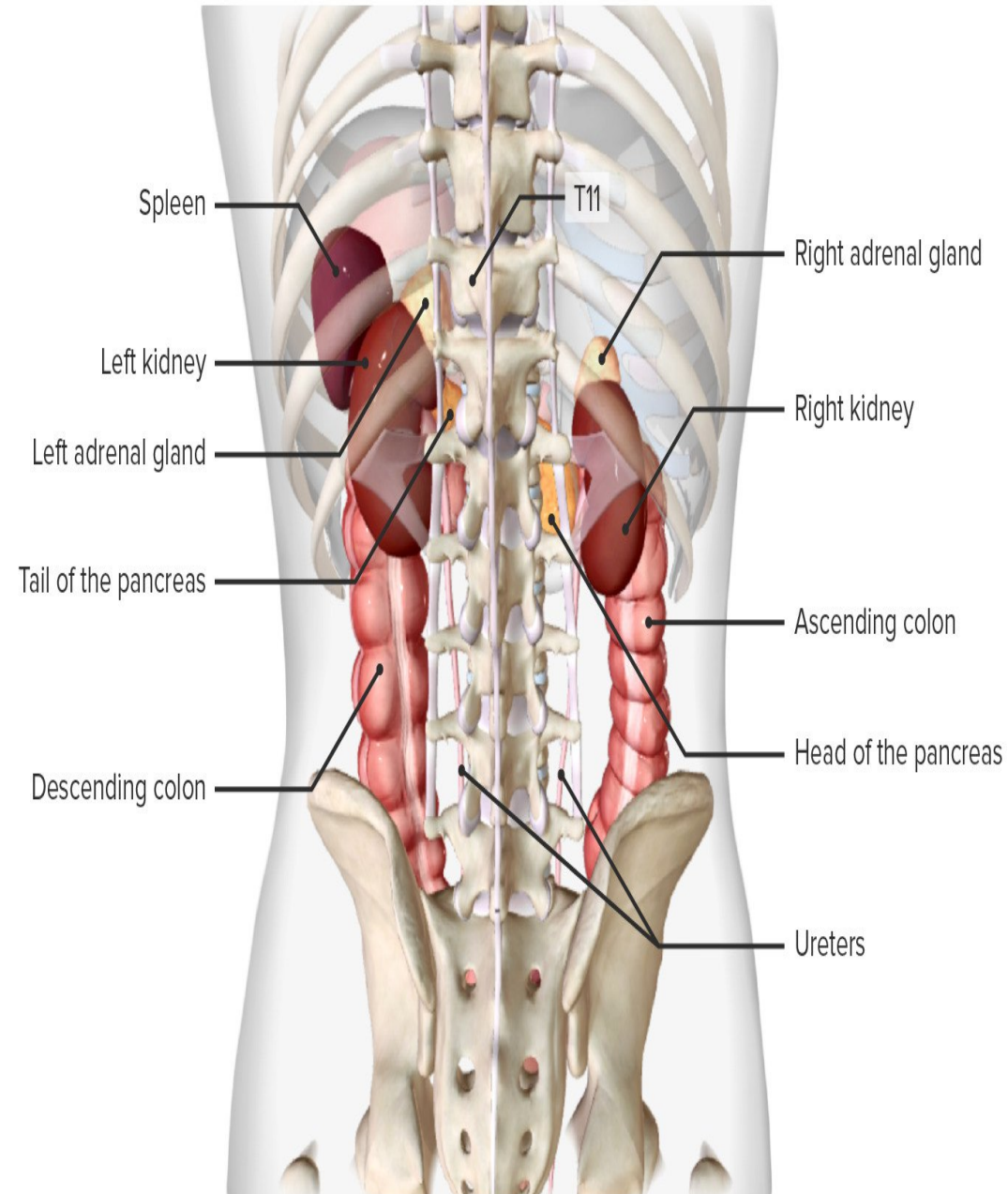


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Gross Anatomy

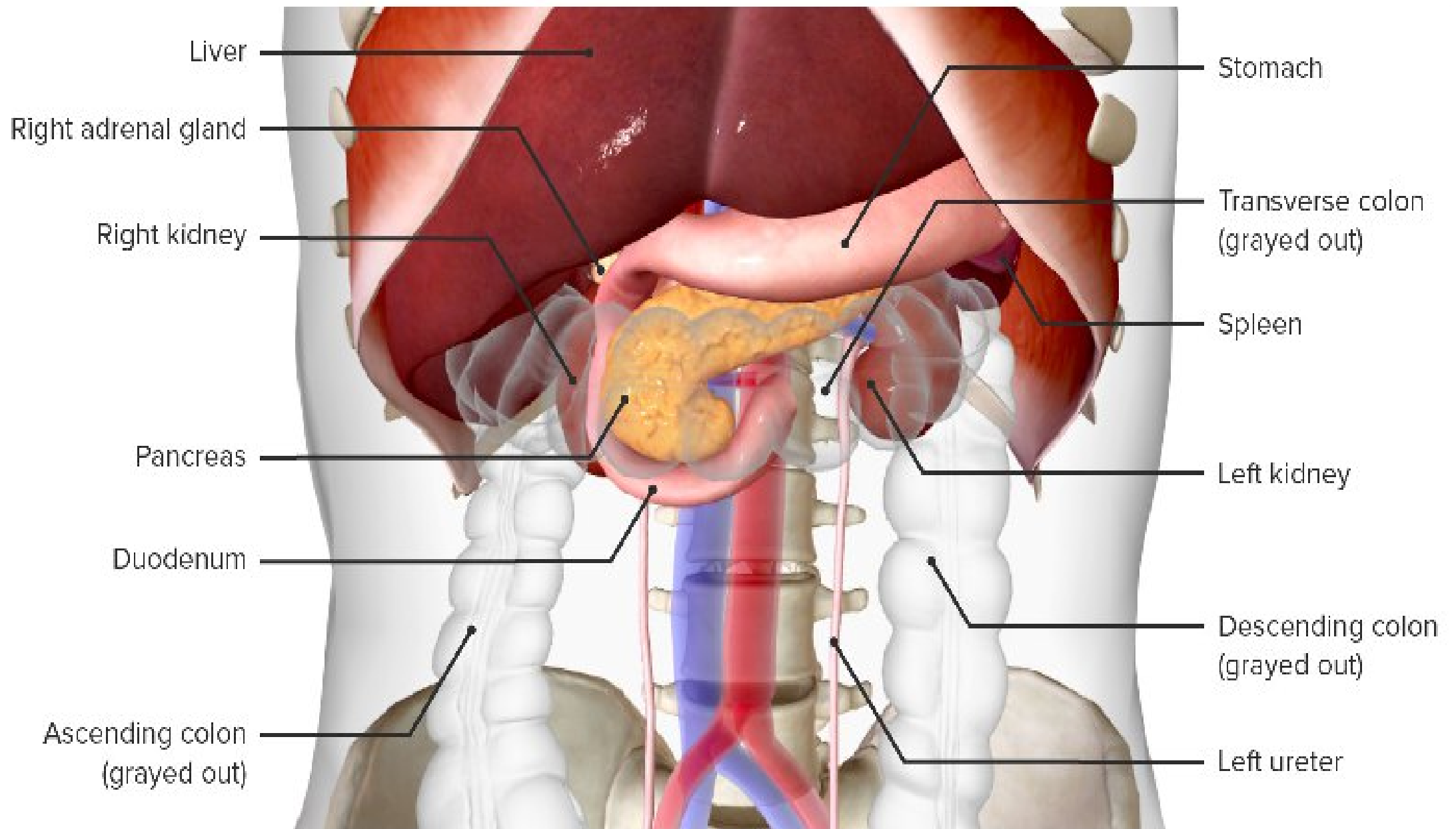
Location

- _ Retroperitoneal organs
- _ Located along the posterior abdominal wall on either side of the vertebral column in the paravertebral gutter
- _ In front of the T12–L3 transverse processes
- _ The superior pole rests against the 11th and 12th ribs.
- _ The lower pole is directed laterally and anteriorly.
- _ The presence of the liver on the right side forces the right kidney to be slightly lower than the left.



Anatomic relations of the kidneys

Direction (in relation to the kidney)	Right	Left
Superior	Right adrenal gland	Left adrenal gland
Anterior	Upper portion: liver Lower portion: hepatic flexure of the colon	Upper portion: stomach Mid portion: pancreas Lower portion: jejunum
Lateral	Liver	Upper portion: Spleen Lower portion: Descending colon
Posterior		Muscles: Posterosuperior: diaphragm Posteromedial: psoas muscle Directly posterior: quadratus lumborum Nerves: Subcostal Iliohypogastric Ilioinguinal



Size and shape

- _ Bean-shaped organs
- _ Dimensions:
 - _ Length: 10–12 cm
 - _ Width: 5–7 cm
 - _ Depth: 2–3 cm
- _ Weight: approximately 150 g

Outer layers

- _ Surrounding the kidneys are several layers of adipose and connective tissue (from outside in):

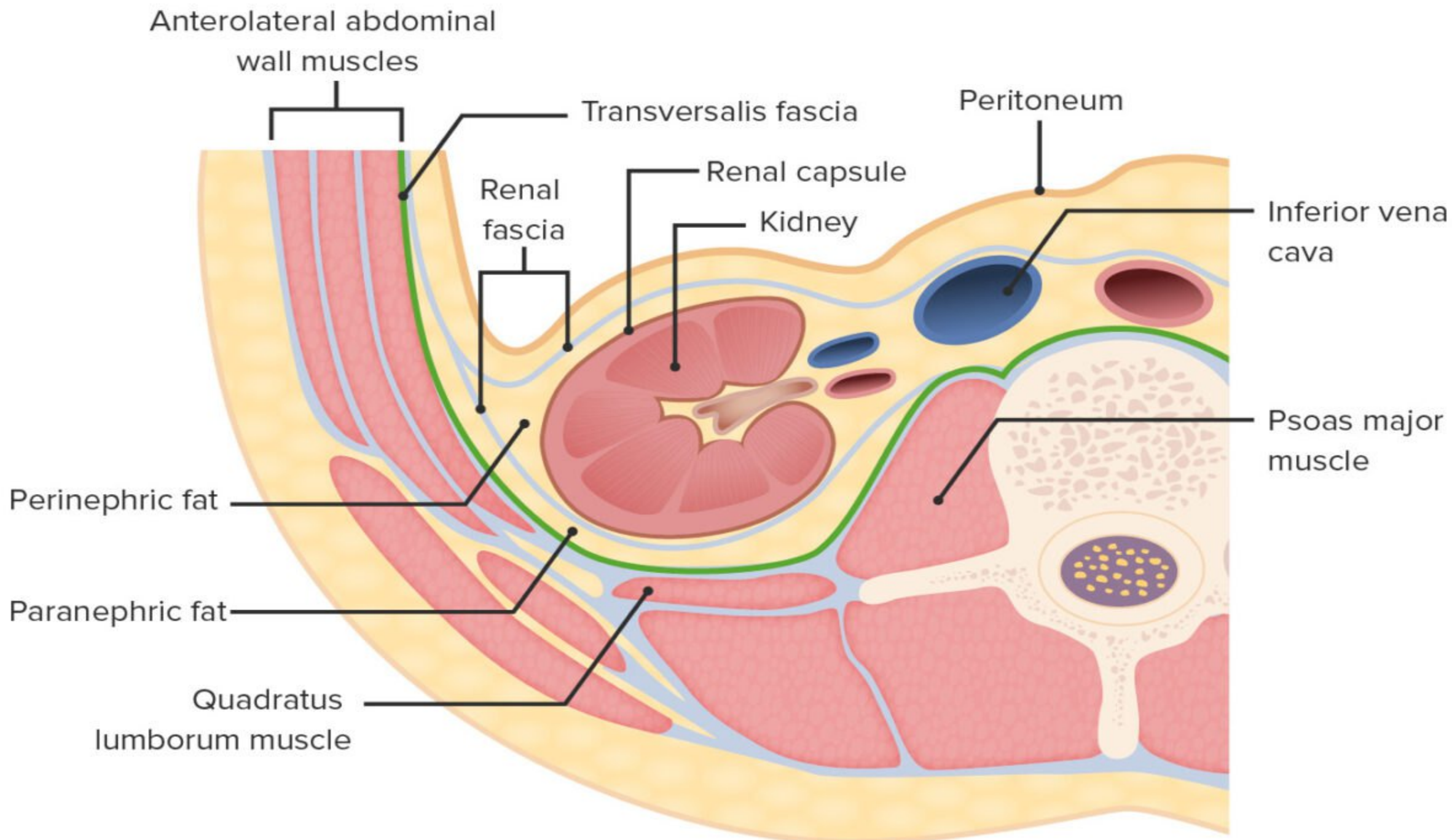
A_ Paranephric fat:

- _ Located posterior to the kidney, between the renal fascia and the back muscles
- _ Anchors kidneys to the posterior abdominal wall
- _ Provides some protection and warmth

B_ Renal fascia, which also encloses the adrenal gland

C_ Perinephric fat

D_ Fibrous capsule

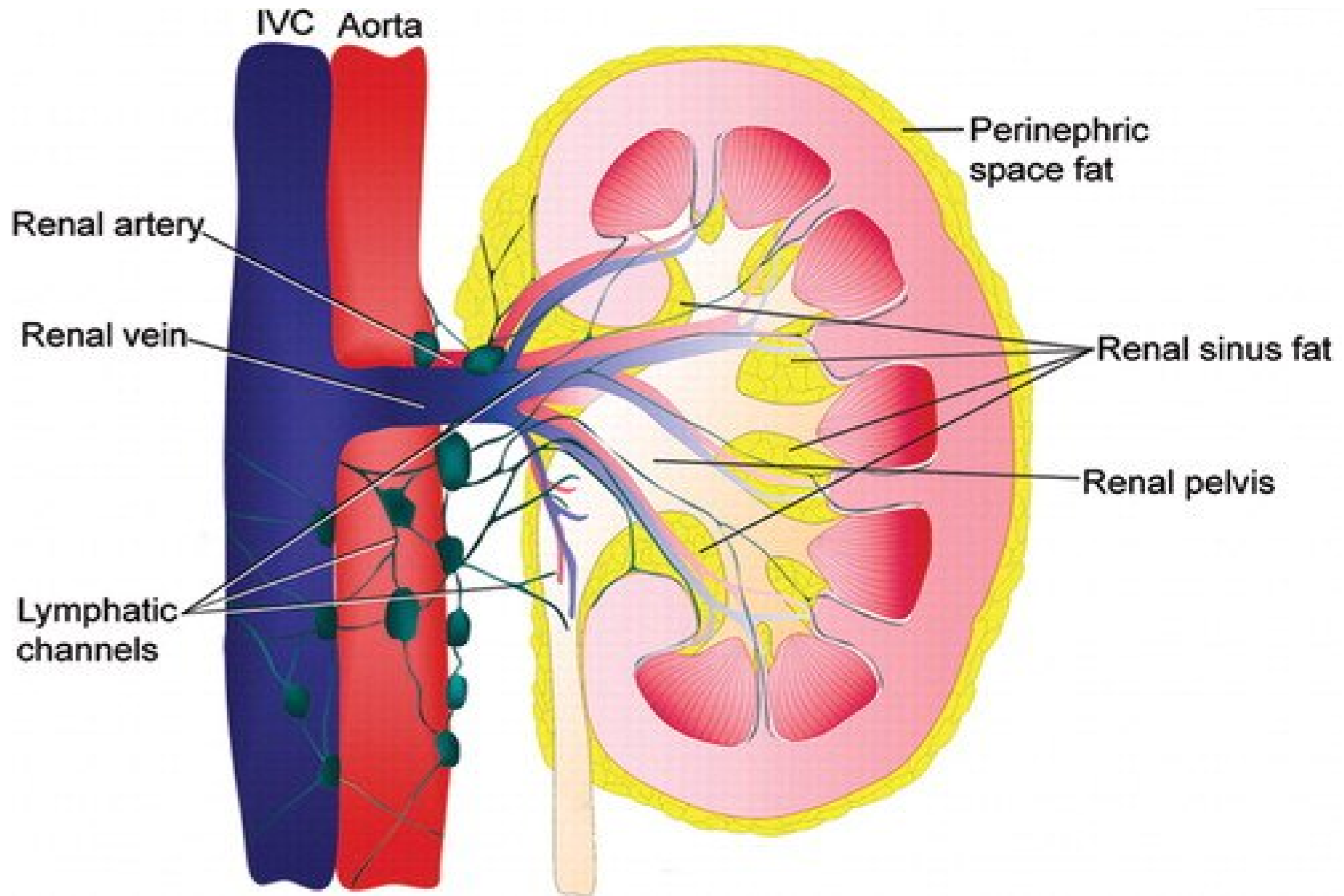


Surface features

- _ Superior and inferior poles
- _ Convex lateral surface
- _ Concave medial surface, which creates a cavity called the renal sinus

The renal sinus contains:

- _ a fat-filled cavity in the middle of the kidney that cushions important parts:
 - A _ Renal neurovasculature, including:
 - _ Arteries and veins
 - _ Lymphatics
 - _ Nerves
 - B _ Renal pelvis (terminal portion of the renal collecting system)
 - C _ Adipose tissue (continuous with the perinephric fat surrounding the kidney)
 - D _ Renal hilum: the entrance to the renal sinus (VAP)



Renal parenchyma

The parenchyma consists of:

A_ Renal cortex:

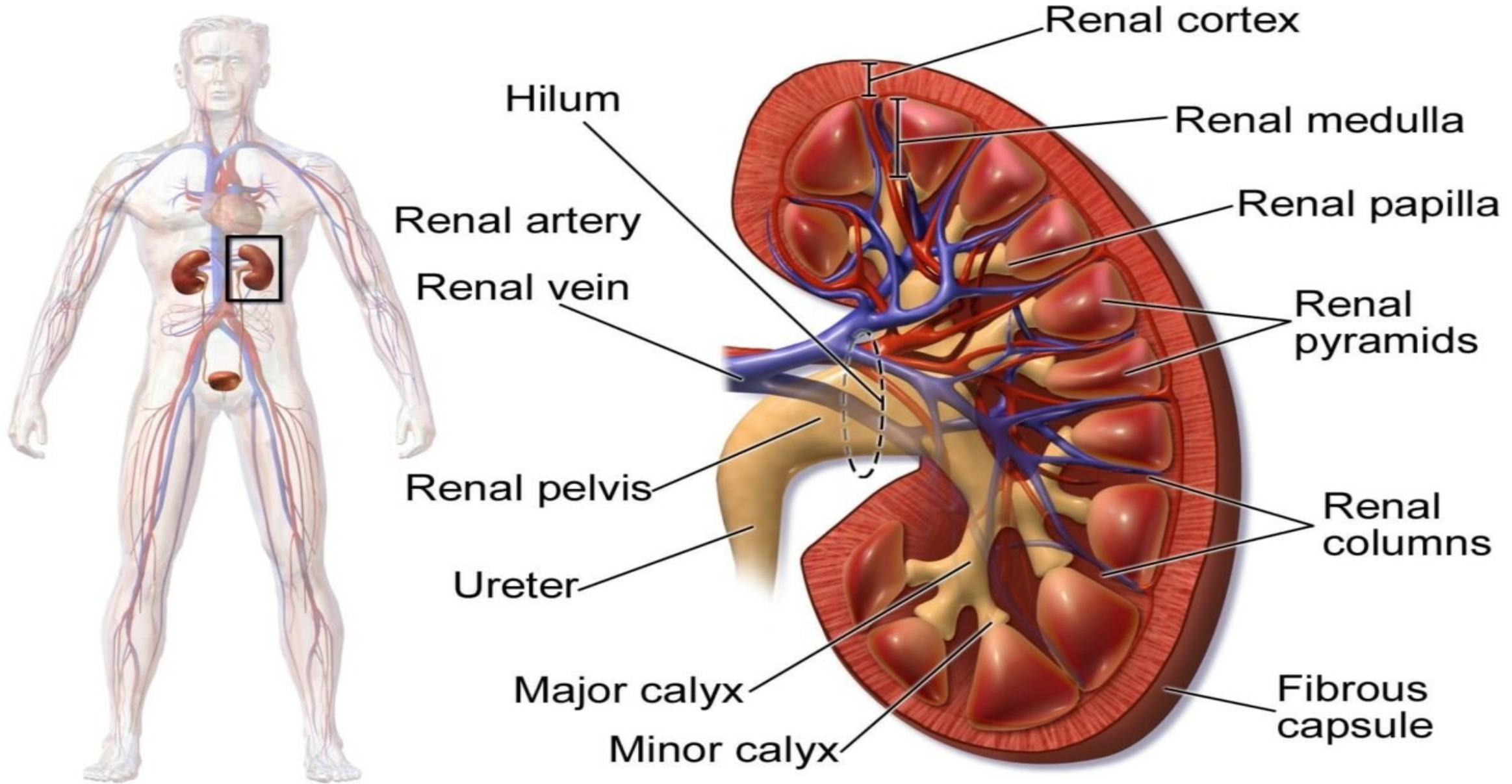
- _ The outermost part of the kidney, approximately 1 cm thick
- _ Located underneath the renal capsule
- _ Projections medially form the renal columns (of Bertin).
- _ Microscopic structures located in the cortex:
 - _ Bowman capsule
 - _ Proximal and distal tubules
 - _ Upper portions of the collecting ducts

B_ Renal medulla:

- _ Divided into units known as renal pyramids
- _ 6–10 renal pyramids separated by the columns of Bertin
- _ Base of pyramid toward the cortex
- _ The apex:
 - _ Projects toward the renal sinus
 - _ Is called a papilla
 - _ Collecting tubules drain out of the papilla into the minor calyces.
- _ Microscopic structures located in the medulla/pyramids:
 - _ Loops of Henle
 - _ Collecting ducts

C_ Collecting system:

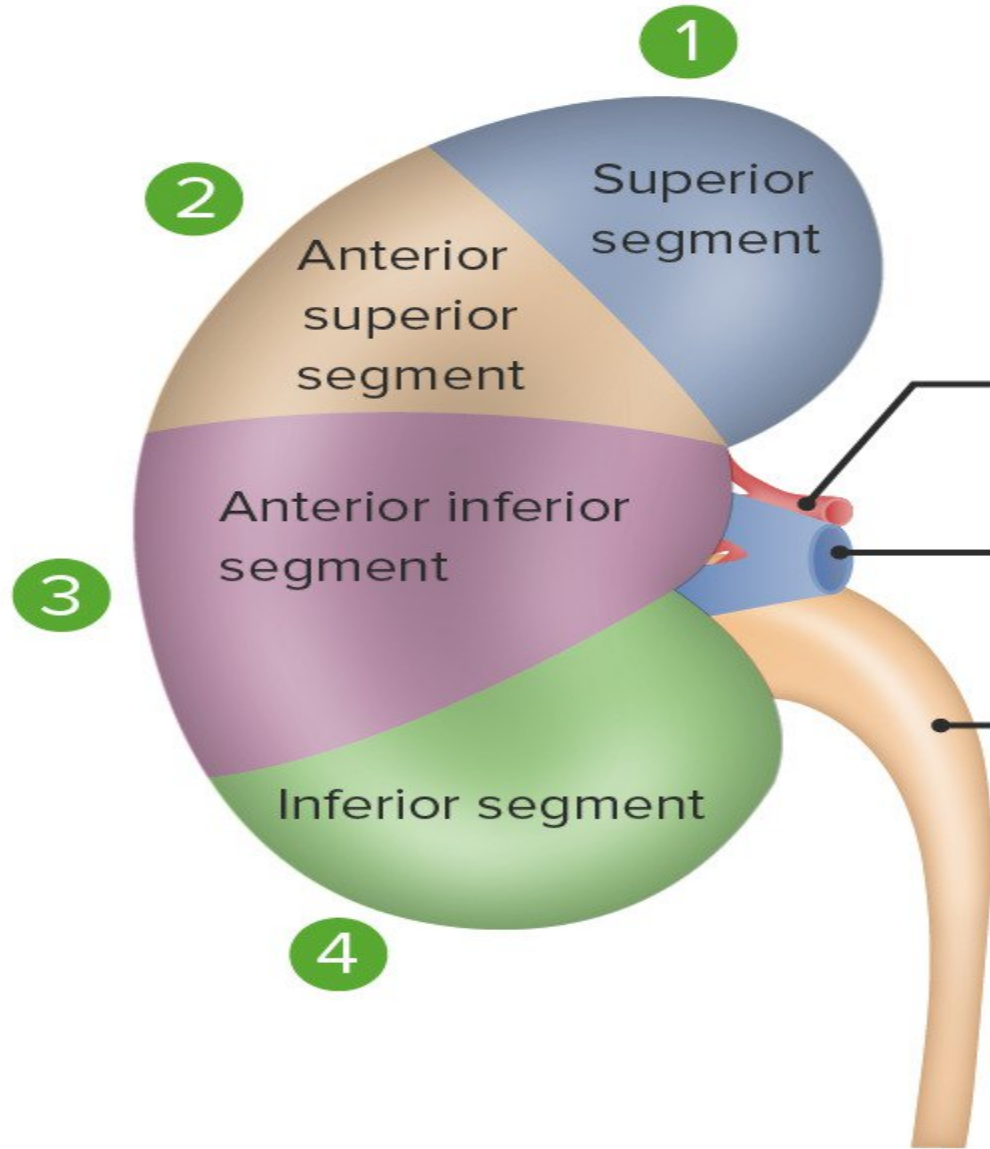
- _ Collects the newly formed urine and directs it to the ureter
- _ Each papilla drains into a minor calyx.
- _ 2–3 minor calyces drain into a single major calyx.
- _ 2–3 major calyces converge to form the renal pelvis, which:
 - _ Is a funnel-shaped structure that is continuous with the ureter
 - _ Occupies most of the renal sinus
 - _ Transitions to the ureter at the ureteropelvic junction



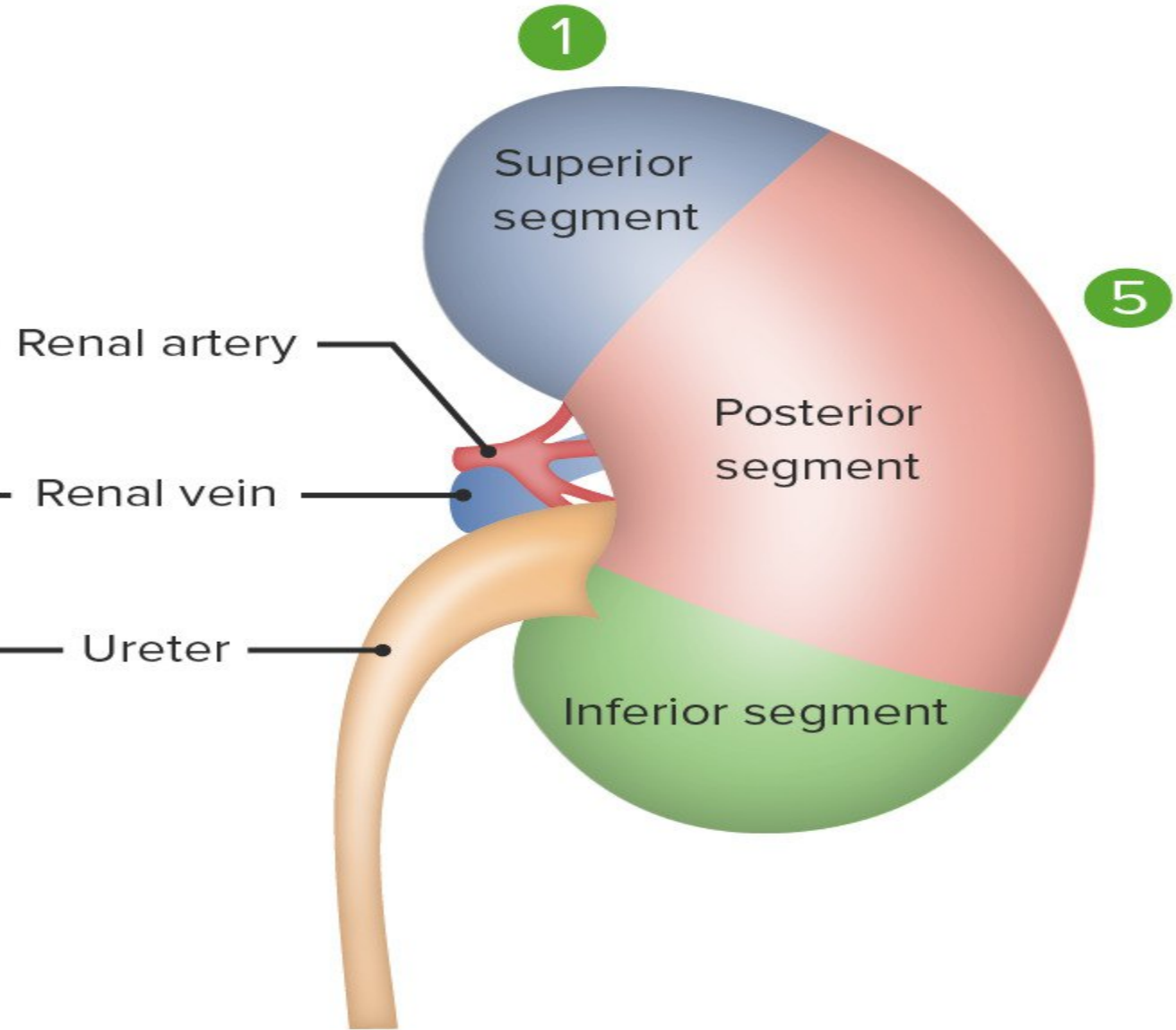
Neurovasculature

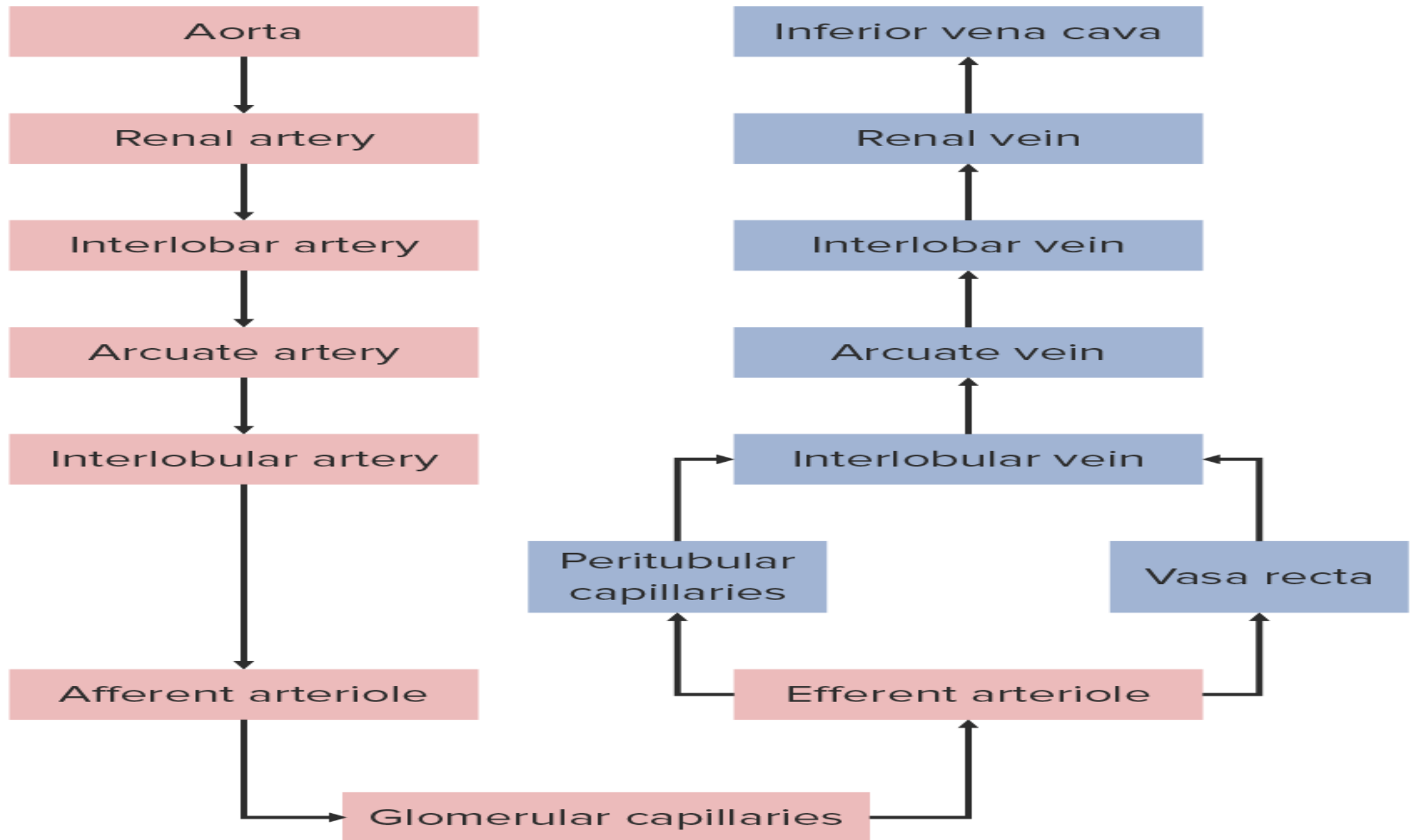
- _ Each kidney is perfused by a renal artery:
 - _ Branch off the abdominal aorta below the superior mesenteric artery (SMA)
 - _ Right renal artery passes posterior to the vena cava.
 - _ The renal arteries divide into 5 segmental arteries, which irrigate separate segments of the kidney (no anastomosis between the segments).
- _ Renal segments:
 - _ Superior
 - _ Anterior superior
 - _ Anterior inferior
 - _ Inferior
 - _ Posterior

Anterior view of the kidney



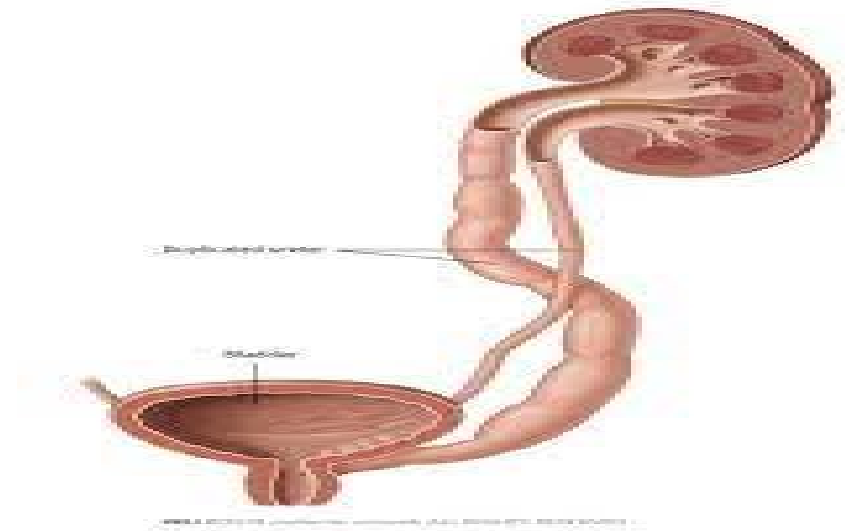
Posterior view of the same kidney





Clinical Relevance

- Duplications of the collecting system: known as a “duplex system.”
 - _ Duplications of the collecting system are the most common congenital anomaly of the urinary tract. In these cases, a kidney will have 2 separate pelvicaliceal systems and 2 ureters.
 - _ Ureteral insertion into the bladder from the duplicated system is often abnormal as well.
 - _ Most affected individuals are asymptomatic, though recurrent urinary tract infection (UTIs) or obstruction may occur.



– Polycystic kidney disease (PKD):

– genetic condition caused by either an autosomal recessive mutation in the PKHD1 gene (fibrocystin) or an autosomal dominant mutation in either the PKD1 or PKD2 gene (polycystin proteins).

– Autosomal recessive PKD is characterized by multiple microscopic cysts and can have serious effects in utero.

– Autosomal dominant PKD is characterized by multiple larger cysts and most commonly presents in adulthood with hematuria and hypertension



Ureters

Anatomy

- _ Collapsible, muscular S-shaped tubes
- _ Approximately 25 cm in length
- _ Start: ureteropelvic junction
 - _ At the level of the second lumbar vertebra on the left
 - _ Right slightly lower
- _ End: ureterovesicular junction

Function:

The function of the ureters is to transport urine from the renal pelvis to the urinary bladder.

Route of ureters:

- _ Leave the kidneys posterior to the renal artery and vein
- _ Descend anterior to the psoas major muscle, where gonadal vessels cross anteriorly.
- _ The right ureter travels behind the duodenum.
- _ The left ureter travels lateral to the inferior mesenteric vessels.
- _ Ureters then enter the pelvis, crossing the iliac vessels (usually at the common iliac artery bifurcation into the internal and external iliac arteries).
- _ Ureters go into the bladder on the posterior aspect in the trigone.

3 sites of narrowing:

- _ Ureteropelvic junction
- _ Crossover of the common iliac arteries
- _ Ureterovesicular junction

Vasculature

- _ Upper or abdominal ureter arterial blood supply:
 - _ Renal artery
 - _ Gonadal arteries
 - _ Ureteric branch of abdominal aorta
 - _ Common iliac arteries
- _ Distal ureter: common iliac branches and internal iliac branches (uterine and vesical arteries)
- _ Venous drainage follows arterial supply.

Urinary Bladder

Anatomy

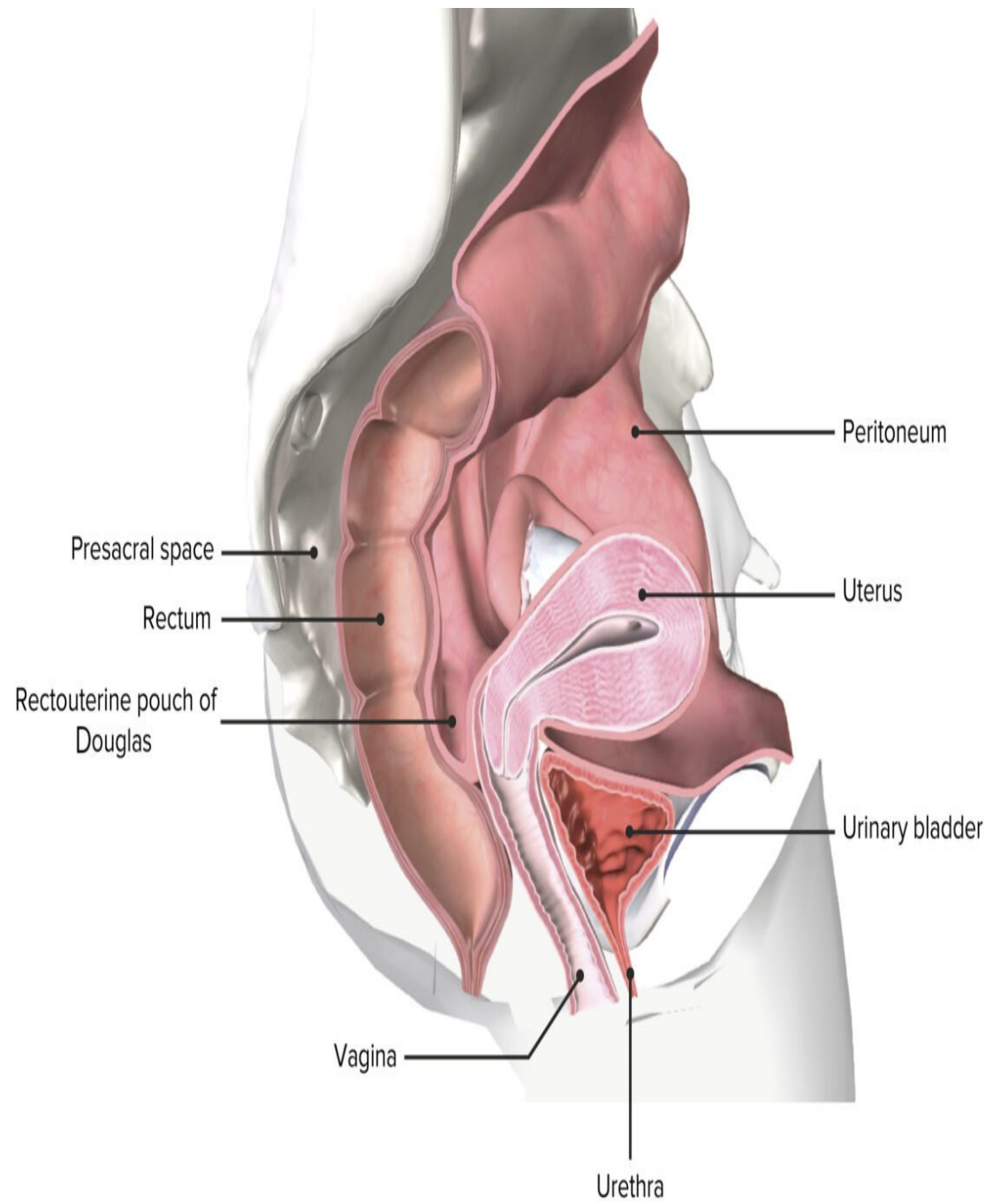
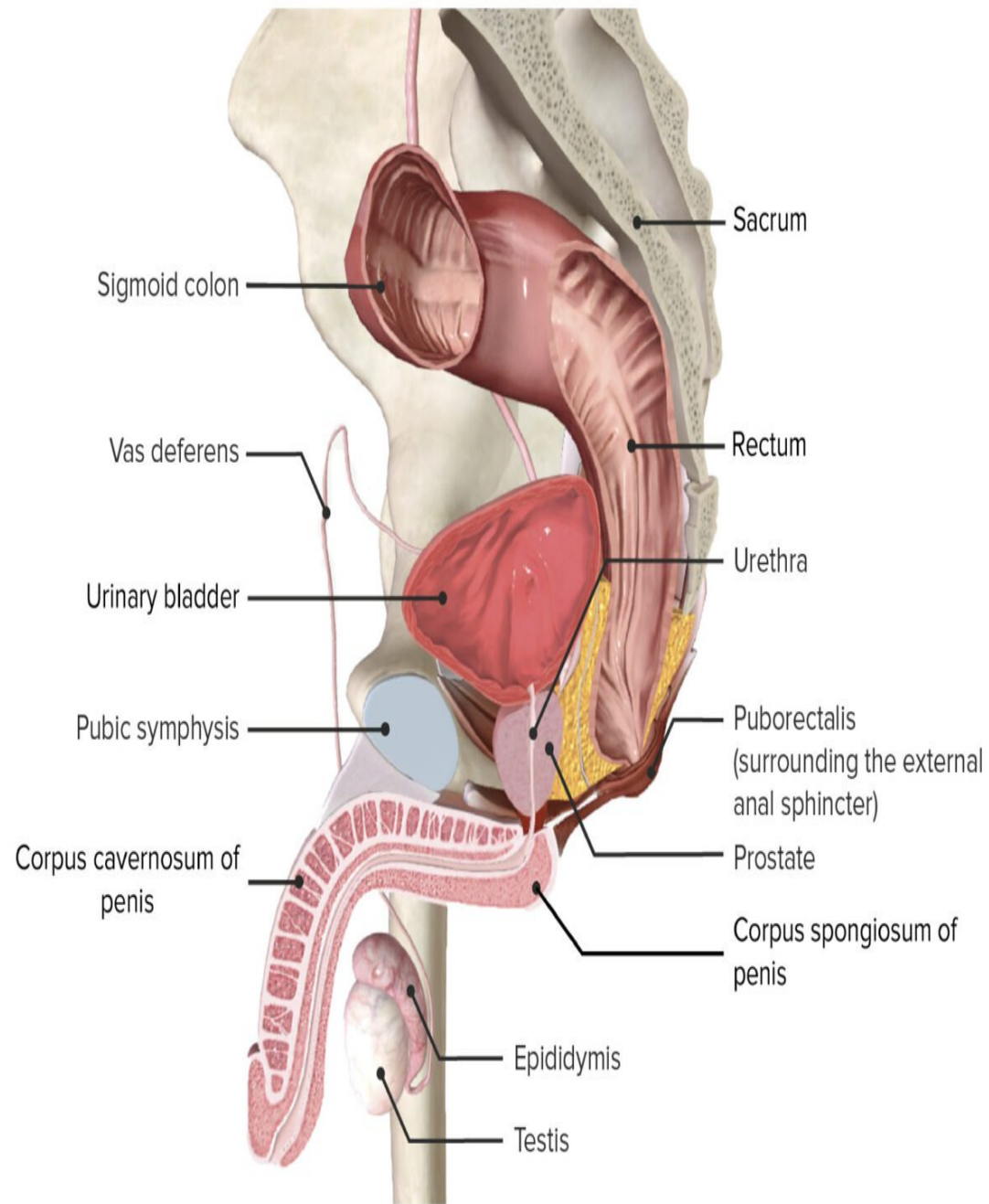
- _ Hollow, muscular organ that sits on the pelvic floor and accepts urine via the ureters.
- _ Musculature connects with that of the urethra, functioning as an internal urethral sphincter.
- _ Connected:
 - _ To the umbilicus via the medial umbilical ligament
 - _ To the pelvic walls by thickened areas of the pelvic fascia
- _ The average bladder capacity is 400 mL.

Parts:

- _ Apex: located anterosuperiorly, toward the public symphysis
- _ Body: main part of the bladder
- _ Fundus: base of the bladder, located posteriorly
- _ Trigone: triangular area within the fundus, defined by the 2 ureteral orifices
- _ Bladder neck:
 - _ Formed by the convergence of the fundus and the 2 inferolateral surfaces of the bladder
 - _ Continuous with the urethra

Spatial relations:

- _ In females, the urinary bladder is anterior to the uterus and anterior vaginal wall.
- _ In males, the urinary bladder is anterior to the rectum.



Vasculature :

– Arterial supply:

Superior and inferior vesical arteries (indirect branches of the internal iliac arteries)

Also from the obturator artery and the inferior gluteal artery

– Venous drainage: most drain into the internal iliac vein

Innervation:

- Sympathetic innervation:

- Produces detrusor relaxation → urine retention

- Parasympathetic innervation:

- Produces detrusor contraction → urination

- Somatic innervation:

- The pudendal nerve (S2–S4), a branch of the sacral plexus
 - Voluntary control to the external urethral sphincter

- Mechanoreceptors (bladder wall):

- Sense bladder fullness or distention

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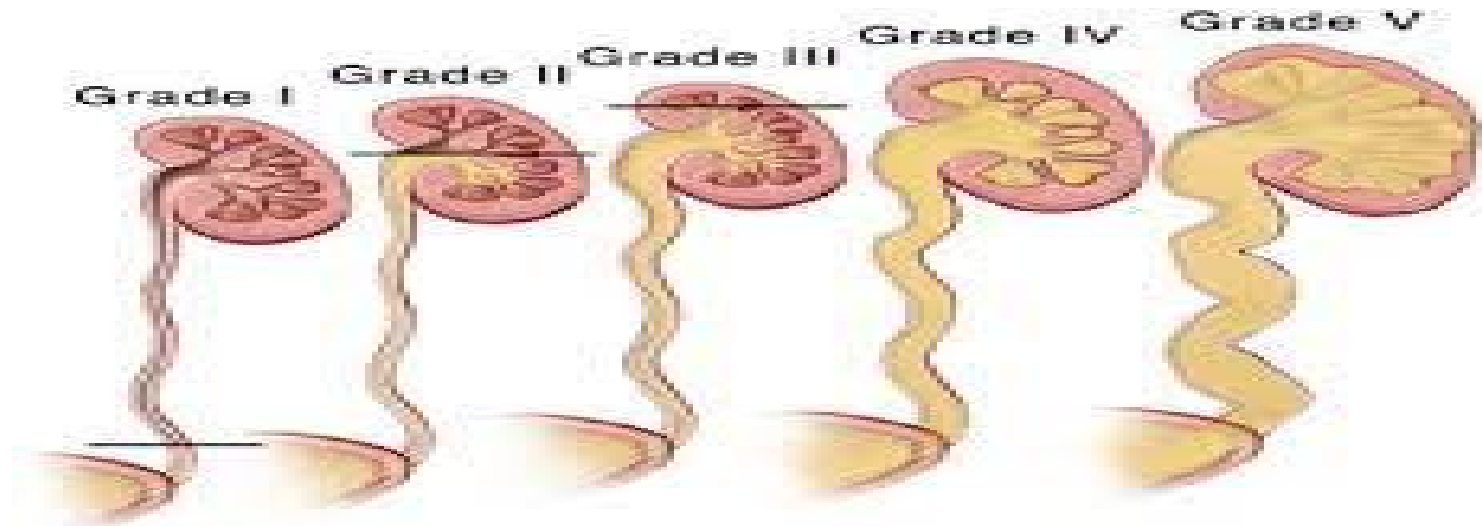
Clinical Relevance

Urinary incontinence:

- _ involuntary loss of bladder control or unintentional voiding.
- _ There are 5 types of urinary incontinence: stress, urge, mixed, overflow, and functional.
- _ The etiology of urinary incontinence is multifactorial.
- _ For women, risk factors include prior vaginal deliveries and menopause; for men, the main risk factor is prior prostate surgery.
- _ Diagnosis is clinical.
- _ Management depends on the type(s) of incontinence and the etiology.

Vesicoureteral reflux:

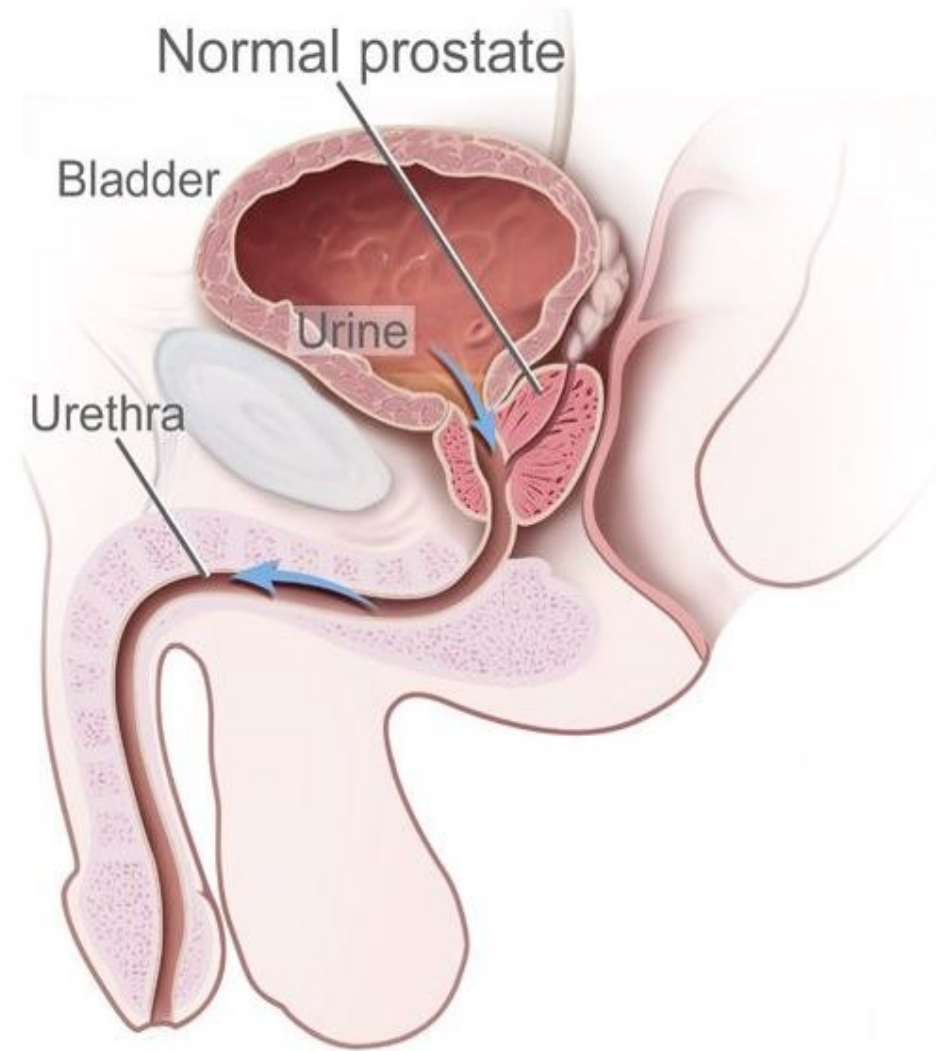
- _ retrograde flow of urine from the urinary bladder to the ureter and the kidney.
- _ Vesicoureteral reflux can be asymptomatic and resolve spontaneously, or may need to be corrected surgically.
- _ The condition is associated with frequent urinary tract infections, leading to pyelonephritis and nephropathy.



Urethra:

Male urethra

- _ Extends from the internal urethral orifice in the bladder neck to the external urethral orifice of the glans penis
- _ Much longer than the female urethra (up to 25 cm long)
- _ Responsible for passage of both urine (from the bladder) and semen (from the ejaculatory ducts)



Structure segments:

_ Preprostatic urethra:

- _ Extends from bladder neck to the prostate

_ Prostatic (within the prostate) urethra:

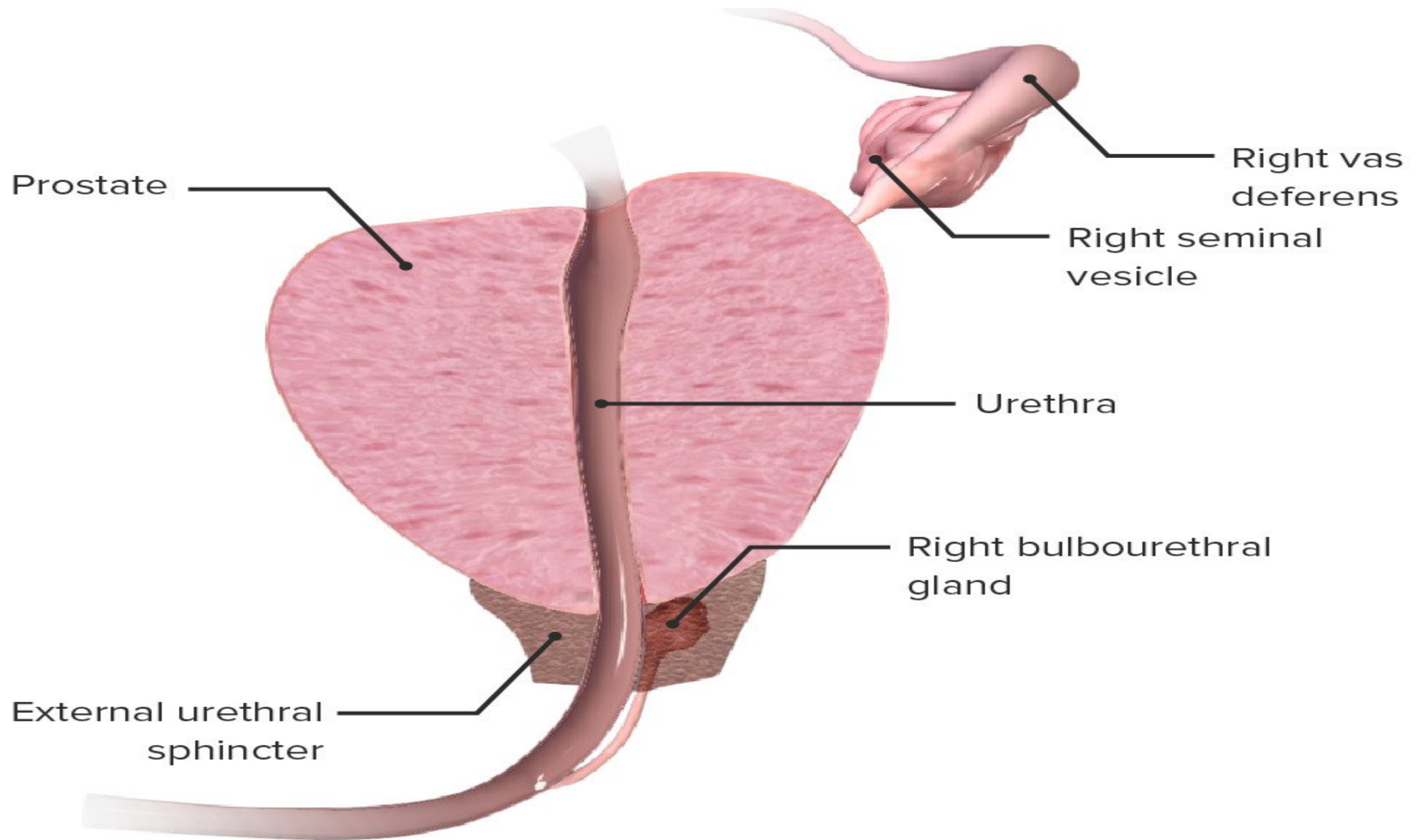
- _ 3–4 cm long
- _ Receives the prostatic ducts and ejaculatory ducts (from the testes and the seminal vesicles)

_ Membranous urethra:

- _ 2 cm long
- _ Runs through urogenital diaphragm
- _ Surrounded by the external urethral sphincter, which voluntarily controls micturition

_ Penile (spongy) urethra:

- _ Passes through the corpus spongiosum of the penis
- _ Ends at the external urethral orifice (meatus)



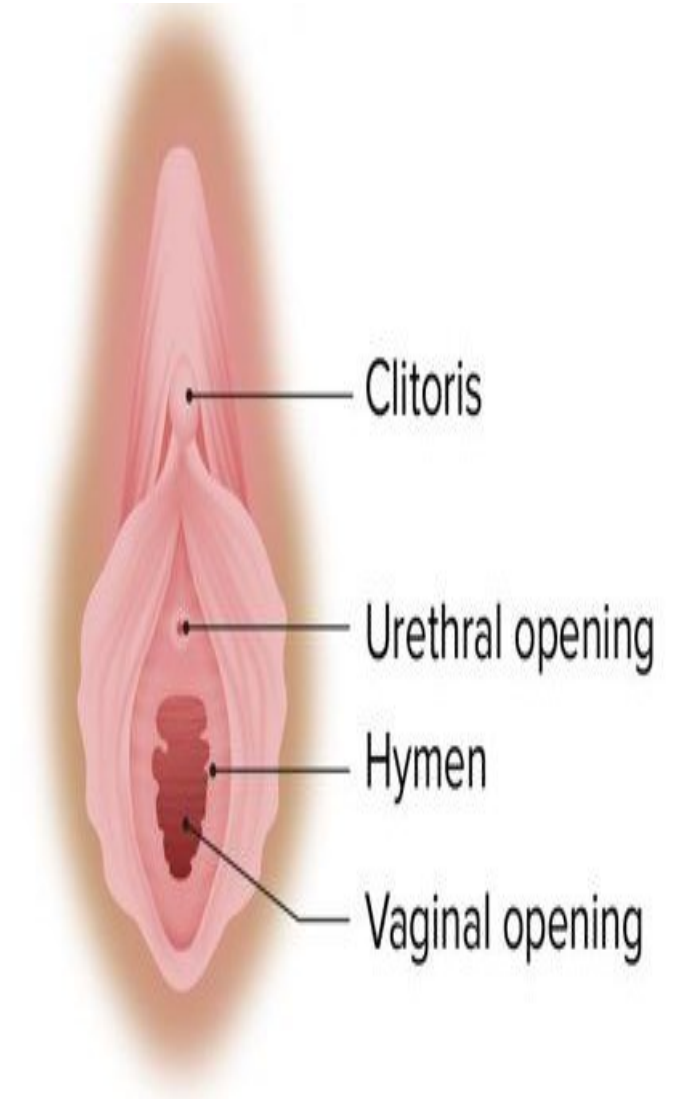
Arterial blood supply:

- _ Prostatic urethra: inferior vesical artery (branch of the internal iliac artery)
- _ Membranous urethra: bulbourethral artery (branch of the internal pudendal artery)
- _ Penile urethra: branches of the internal pudendal artery

Venous drainage: follows the arterial supply

Female urethra

- _ Much shorter than the male urethra (approximately 5 cm long)
- _ Extends from the internal urethral orifice in the bladder neck to an area between the labia minora; embedded in the anterior wall of the vagina
- _ Runs behind the pubic symphysis and pierces through the perineal membrane and pelvic floor



Parts:

- _ Proximal area (about $\frac{2}{3}$) is surrounded by the external urethral sphincter muscle (circular fibers)
- _ Distal end is encircled by the compressor urethrae muscle.
- _ The external urethral orifice is located:
 - _ Anteriorly to the vaginal opening
 - _ 2–3 cm posteriorly to the clitoris
 - _ 2 mucous glands (Skene glands) lie on either side of the orifice.

Arterial blood supply: internal pudendal artery, vaginal artery

Venous drainage: internal pudendal veins