Contents

Intended learning outcomes

N	Topic	ILOS
1	**Anatomy of the Kidney.**	1. Describe the external structure of the kidney, including its location, support structures, and covering. 2. Trace the path of blood flow through the kidneys. 3. Identify the major structures and subdivisions of the renal corpuscle, renal tubules, and renal capillaries.Structure, site, arterial supply, nerve supply, venous drainage, lymphatic drainage and relations of the kidney. 4. Renal coverings are important in fixation of the kidney in position. 5. Surface marking of kidney.
2	**Anatomy of the Ureter.**	1. Structure, site, arterial supply, nerve supply, venous drainage, lymphatic drainage and relations of the ureter. 2. Surface marking of ureter.
3	**Anatomy of urinary bladder and urethra.**	1. Site, arterial supply, nerve supply, venous drainage, lymphatic drainage. 2. Relations of the urinary bladder and urethra.
4	**Development of the Kidney and Ureter and their Congenital Anomalies.**	1. Describe the development of the kidney and ureter. 2. Explain the congenital anomalies of the kidney and ureter.
5	**Development of the Urinary Bladder and Urethra and their Congenital Anomalies.**	1. Describe the development of the urinary bladder and its congenital anomalies. 2. Explain the development of the urethra and its congenital anomalies. 3-Differentiate between male and female development of urethra

Introduction: The urinary system is comprised of the kidneys, ureters, urinary bladder, and urethra.

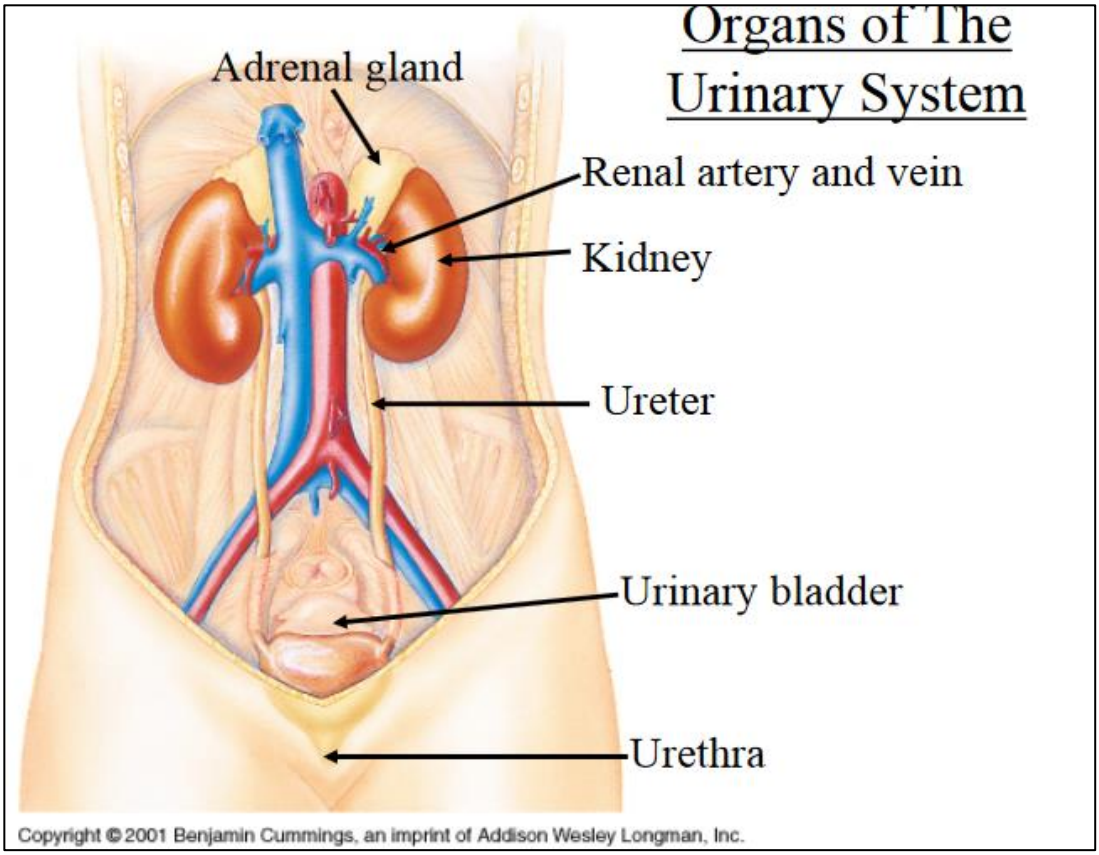


Fig.1: **Organs of the urinary system.**

1- KIDNEYS

Site:

- The kidneys lie on the posterior abdominal wall, retroperitoneal (between the dorsal body wall and the parietal peritoneum) in the superior lumbar region, one on each side of the vertebral column opposite the 12th thoracic and upper 3 lumbar vertebrae.
- The left kidney is slightly higher than the right kidney by half an inch. It reaches up to the level of the **11th** rib, while the right kidney reaches up to the **11th** space.

Size of the kidney: is 10 cm long, 5 cm wide and 2.5 cm thick.

Shape: the kidney is bean-shaped organ and has 2 Poles, 2 borders and 2 surfaces.

- **Two poles: upper and lower:** the upper pole is slightly thicker.
- **Two borders: lateral and medial.**
  - The lateral border: is convex.
  - The medial border: is concavo-convex. It is convex at both ends, but is concave in the middle where it presents a vertical slit called the hilum of the kidney.
- **Two surfaces: anterior and posterior.**

The anterior surface	The posterior surface
Faces anterolateral	Faces posteromedial
Covered with peritoneum.	No peritoneal covering.

Identification of the side of the kideny: -

1. The medial border contains the hilum.
2. Anterior surface: convex and corresponds to the renal vein.
3. Posterior surface: flat and lies close to the pelvis of the ureter.
4. The ureter is directed downwards towards the lower end.

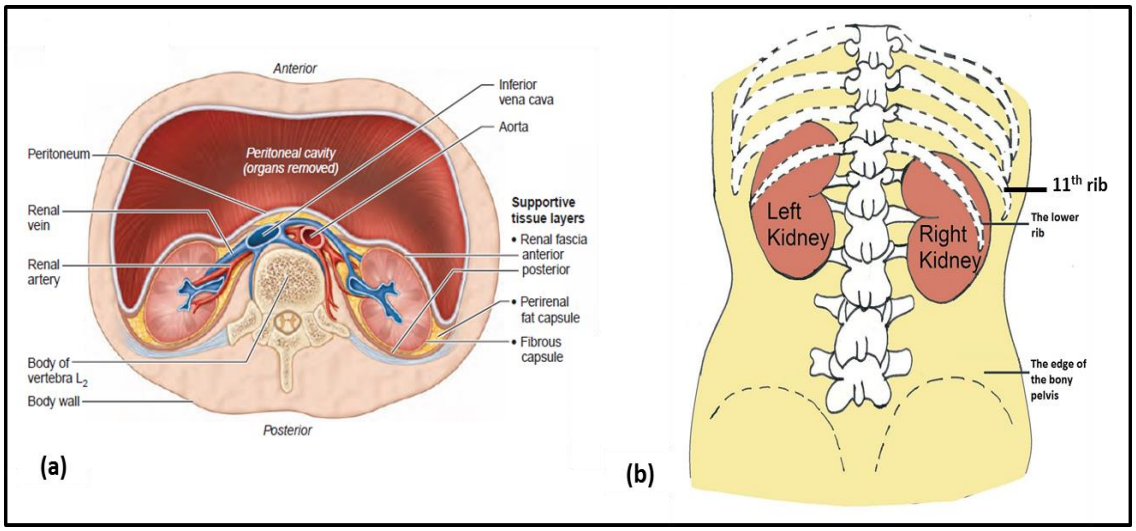


Fig. (2): **Position of the kidneys against the posterior body wall. (a)** Cross-section viewed from inferior direction. **(b)** Posterior in situ view showing relationship of the kidneys to the 11th rib.

Hilum of the kidney:

- It is a vertical opening at the middle of the medial border at the level of **L1** vertebrae (transpyloric plane). It leads to sinus of the kidney.
- It transmits the following:
  - Renal **V**ein (anteriorly)
  - Renal **A**rtery (middle)
  - Renal **P**elvis (posterior and downward) (Member VAP).
  - Lymphatics and fat.

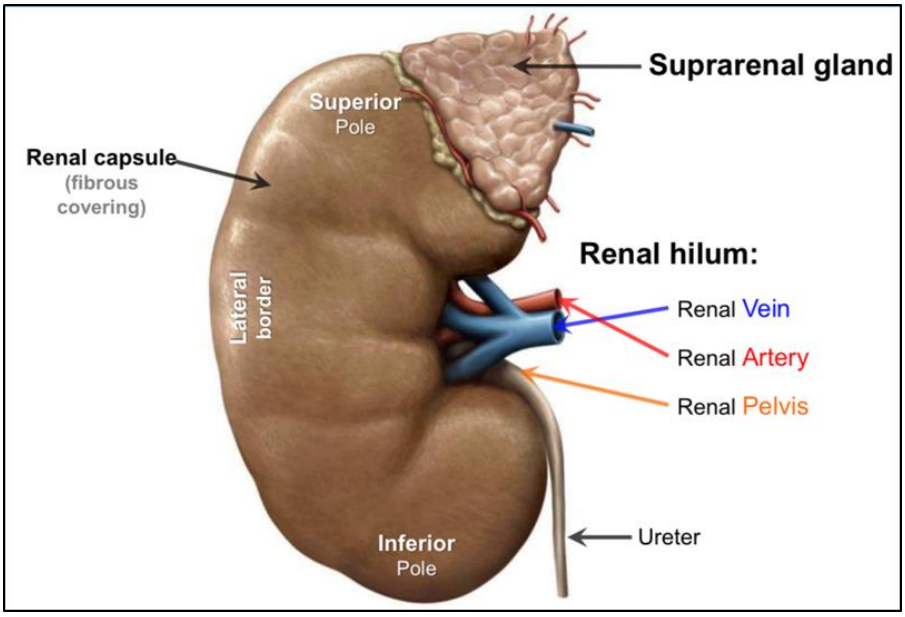


Fig. 3: **Hilum of the kidney**

Relations:

- **Posterior relations:** Are the same in the right and left kidneys:
  - ***4 Muscles:***
    - ***Diaphragm:*** is related to upper end separating it from the costo-diaphragmatic recess of the pleura and 11th and 12th ribs (on the left side) or 12th rib (on the right side).

      Below the diaphragm: the kidney is related to the other 3 muscles:
    - ***Psoas major:*** medially.
    - ***Quadratus lumborum:*** the intermediate part (main part).
    - ***Transversus abdominis:*** laterally.
  - ***4 Neurovascular structures:*** lies between kidney and the quadratus lumborum muscle, they include the followings:
    - Subcostal vessels.
    - Subcostal nerve (T12).
    - Iliohypogastric nerve (L1).
    - Ilioinguinal nerve (L1).

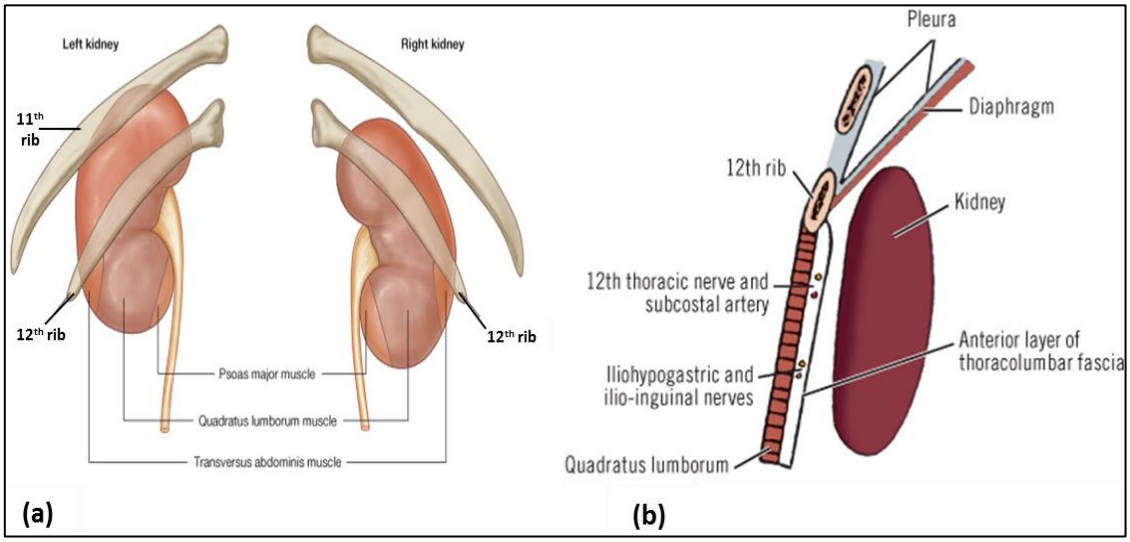


Fig. (4): **Posterior relations of the kidney.** (a) Posterior view (b) Saggital section

- **Anterior relations:** are different on both sides:

Right kidney	Left kidney
1- Right suprarenal gland: at its upper pole	***1- Left suprarenal gland:*** from the upper pole to the hilum
2- ***2nd part of the duodenum:*** at the medial border and adjacent area of the anterior surface around the hilum	***2-Stomach (posterior surface):*** is related to the triangular area at the upper third between the areas for the pancreas, spleen and left suprarenal gland.
3- ***Right lobe of the liver:*** is related to large area lateral to the second part of the duodenum (upper three-fourth of the anterior surface).	***3- Spleen:*** close to the upper lateral part
4- ***Right colic flexure:*** below the hepatic area	4- ***Descending colon:*** is related to the anterior surface close to the lower part of the lateral border.
5- ***Loops of jejunum & ascending branch of right colic artery:*** are related to lower medial area of anterior surface	5- ***Loops of jejunum & ascending branch of left colic artery:*** are related to lower medial area of anterior surface
	6- ***Body of pancreas and splenic vessels:*** are related to quadrilateral area at the middle third of the anterior surface

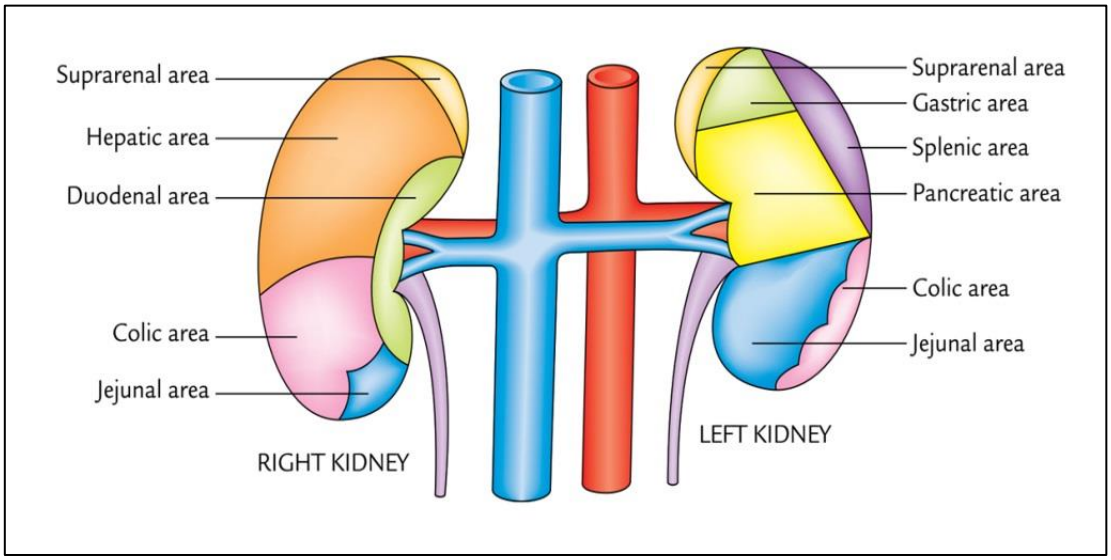


Fig. (5): **Anterior relations of the kidney**

Peritoneal covering:

The anterior surface is the only surface covered with peritoneum.

a. Right kidney:

- ♦ Two areas are covered: hepatic and jejunal areas.
- ♦ Three areas are not covered: Suprarenal, Duodenal and Right colic flexure.

b. Left kidney:

- ♦ Three areas are covered with peritoneum: splenic, gastric and jejunal areas.
- ♦ Three areas are not covered with peritoneum: suprarenal, pancreatic and descending colon.

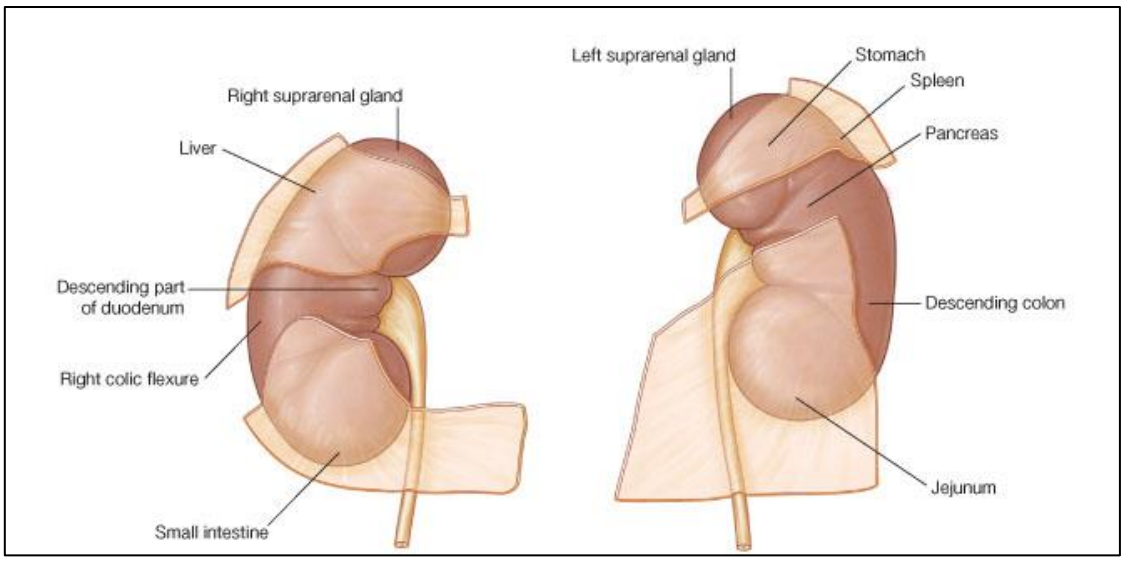


Fig. (6): **Peritoneal covering of the kidney**.

Coverings of the kidney: Arranged from within outwards:

1. **Fibrous capsule:** Can be easily stripped off from normal kidney substance.
2. **Perirenal (perinephric) fat:** Lies outside the fibrous capsule.
3. **Renal fascia:** Lies outside the perirenal fat and surrounds the suprarenal gland.
4. **Pararenal (paranephric) fat:** It is a large mass of fat, outside the renal fascia**.**

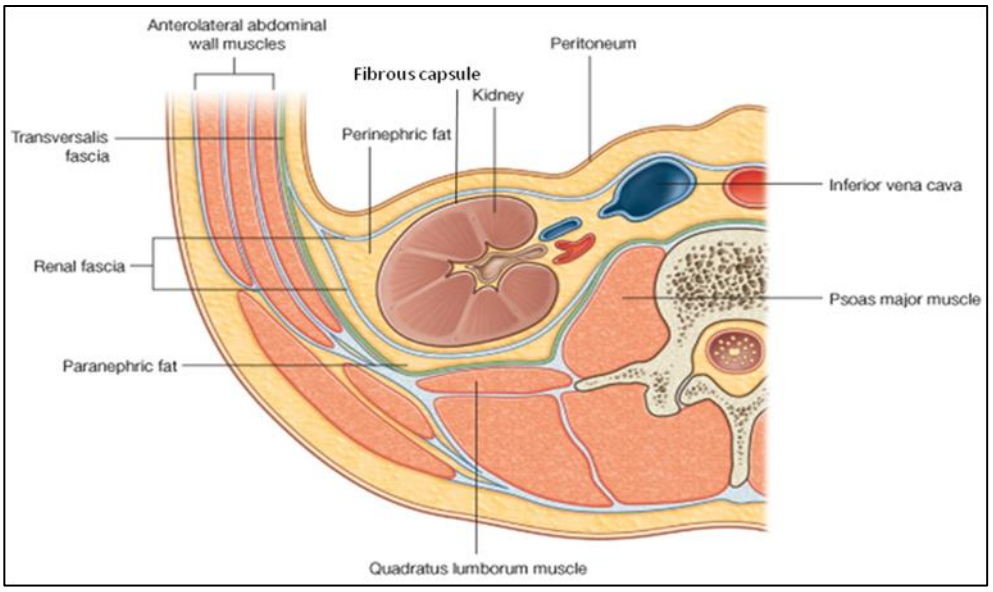


Fig. (6): **Coverings of the kidney**.

Internal Anatomy

The kidney through frontal section reveals three distinct regions: cortex, medulla, and pelvis.

a- **Renal cortex**:

- Is the most superficial part, light in color and has a granular appearance.
- It forms the outer part of the kidney and also projects into the medullary region between the renal pyramids as renal columns.

b- Renal medulla:

- Is deep to the cortex, darker and reddish-brown. It exhibits cone-shaped tissue masses called **medullary** or **renal pyramids**. The broad base of each pyramid faces toward the cortex, and its apex, or papilla points internally.

c- The renal pelvis:

- Is a funnel-shaped tube, continuous with the ureter leaving the hilum. Branching extensions of the pelvis form two or three **major calyces.** Each one subdivides to form several **minor calyces**, cup-shaped areas that enclose the papillae.

- The calyces collect urine, which drains continuously from the papillae, and empty it into the renal pelvis.

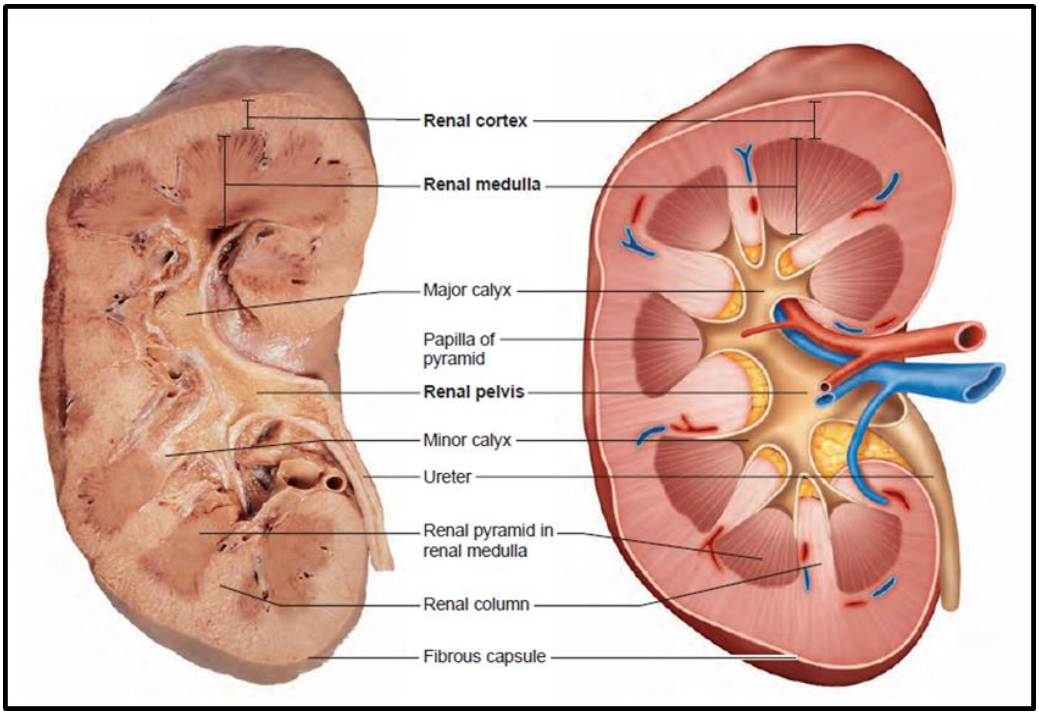


Fig. (7): **The internal anatomy of the kidney**.

Renal vessels:

♦ **Renal arteries:**

- Arise from the aorta at right angle, at the level of the upper border of L2.
- The right renal artery is longer than the left and passes posterior to the IVC; the left artery passes posterior to the left renal vein.

♦ **Renal veins**:

- Terminate in I.V.C. The left is longer than the right one.

♦ **Lymphatic vessels of the kidney**:

- Are drained into the lateral aortic lymph nodes around the origin of the renal artery.

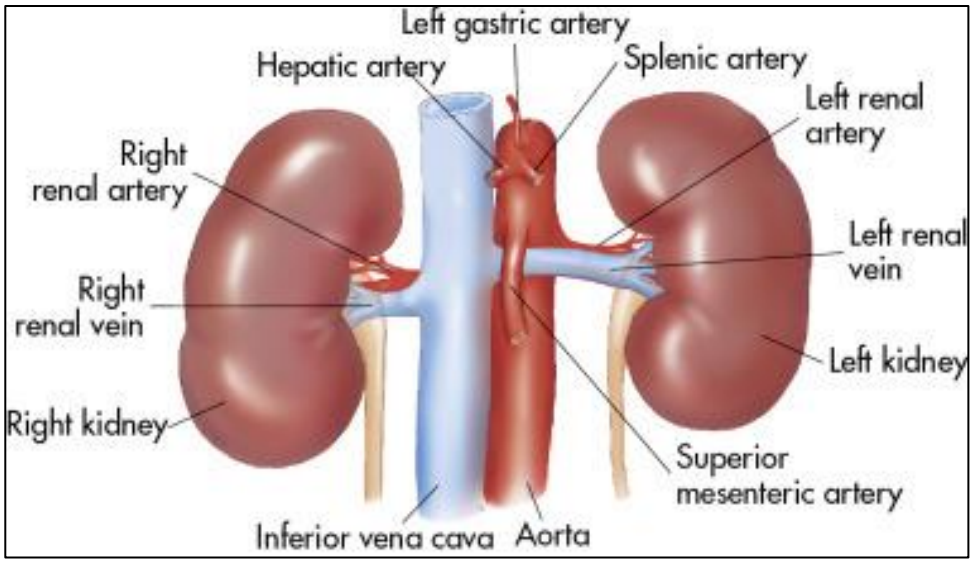


Fig. (8): **Blood supply of the kidney.**

Nerve supply of the kidney:

by renal plexus derived from coeliac plexus.

- Sympathetic fibers: are derived from the 10th, 11th, 12th thoracic and 1st lumber segments of the spinal cord.
- Parasympathetic fibers: are unknown probably from the vagi.

Factors supporting kidneys in its position:

- Perinephric fascia: false capsule from the surrounding tissues.
- Perinephric fat: between perinephric fascia and true capsule of kidneys.
- Renal vessels.
- Suspensory ligament from the diaphragm.
- Apposition of the neighboring viscera and the intra-abdominal pressure

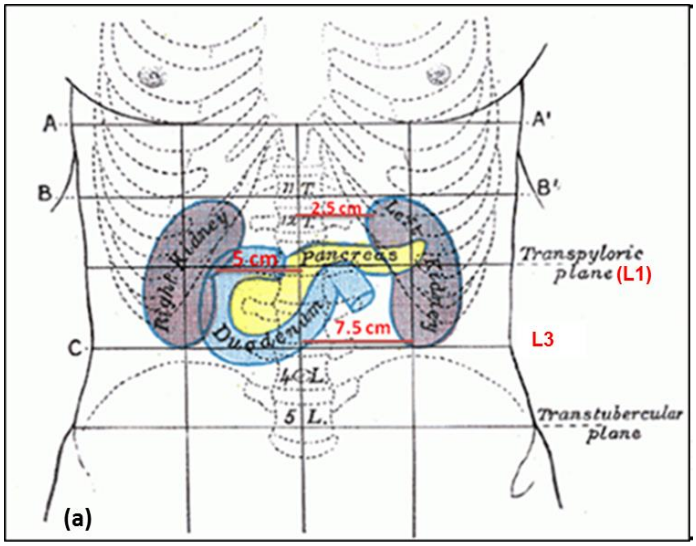
Surface anatomy of kidneys:

♦ **Anteriorly:**

	Right kidney	Left kidney
Upper end	2.5 cm to the right of midline Opposite posterior part of 11th intercostal space.	2.5 cm to the left of midline Opposite posterior part of 11th rib and 2 inches above the hilum.
Hilum	5 cm from midline Just below transpyloric plane.	5 cm from midline At transpyloric plane.
Lower end	7.5 cm from midline At level of intervertebral disc between L3 & L4 above iliac crest by 4 cm.	7.5 cm from midline At level of intervertebral disc between L3 & L4 above iliac crest by 5 cm.

♦ **Posteriorly: (Morris's rectangle)**

- The kidney lies within Morris's rectangle, which is drawn by two horizontal and two vertical lines:
  - The upper horizontal line: opposite the spine of T11.
  - The lower horizontal line: opposite the spine of L3.
  - The two vertical lines are drawn 2.5 cm and 7.5 cm from the median plane.
  - The hilum of kidney will be opposite the first lumbar spine, 5 cm from the median plane



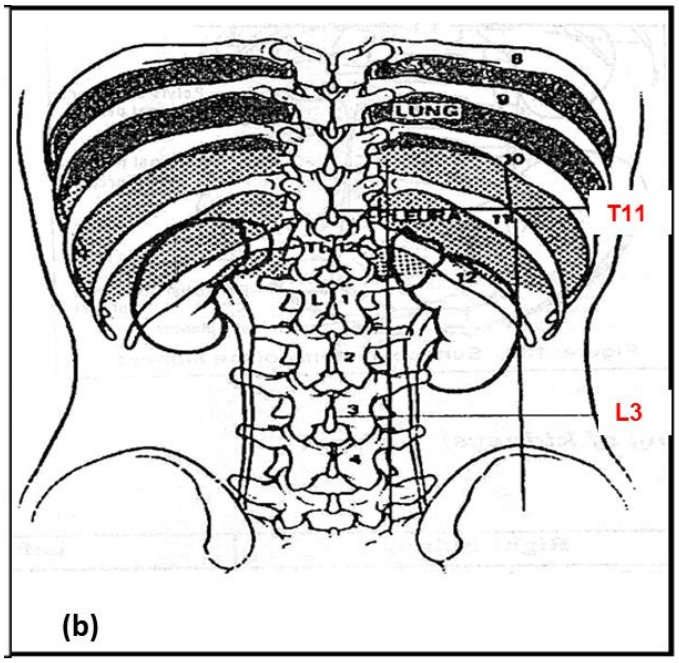


Fig. (9): **Surface anatomy of the kidney** (a) anterior view, (b) posterior view (Morris rectangle).

2-URETERS

Definition: Expansible muscular tube, whitish in color, begins with the renal pelvis and extends from the kidney to the urinary bladder.

Length: Ten inches (25 cm) long.

Origin: At the level of L2, the ureter begins inside the sinus of the kidney by union of the major calyces.

Function: Plays an active role in transporting urine.

Course: It can be divided into three parts:

a. Renal pelvis.

b. Abdominal part.

c. Pelvic part.

a- Renal pelvis (pelvis of the ureter):

- **Site*:*** the renal pelvis lies partly inside the renal sinus and partly outside along the medial border of the kidney till its lower end where it becomes continuous with the ureter proper.
- **Formation:** by the union of 2 - 3 major calyces.

b- Abdominal part:

- **Length:** 12.5 cm long.
- **Course:**
  - Begins at the lower end of the kidney.
  - Descends downwards and medially behind the peritoneum of posterior abdominal wall opposite the tips of the lumbar transverse processes (L2 - L5).
  - Enters the pelvis by crossing pelvic inlet in front of the bifurcation of common iliac or the beginning of the external iliac artery.

♦ Relations:

Posteriorly: (the posterior relations of two ureters are the same).

- Medial part of the psoas major and its fascia.
- Genitofemoral nerve (crosses behind the ureter).
- Bifurcation of common iliac or beginning of external iliac artery.

Anteriorly: (different in right from the left side).

***a.* Right ureter:**

- Third part of duodenum.
- Right testicular or ovarian vessels.
- Right colic and ileocolic vessels.
- Root of mesentery.

***b.* Left ureter:**

- Left testicular or ovarian vessels.
- Left colic and sigmoid vessels.
- Sigmoid mesocolon containing superior rectal vessels.

Medially: (veins)

***a.* Right ureter:** Inferior vena cava.

b. Left ureter: Inferior mesenteric vein.

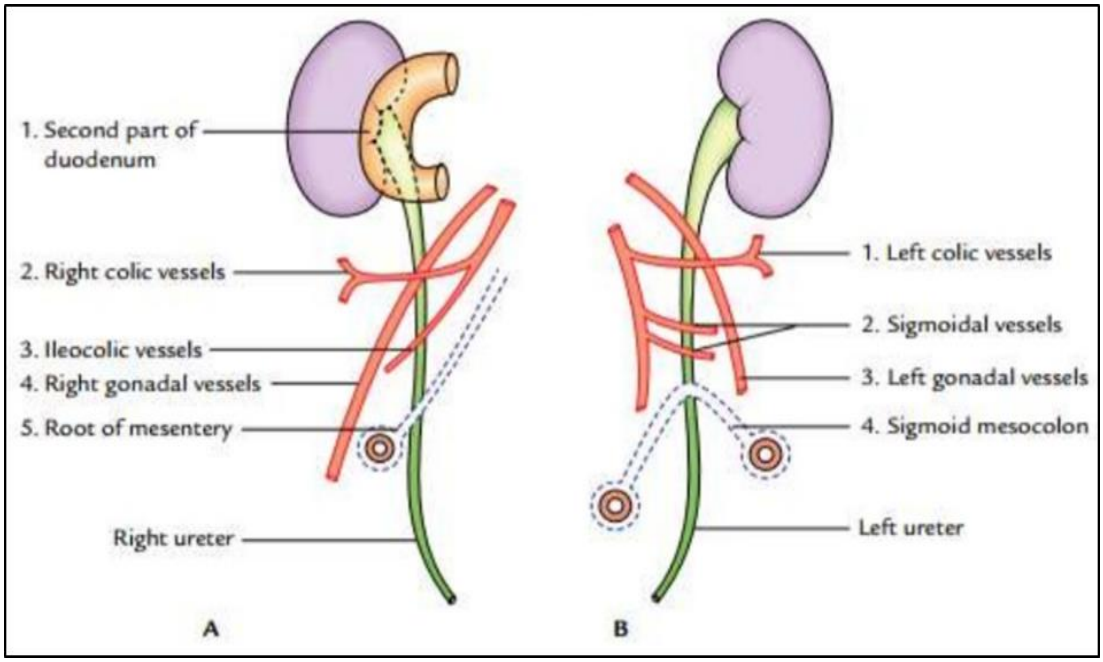


Fig.. (10): **anterior relation of abdominal ureter.**

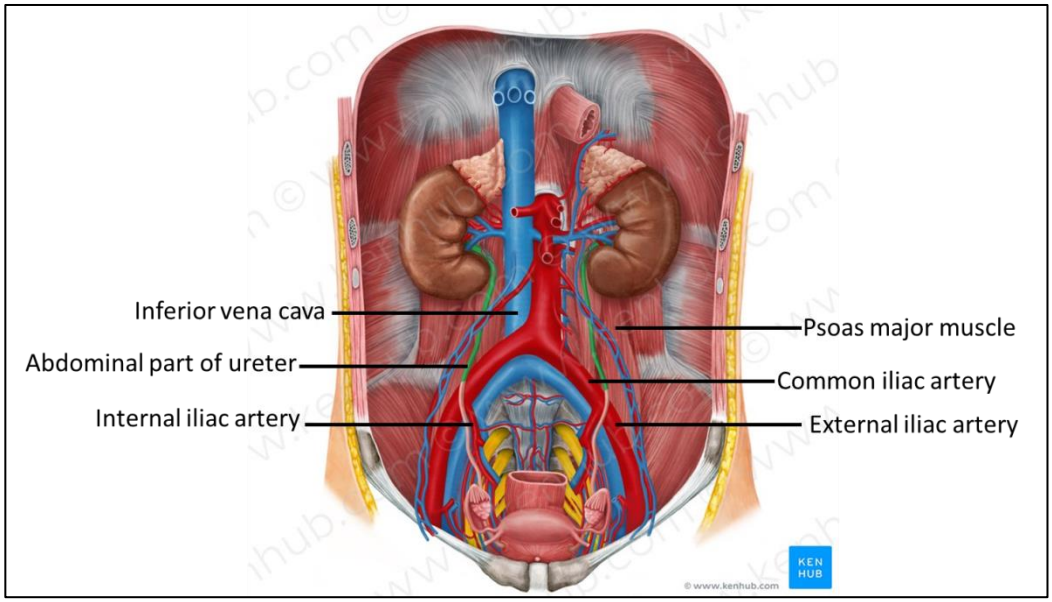


Fig. (11): **posterior relation of abdominal ureter**

c- Pelvic part:

Length: 5 inches long.

Course: divided into three parts:

1. On the lateral wall of the pelvis.
2. Floor of the pelvis.
3. In the wall of the bladder.

- **On the lateral wall of the pelvis**: Crosses the **pelvic brim** in front of the bifurcation of the common iliac artery; descends retroperitoneally on the lateral pelvic wall; and runs medial to the umbilical artery and the obturator vessels and posterior to the ovary, forming the posterior boundary of the ovarian fossa.
- **Floor of the pelvis:**
  - **In females:** it is accompanied in its course by the uterine artery, which runs above and anterior to it in the base of the broad ligament of the uterus. Because of its location, the ureter is in danger of being injured in the process of hysterectomy. It can be

remembered by the mnemonic device, "water (ureter) runs under the bridge (uterine artery)."

- **In males:** passes posterior and inferior to the ductus deferens and lies in front of the seminal vesicle before entering the posterolateral aspect of the bladder.

- **In the wall of the bladder:** it enters obliquely through the base of the bladder and opens by a slit-like orifice that acts as a valve, and the circular fibers of the intramural part of the ureter act as a sphincter. When the bladder is distended, the valve and sphincter actions prevent the reflux of urine from the urinary bladder into the ureter.

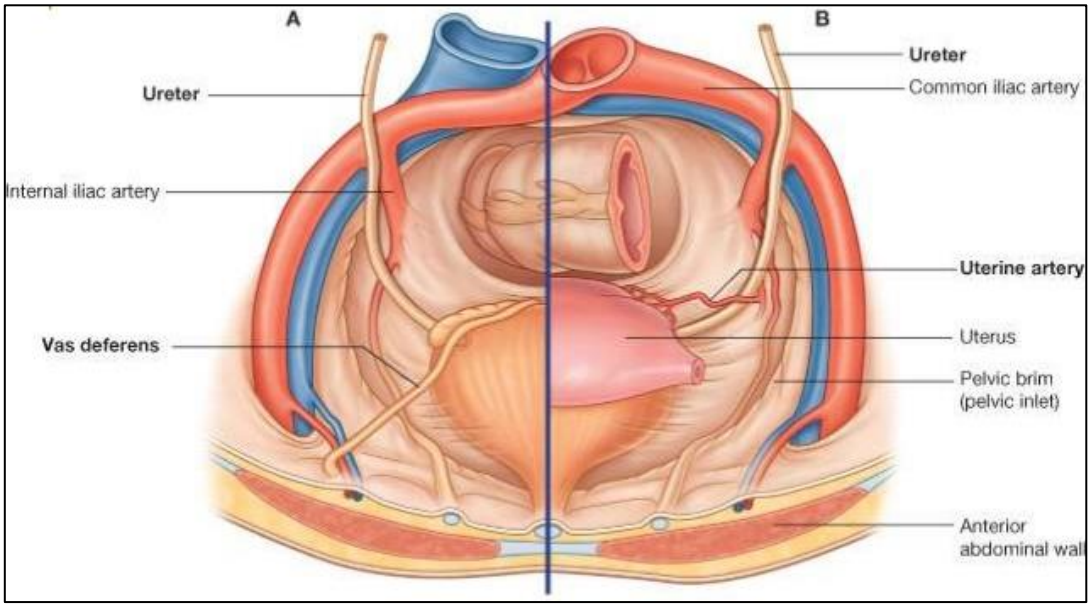


Fig. (12): **relations of pelvic ureter**

Constrictions of the ureter:

1. At the lower end of kidney: at the junction between pelvis and the ureter proper.
2. At the site of crossing the bifurcation of common iliac artery.
3. Inside the wall of urinary bladder (intramural part).

Arterial supply of the ureter:

The ureter gets its arterial supply from many arteries, which join together to form a longitudinal anastomosis. These arteries are:

1. Renal artery: supply the pelvis of the ureter.
2. Testicular or ovarian artery.
3. Abdominal aorta.
4. Common iliac artery.
5. Internal iliac artery.
6. Inferior vesicle artery (supplies the lower most part of the ureter)
7. Uterine artery (in the female).

(N.B): this multiple arterial supply is explained by the ascent of kidney during development and thus taking blood supply at different

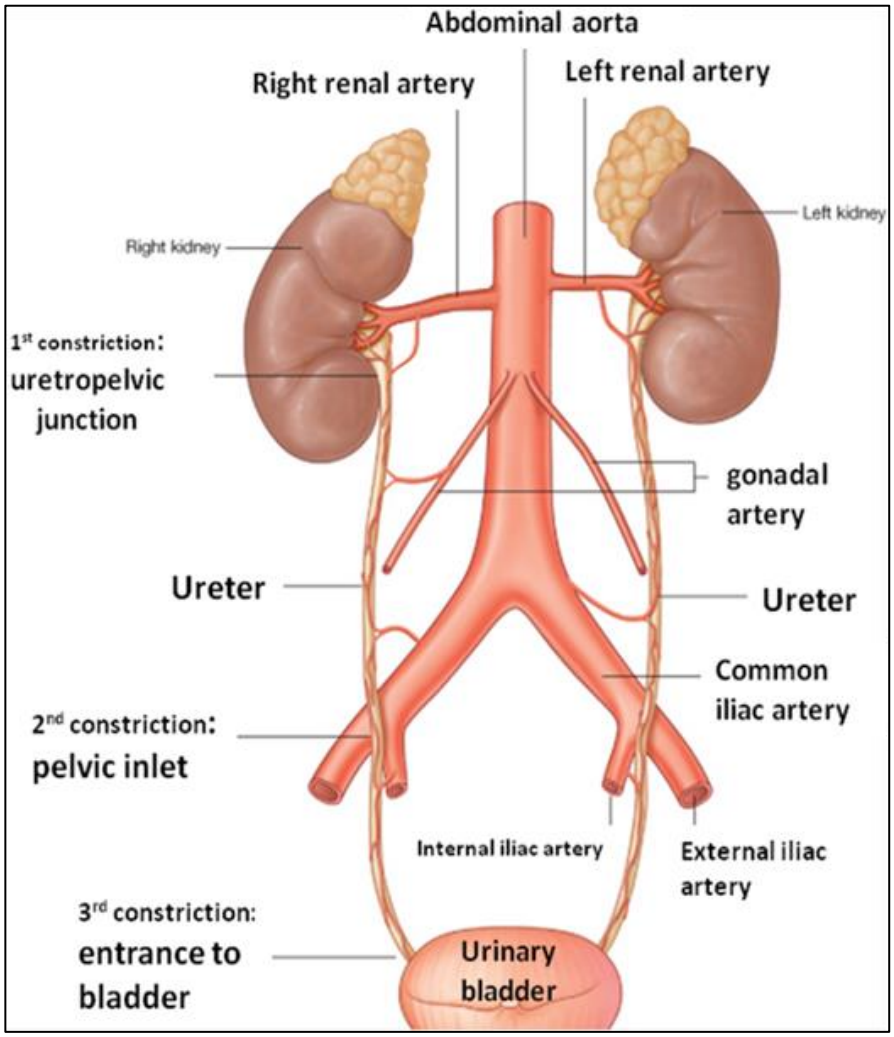


Fig. (13): **arterial supply and constrictions of the ureter**

Nerve supply:

- **Sympathetic fibers:** from the lower 3 thoracic and first lumbar spinal segments.
- **Parasympathetic fibers:** from 2nd, 3rd and 4th sacral segments of spinal cord.

Lymphatic drainage:

It drains to the following lymph nodes:

1. Lateral aortic lymph nodes.
2. Common iliac lymph nodes.
3. External iliac lymph nodes.
4. Internal iliac lymph nodes.

Surface anatomy of ureter:

1. **From in front:** corresponds to the upper two-thirds of a line, which extends from the hilum of the kidney to the pubic tubercle.
2. **From behind:** corresponds to a line extending from hilum to dimple above the buttocks, which overlies the posterior superior iliac spine.

URINARY BLADDER

- The bladder is the most anterior element of the pelvic viscera. Although it is entirely situated in the pelvic cavity when empty, it expands superiorly into the abdominal cavity when full.
- The empty bladder is shaped like a three-sided pyramid that has tipped over to lie on one of its margins.

Site:

- Although the bladder is considered to be pelvic in the adult, it has a higher position in children.
- At birth, the bladder is almost entirely abdominal; the urethra begins approximately at the upper margin of the pubic symphysis.
- With age, the bladder descends until after puberty when it assumes the adult position.

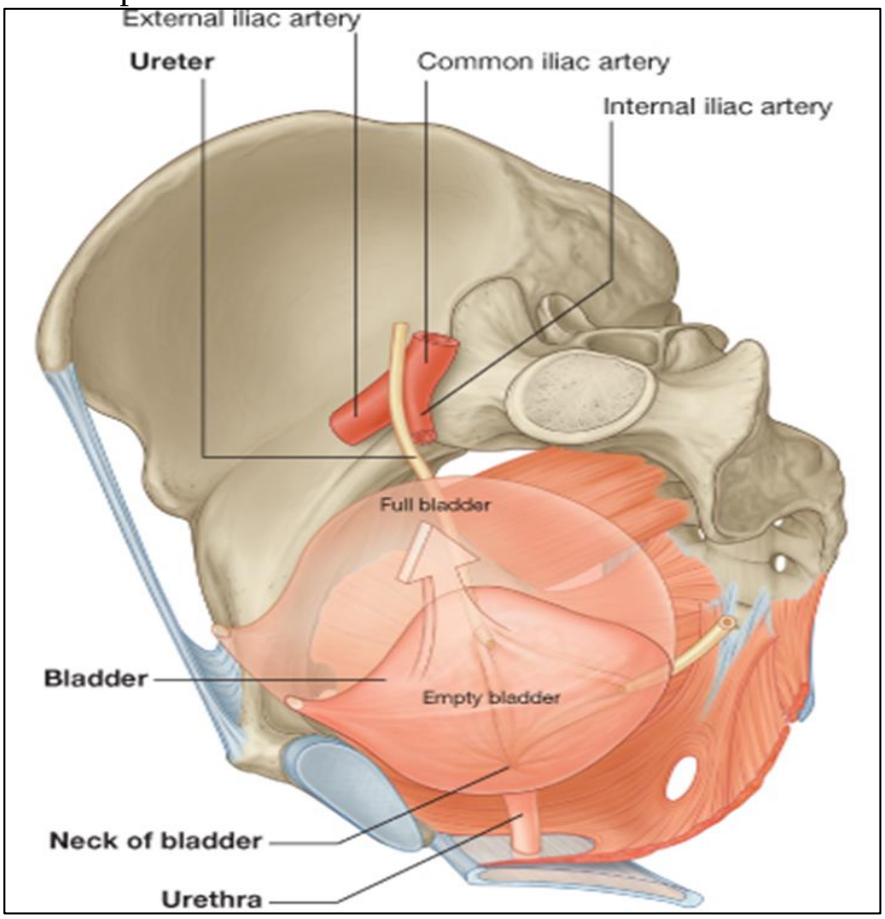


Fig. (14): **urinary bladder**

Shape:

It has an apex, a base, a superior surface, and two inferolateral surfaces.

a) **The apex of the bladder** is directed toward the top of the pubic symphysis; a structure known as the **median umbilical ligament** continues from it superiorly up the anterior abdominal wall to the umbilicus.

b) **The base of the bladder** is shaped like an inverted triangle and faces posteroinferiorly. The two ureters enter the bladder at each of the upper corners of the base, and the urethra drains inferiorly from the lower corner of the base.

c) **The inferolateral surfaces of the bladder:**
   - Not covered by peritoneum
   - **Related to** the levator ani muscles of the pelvic diaphragm and the adjacent obturator internus muscles above the attachment of the pelvic diaphragm.

d) **The superior surface** is slightly domed when the bladder is empty; it balloons upward as the bladder fills and covered by peritoneum.

e) **Neck of bladder:** it is the most inferior part of the bladder and also the most "fixed" part. It is anchored into position by a pair of tough fibromuscular bands, which connect the neck and pelvic part of the urethra to the posteroinferior aspect of each pubic bone.

Interior of the urinary bladder: the mucosal lining on the base of the bladder is smooth and firmly attached to the underlying smooth muscle coat of the wall unlike elsewhere in the bladder where the mucosa is folded and loosely attached to the wall. The smooth triangular area between the openings of the ureters and urethra on the inside of the bladder is known as the **trigone**.

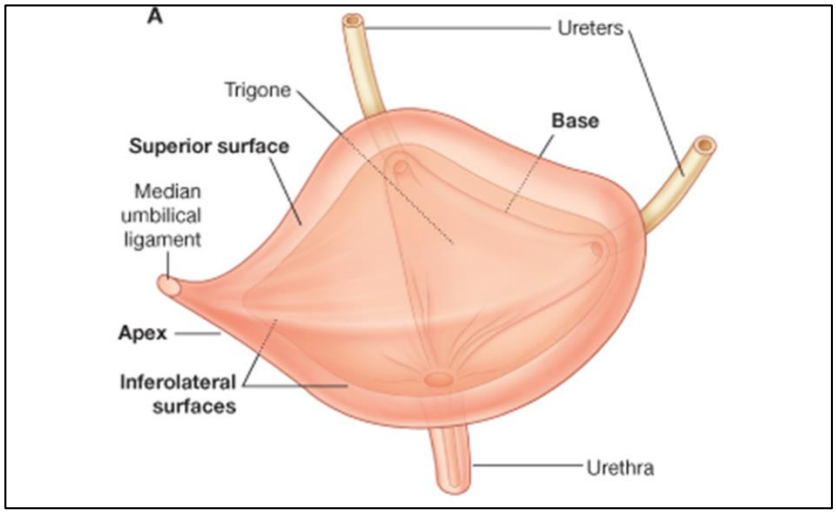


Fig. (15): **shape of the urinary bladder**

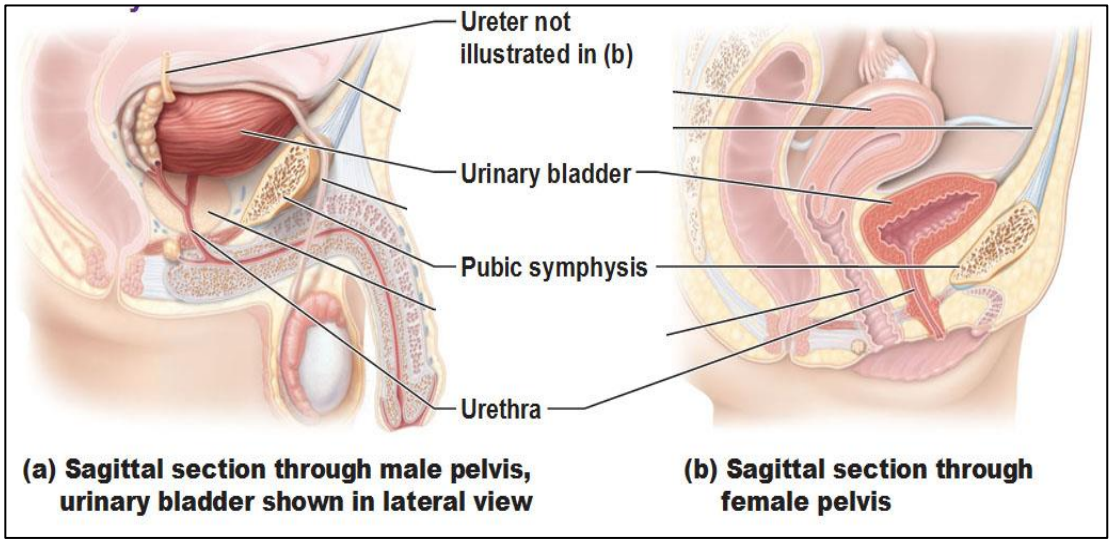


Fig. (16): **relations of the urinary bladder**

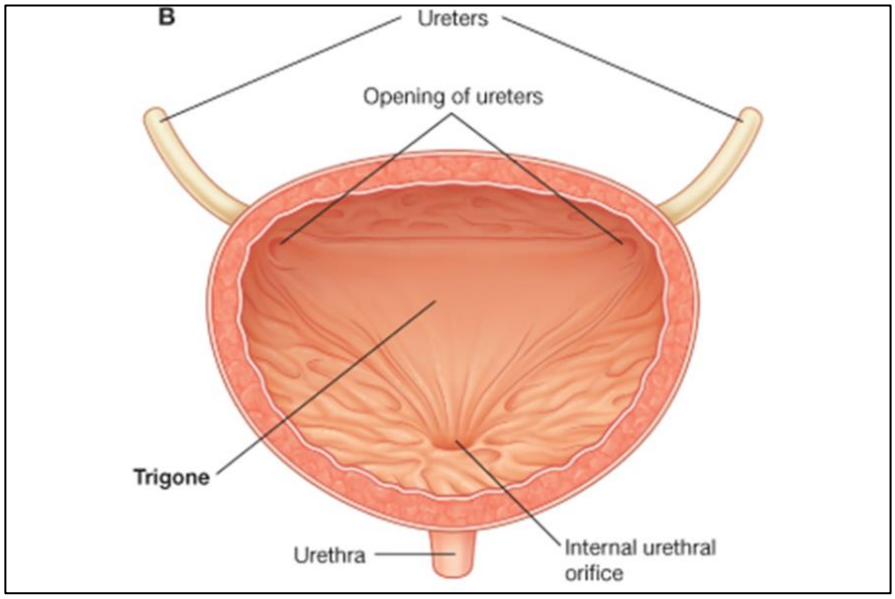


Fig. (17): **interior of the urinary bladder**

Ligaments of the urinary bladder:

1. Median umbilical ligament: Continuous with apex of the bladder (it is the embryonic urachus).

2. Puboprostatic and pubovesical ligaments:

- In the male, the puboprostatic ligaments extend from back of the bodies of pubic bones to the anterior surface of the sheath of the prostate and neck of the bladder.
- In the female, the pubovesical ligaments extend from pubic bones to the urethra and neck of the bladder.

3. Lateral ligaments of the bladder:

- Each extends laterally from the side of the base of the bladder across the pelvic floor to the tendinous arch in side wall of the pelvis.

4. Posterior ligaments:

- Each extends backwards from the base of the bladder to the corresponding internal iliac vein.

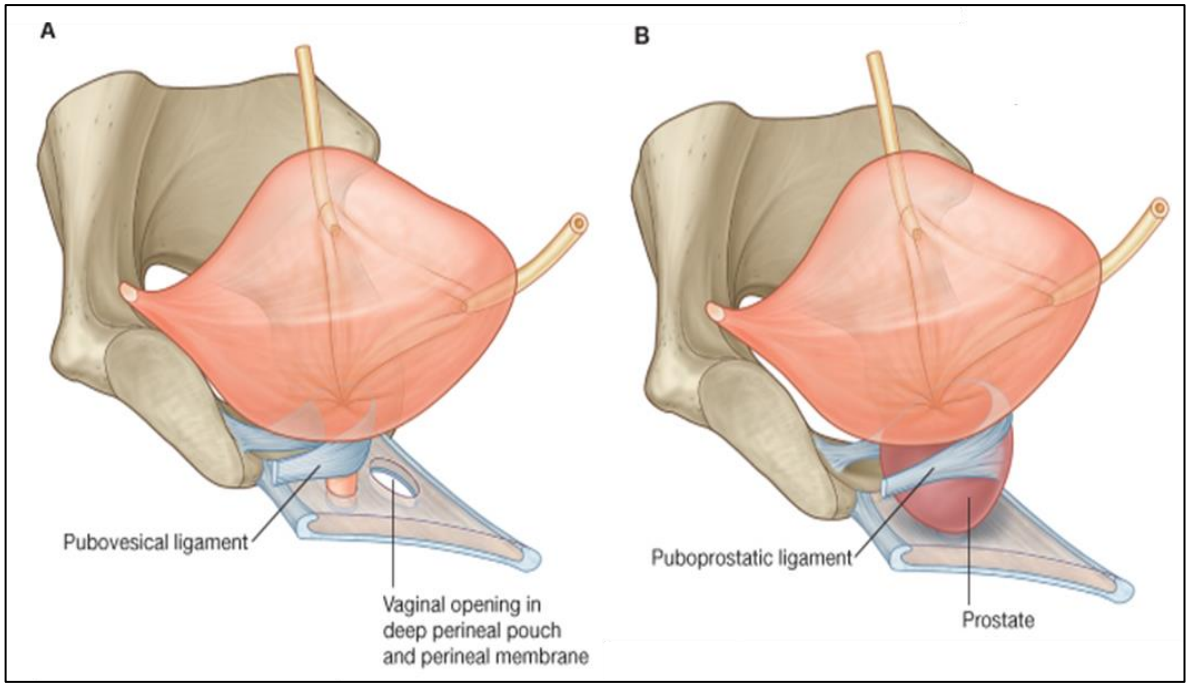


Fig. (18): **female and male bladder**

Blood supply:

- **Arterial supply:** Receives blood from the superior and inferior vesical arteries (and from the vaginal artery in females).
- **Venous drainage:** Its venous blood is drained by the **prostatic (or vesical) plexus** of veins, which empties into the internal iliac vein.

Nerve supply:

It is innervated by nerve fibers from the vesical and prostatic plexuses.

- The **parasympathetic nerve** (pelvic splanchnic nerve originating from S2–S4) stimulates to contract the musculature (detrusor) of the bladder wall, relaxes the internal urethral sphincter, and promotes emptying.
- The **sympathetic nerve (T11,T12,L1,L2)** relaxes the detrusor of the bladder wall and constricts the internal urethral sphincter.

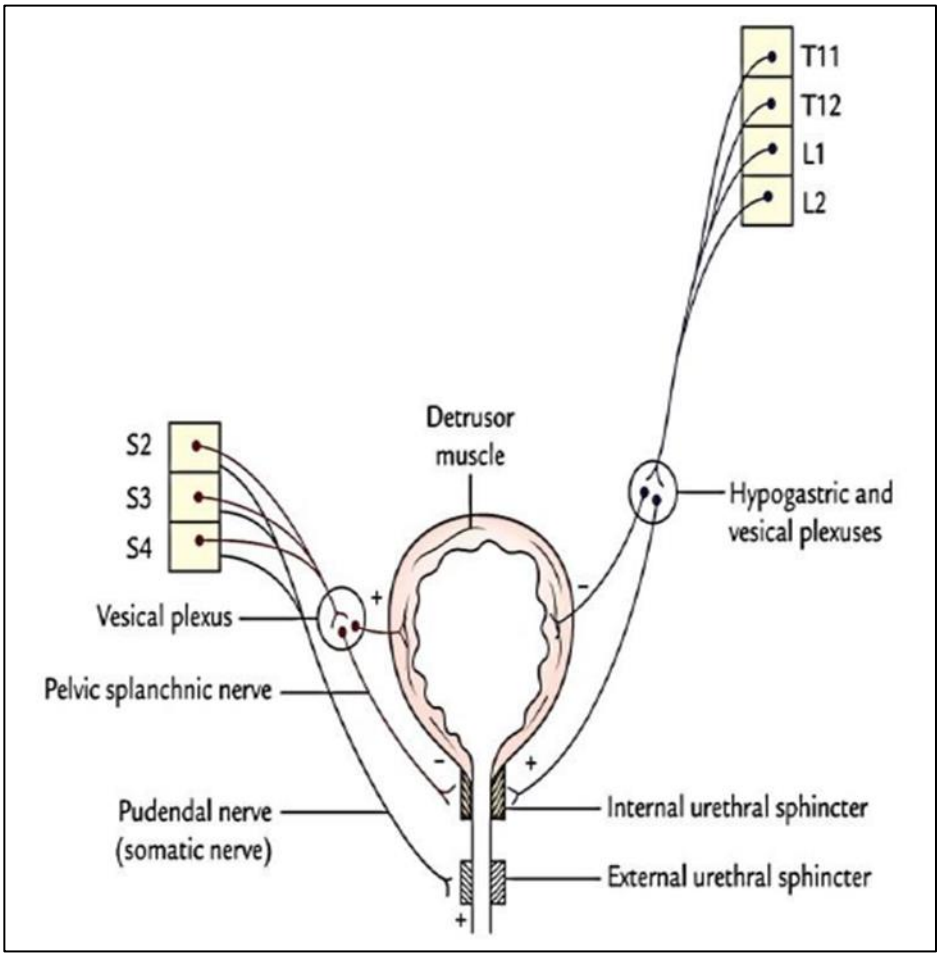


Fig. (19): **nerve supply of the bladder**

URETHRA

Is serves as a passage for urine from the urinary bladder to the exterior, but in male, it also serves as a passage for semen.

Female Urethra

Length: The female urethra is about 3 to 5 cm long.

Extent, course, relations:

- It begins at the internal urethral orifice of the bladder where the detrusor muscle extends longitudinally into the urethra but does not form a significant internal urethral sphincter.
- The female urethra courses through the urogenital diaphragm where it becomes related to the deep transverse perineal muscle and sphincter urethrae muscle (also called external urethral sphincter), both of which are skeletal muscles innervated by the pudendal nerve.
- The posterior surface of the female urethra fuses with the anterior wall of the vagina such that the external urethral sphincter does not completely surround the female urethra. This may explain the high incidences of stress incontinence in women especially after childbirth.
- The female urethra terminates as the navicular fossa at the external urethral orifice which opens into the vestibule of the vagina between the labia minora just below the clitoris.

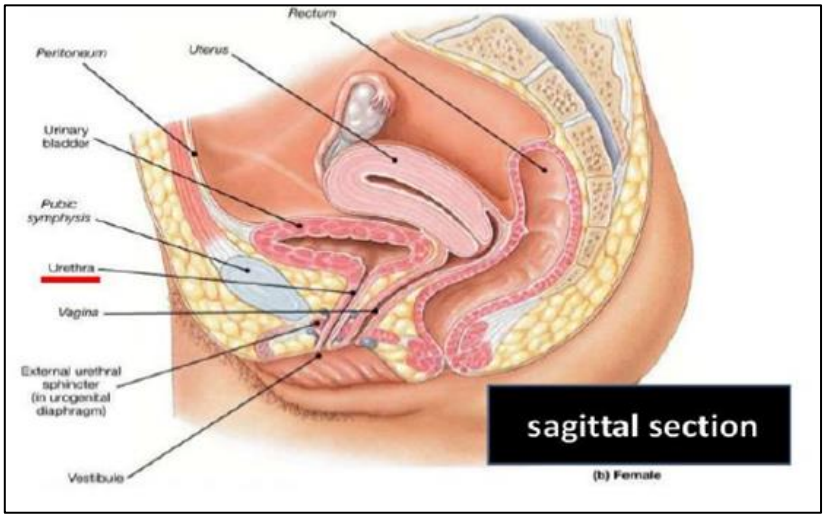


Fig. (20): **female urethra**

B. Male Urethra

Length: is about 18 to 20 cm long

Beginning: it begins at the internal urethral orifice of the bladder where the detrusor muscle extends longitudinally into the prostatic urethra and forms a complete collar around the neck of the bladder called the internal urethral sphincter.

The male urethra is divided into 4 parts.

i. Preprostatic part.

- The preprostatic part of the urethra is about 1cm long.
- Extends from the base of the bladder to the prostate, and is associated with a circular cuff of smooth muscle fibers (the internal urethral sphincter).

ii. Prostatic urethra

- Is the widest part, about 3 cm long.
- The prostatic urethra courses through and is surrounded by the prostate gland.
- The posterior wall has an elevation called the urethral crest.
- The prostatic sinus is a groove on either side of the urethral crest that receives most of the prostatic ducts from the prostate gland.
- At a specific site along the urethral crest there is an ovoid enlargement called the seminal colliculus where the ejaculatory ducts open and the prostatic utricle (a vestigial remnant of the paramesonephric duct in males that is involved in the embryologic development of the vagina and uterus) is found.

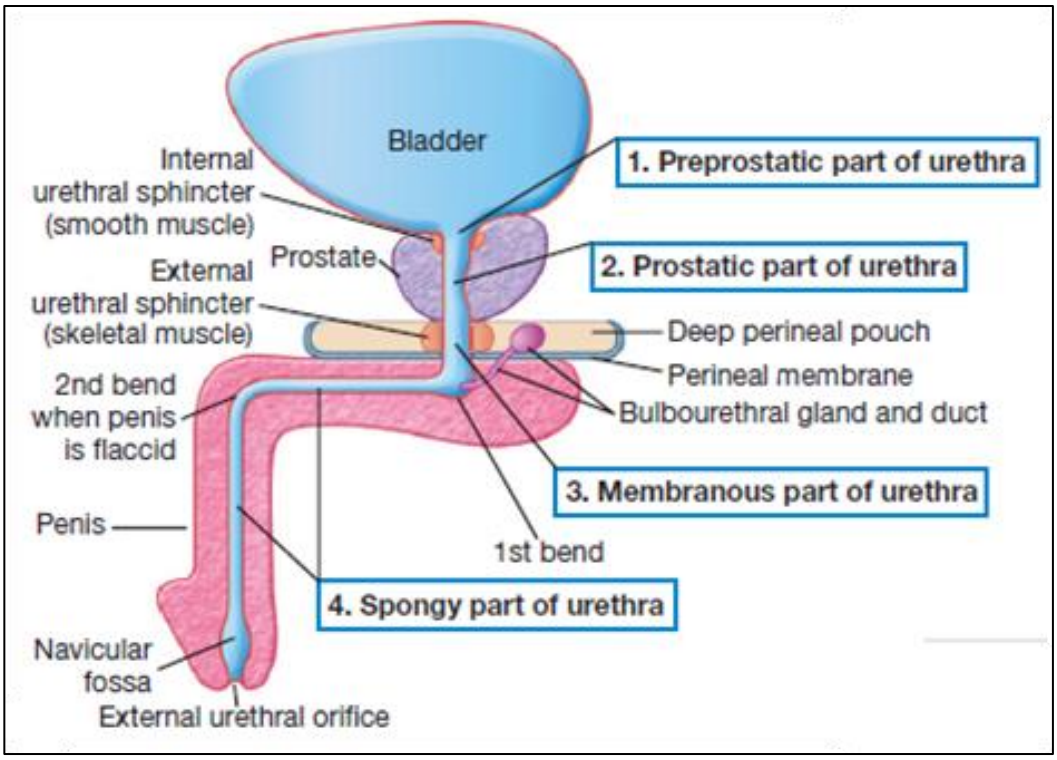


Fig. (21): **male urethra**

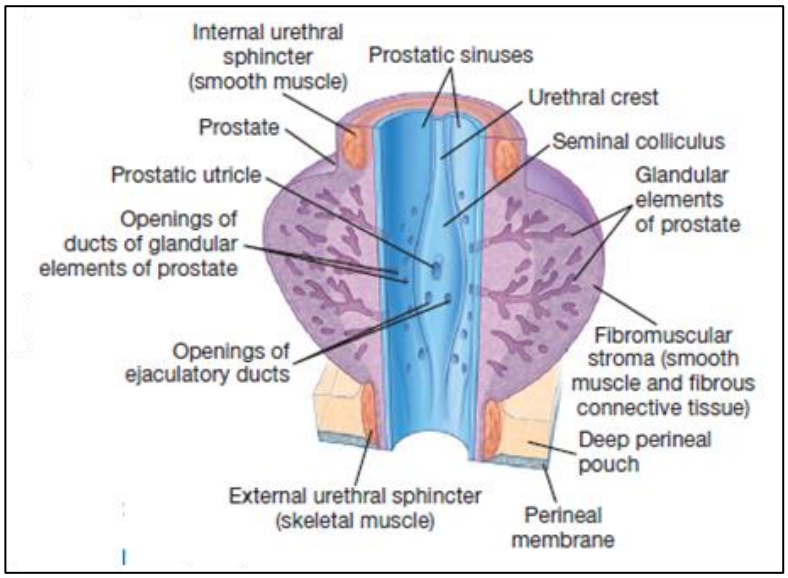


Fig. (22): **prostatic urethra**

iii. Membranous urethra

- Is the shortest part 2 cm in length.
- The membranous urethra courses through the urogenital diaphragm where it becomes related to the deep transverse perineal muscle and sphincter urethrae muscle (also called external urethral sphincter),

both of which are skeletal muscles innervated by the pudendal nerve.

- The external urethral sphincter completely surrounds the male urethra.

vi. Spongy urethra.

- It is 15 cm long.
- The spongy urethra is surrounded by erectile tissue (the **corpus spongiosum**) of the penis. It is enlarged to form a bulb at the base of the penis and again at the end of the penis to form the **navicular fossa.**
- The two bulbourethral glands in the deep perineal pouch are part of the male reproductive system and open into the bulb of the spongy urethra.
- The external urethral orifice is the sagittal slit at the end of the penis.

Sphincters of the urethra

	Internal urethral sphincter	**External urethral sphincter**
Site	Lies in the pelvis around the neck of the bladder and preprostatic part of the urethra	Lies in the perineum surrounds the membernous urethra in the deep perineal pouch
Structures	Formed of smooth muscle fibers	Formed of striated muscle fibers
Functions	• Acts involuntary • Well developed in male • Maintains continence of urine • In male: Contraction of this sphincter prevents retrograde movement of semen into the bladder during ejaculation	• Acts voluntary • Well developed in male and female • Maintains continence of urine

Blood supply:

- Prostatic and membranous parts supplied by inferior vesical, middle rectal and internal pudendal artery,
- Spongy urethra by urethral branches of the bulb from internal pudendal artery.

Lymphatic drainage:

- The prostatic and membranous parts of the urethra drain into the internal iliac lymph node,
- The spongy urethra into superficial inguinal lymph node

Nerve supply

- Prostatic urethra by inferior hypogastric plexus
- Membranous and spongy by perineal nerve
- Internal urethral sphincter by autonomic nerves
- External urethral sphincter by perineal nerve

Development of the kidney

- It develops from the intermediate mesoderm.
- Three successive kidneys are formed during intrauterine life.
- These are: Pronephros, mesonephros and metanephros or permanent kidney.

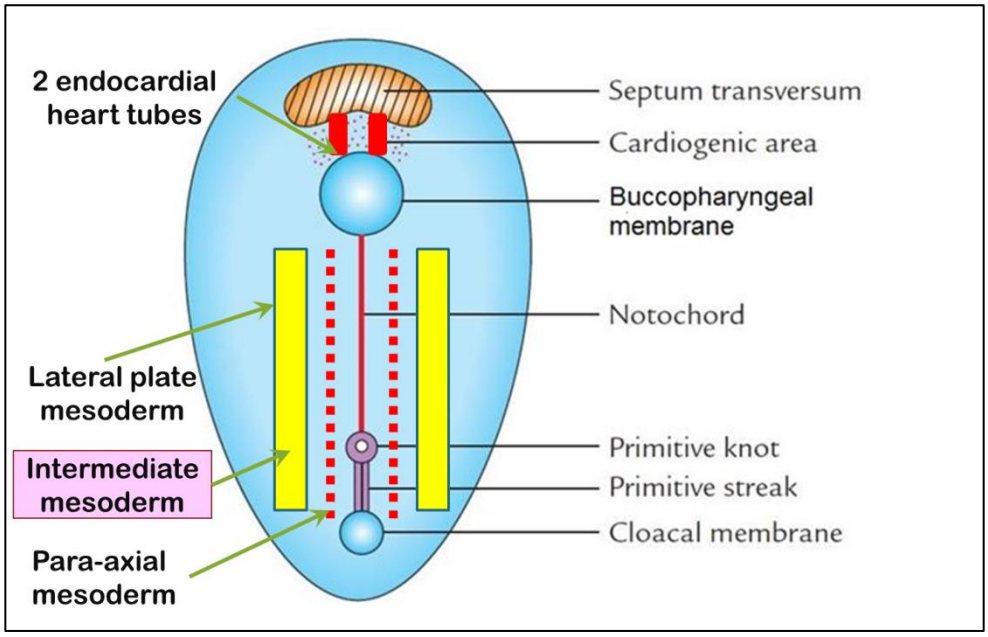


Fig. (23): **showing the intermediate mesoderm.**

A- Pronephros

It is the 1st kidney to appear at the beginning of the 4th week.

- **Site:** in the cervical region
- **Structure:** 7 to 10 solid masses known as nephrotomes that has
  - ***Medial end:*** Connected with the coelomic cavity and have internal & external glomeruli
  - ***Lateral end:*** unite with the others to form the pronephric duct.
- **Pronephric duct:** extends downwards to open into the cloaca.
- These nephrotomes regress before more caudal ones are formed.
- **Fate*:*** By the end of the 4th week,
  - ***Pronephric tubules:*** degenerate completely.

Pronephric duct: persists & forms mesonephric duct for the developing mesonephros

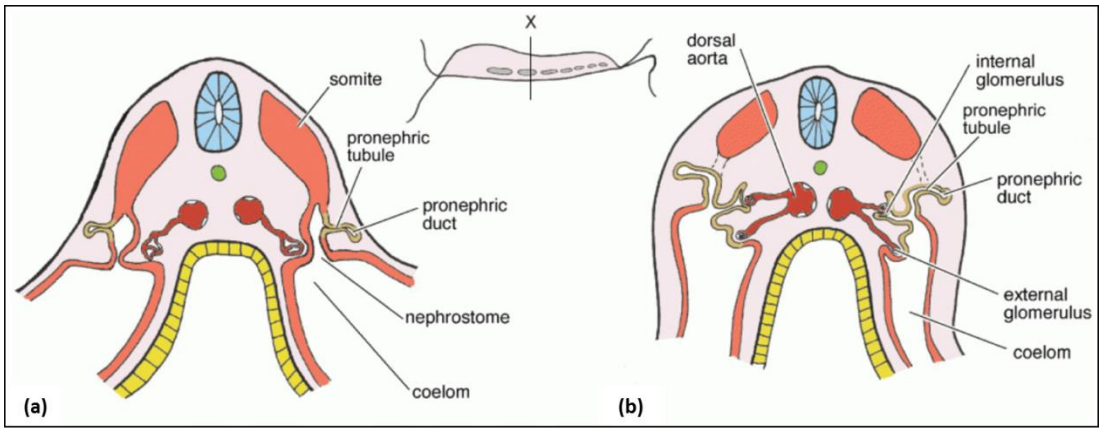


Fig. (24): **Cross-section, at the level indicated, through an early embryo, (a) and an embryo at a later stage of development, (b) showing formation of a pronephric duct and an internal and external glomerulus.**

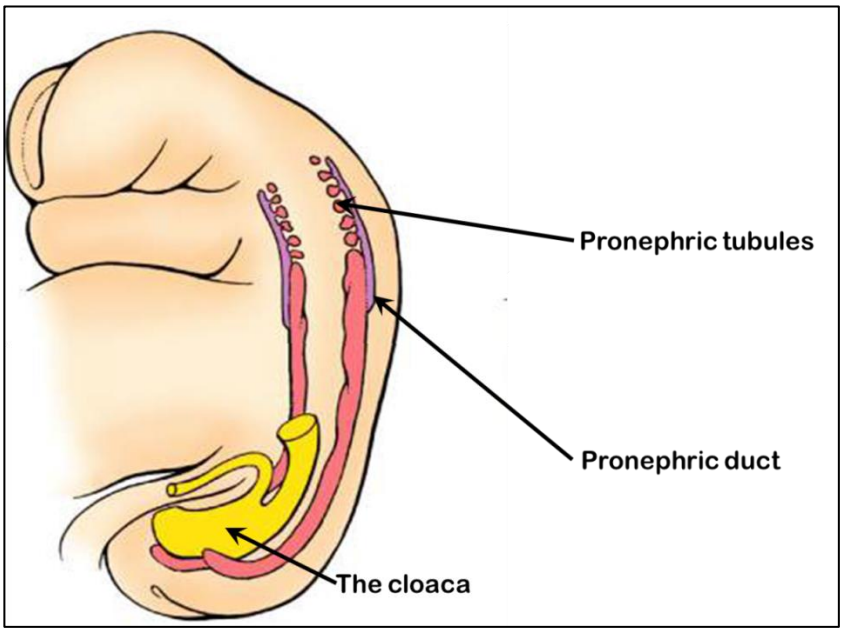


Fig. (25): **showing the pronephric kidney**

B- Mesonephros

- It is the 2nd kidney to appear.
- **Site:** the thoracic and upper lumbar regions.
- **Structure:** The mesoderm of the intermediate cell mass gives rise to 70-80 mesonephric tubules.

Each tubule elongates forming an S-shaped loop which acquires a glomerulus at its medial end forming a Bowman's capsule.

- Laterally, the tubules join a collecting duct known as mesonephric or Wolffian duct.

- In the middle of the 2nd month, the mesonephros forms a large ovoid organ on each side of midline. Since the gonad develops on its side the ridge formed called urogenital ridge.

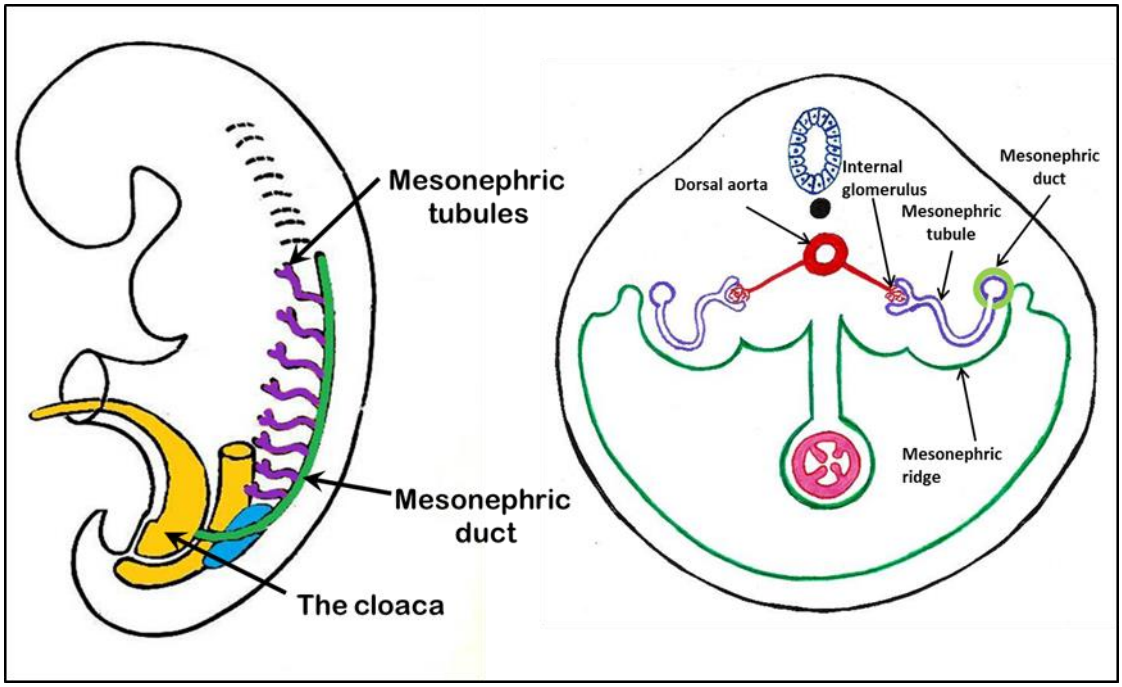


Fig (26): **showing development of the mesonephric kidney.**

- ***Fate:*** differ in male and female

	Male	**Female**
Mesonephric tubules	• Vasa efferentia • Head of epididymis. • Paradidymis	• Epoophron • Paroophron
Mesonephric duct	• Appendix of epididymis • Body & tail of epididymis. • Vas deferens • Seminal vesicle & ejaculatory duct.	• Gardener's duct.
	Ureteric bud & trigone of urinary bladder	

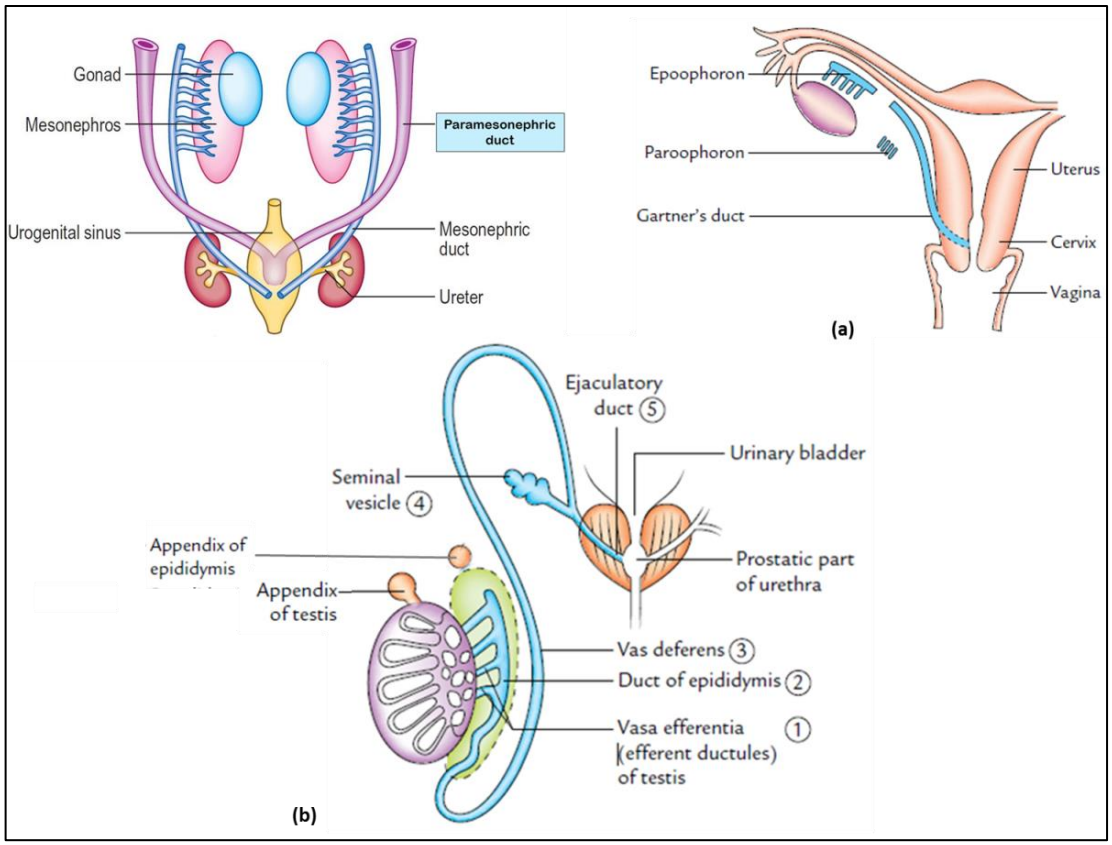


Fig. (27): **fate of mesonephric kidney in (a) female and (b) male.**

C- Metanephros

- It is the 3rd or permanent kidney; it appears in the 5th month.
- **Site:** lower lumbar and sacral regions of the intermediate cell mass.
- **Structure:** It develops from 2 sources:

1- ***The collecting system:*** develops from the ureteric bud.

- The bud arises as an outgrowth from the mesonephric duct close to its entrance to the cloaca.
- The cranial end of the bud grows up and penetrates the metanephric tissue, which forms a cap over its distal end.
- Then, the cranial end dilates forming the primitive renal pelvis and the rest of the bud elongates forming the ureter.
- The pelvis divides continuously into several generations of divisions, up to 12 or more generations, penetrating metanephric tissue forming the major calyces, minor calyces and collecting tubules.

2- Excretory system: develops from the metanephric cap.

- The metanephros becomes segmented repeatedly by the branching ureteric bud.
- Each newly formed collecting tubule becomes covered by a metanephric tissue cap.
- Cells of the tissue cap form small vesicles, renal vesicles, which give rise to S-shaped tubules that form the nephrons.

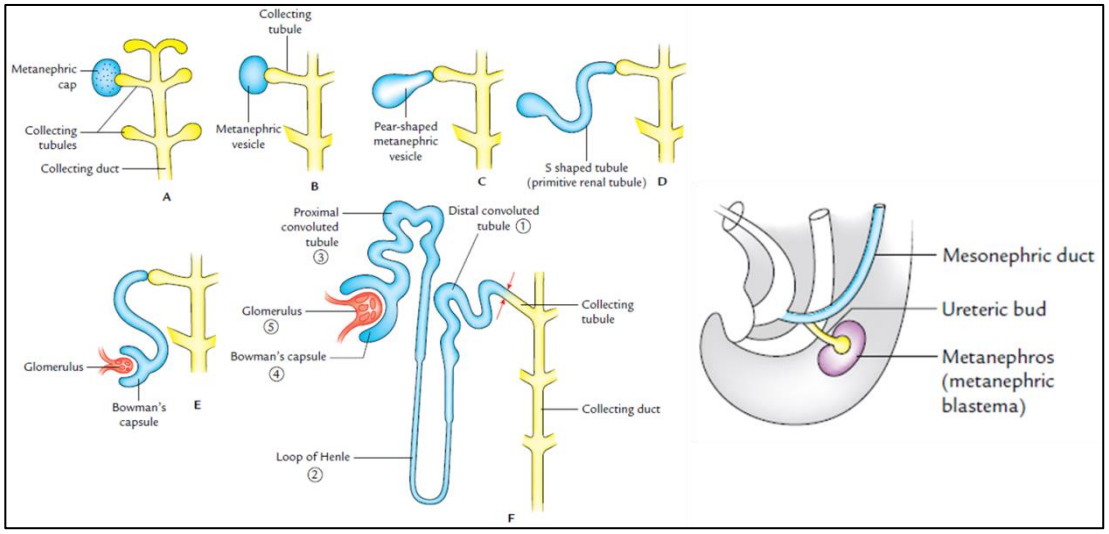


Fig. (28): **Stages of development of nephron. Arrows (red) indicate the place where excretory unit (blue) establishes a communication with the collecting system (yellow).**

Changes of the metanephros during Growth

1) Changes in shape: At first the kidney is lobulated, then becomes smooth at the end of 1st year of infancy

2) Ascent of the kidney:

Initially, the kidneys lie close to each other's in front of sacrum.

Later, the kidneys move upward to the abdomen at the 9th week

3) Change in the direction:

Initially the hilum of the kidney faces ***ventrally.***

As the kidney ascends it ***rotates medially 90°.***

4) **Change in the blood supply:** As it ascends it changes its blood supply:

At 1st from the common iliac artery and finally from abdominal aorta.

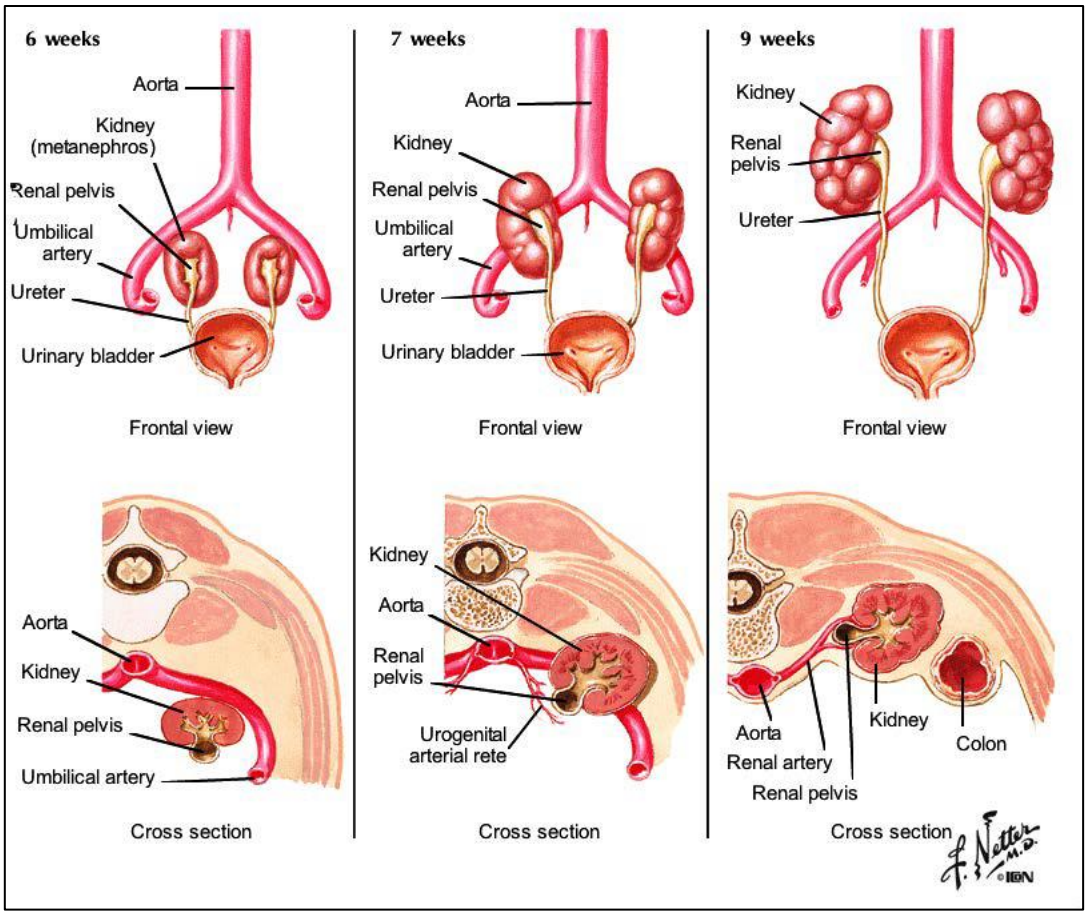


Fig. (29): **changes of the metanephros during Growth**

Congenital anomalies of the kidney

1- **Renal agenesis:** unilateral or bilateral absence of kidney.

Cause: non development or degeneration of the ureteric bud or non-contact between ureteric bud and metanephric mesoderm.

Features:

Unilateral agenesis: is common and the other kidney can perform the function.

Bilateral agenesis: incompatible with postnatal life.

2- Ectopic kidney: one kidney may fail to ascend & remains in the pelvis. The ectopic kidney usually locates at the pelvis & sometimes lies in the lower part of abdomen.

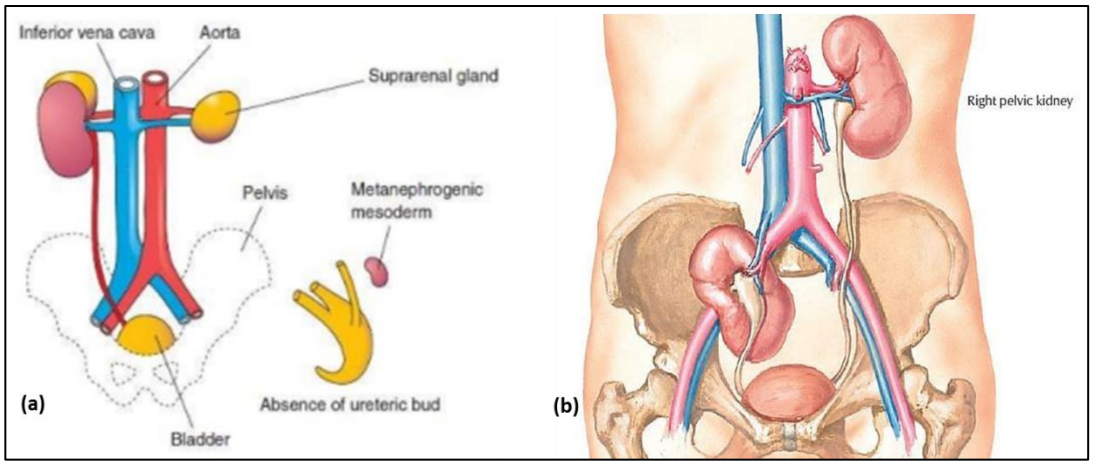


Fig. (30):showing (a) left renal agenesis (b) right pelvic kidney (ectopic)

3- Horse-shoe kidney: is due to fusion of the lower poles of the 2 kidneys across the midline.

It is located in front of the lower lumbar vertebrae as the normal ascent is prevented by the IMA.

4- Congenital polycystic kidney: caused by failure of union between some collecting and excretory tubules.

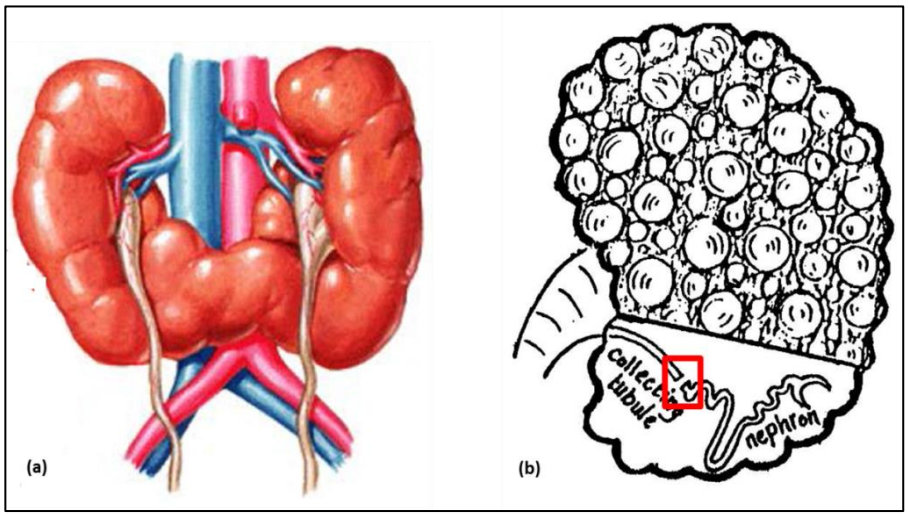


Fig. (31):showing (a) horse-shoe kidney (b) congenital polycystic kidney

5- Supernumerary kidney: It results from formation of two ureteric buds.

6- Mal-rotated kidney: The hilum of the kidney may:

- Faces anteriorly in non-rotated kidney
- Faces posteriorly in excessive rotation.
- Faces laterally if the rotation occurs laterally instead of medially.

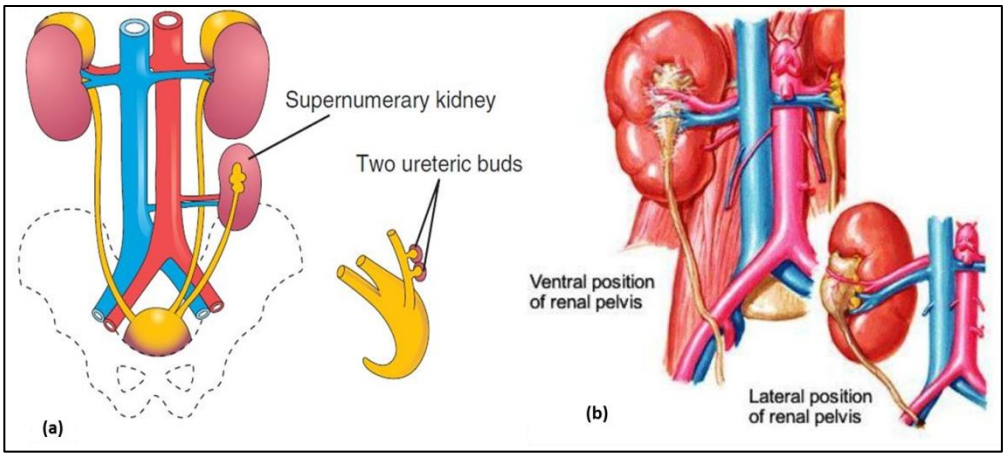
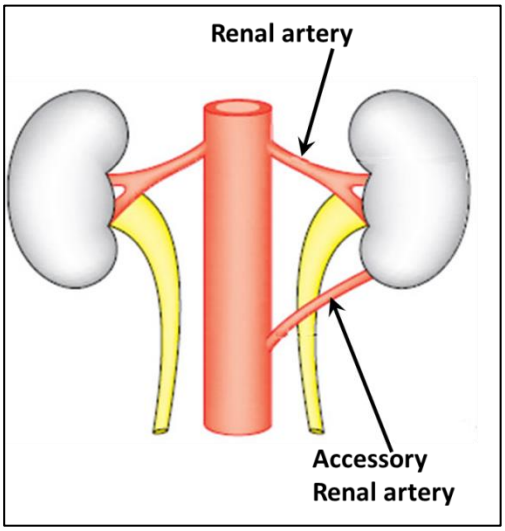


Fig. (32): **showing (a) supernumerary kidney (b) mal-rotated kidney**

7- Accessory renal arteries:



- Very common and 25% of kidneys have 2 or more arteries (surgical important)
- Accessory artery at upper pole may arise from suprarenal arteries
- Accessory artery at lower pole may compress the ureter
- Some lower arteries represent undegenerated embryonic arteries.

Development of the ureter

- It develops from the ureteric bud which arises from the mesonephric duct.
- The caudal part of the mesonephric duct (below the ureteric bud) is absorbed into the ventral part of the cloaca to form the trigone of the urinary bladder.
- As the result, the 2 ureteric buds and the 2 mesonephric ducts open separately into the urinary bladder.
- As the result of ascent of the kidneys, the ureters elongate.

Congenital anomalies of the ureter

1- Double pelvis & double ureter: abnormal division of ureteric bud

- Incomplete division: divided pelvis & ureter
- Complete division: double ureter.

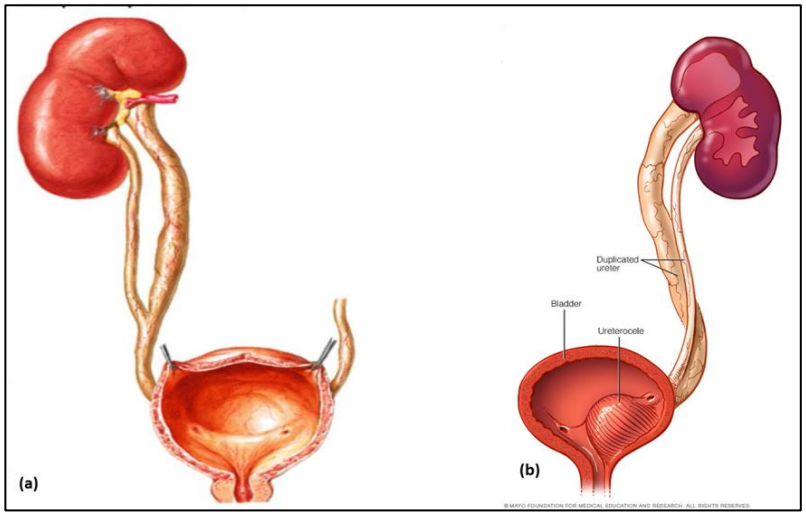


Fig. (33): showing (a) bifid pelvis and ureter (b) double pelvis & ureter

2- Ectopic ureter: open anywhere except in the urinary bladder

3- Congenital ureteric stenosis: failure of proper canalization of ureter.

- Associated with hydronephrosis & hydroureter proximal to the obstruction
- Need early management to avoid renal failure especially in bilateral cases

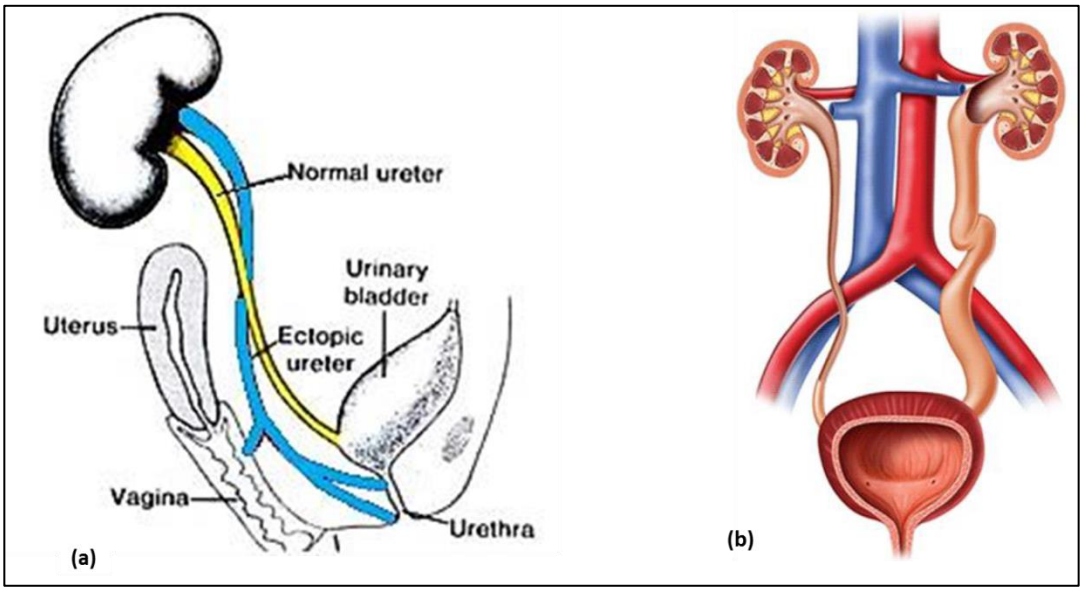


Fig. (34): **showing (a) ectopic ureter (b) congenital ureteric stenosis**

Development of the urinary bladder

It is derived from 2 sources:

1- The endoderm part of the cloaca:

The cloaca is divided by the urorectal septum into 2 parts:

A- The primitive urogenital sinus: is the ventral part and closed caudally by the urogenital membrane.

B- The anorectal canal: that is closed caudally by the anal membrane.

The primitive urogenital sinus is connected to the mesonephric ducts and the allantois which extends to the umbilicus.It differentiates into 3 portions:

a- The vesical (vesico-urethral canal) portion: the cranial largest part

- Its apex is connected to the allantois.
- *In male*: it gives the epithelium of most of the urinary bladder and part of the prostatic urethera.
- *In female*: it gives the epithelium of most of the urinary bladder and the whole urethera.

○ The intraembryonic part of the allantois constricts forming the urachus; a fibrous cord that connects the apex of the bladder with the umbilicus. In adults, the urachus forms the median umbilical ligament.

b- Definitive urogenital sinus: it is subdivided into pelvic and phallic parts.

Pelvic portion: the middle narrow part. The mesonephric ducts are attached between the vesical and pelvic portions.

Phallic portion: the caudal part which is closed by the urogenital membrane.

2- The mesoderm of the lower part of the mesonephric ducts:

- The caudal ends of the mesonephric ducts below the ureteric buds are absorbed forming the trigone of the urinary bladder.
- As the kidneys ascend, the ureteric orifices are dragged craniolaterally while the mesonephric ducts remain at a lower level.

N.B.

- The rest of the bladder wall is derived from the surrounding splanchnic mesoderm.
- At birth, the urinary bladder is an abdominal organ. It becomes a pelvic organ at puberty.
- As the trigone of the bladder develops from the mesonephric ducts, it is mesodermal.

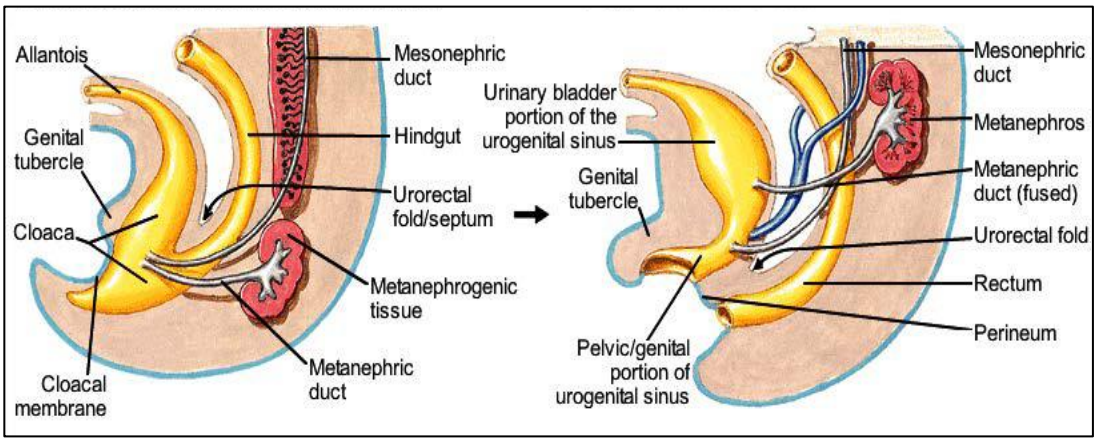


Fig. (35): **showing division of the cloaca.**

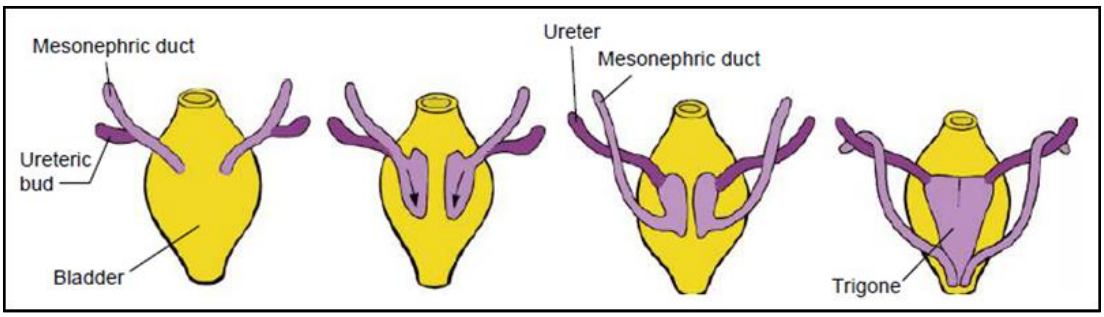


Fig. (36): **showing formation of the trigon of the urinary bladder**

Congenital anomalies of the urinary bladder

1- Uro-rectal fistula: Malformation of the *urorectal* septum can lead to several different types of *fistula*

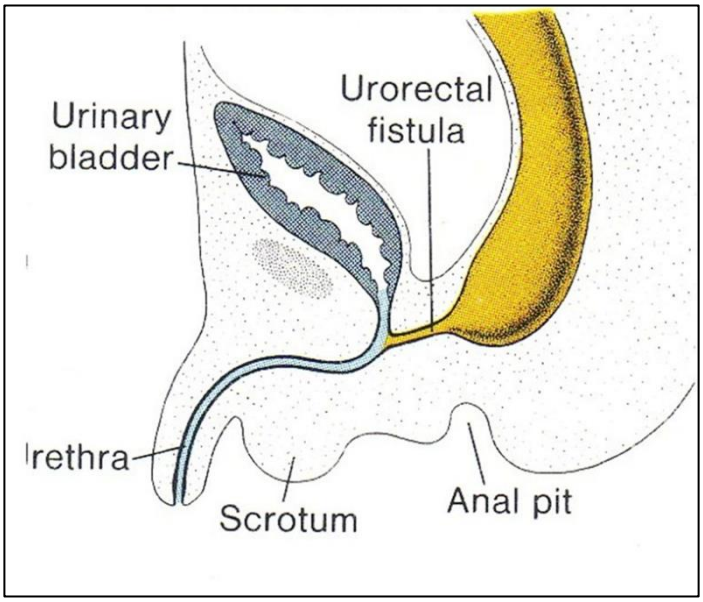


Fig. (37): **uro-rectal fistula**.

2) **Persistence of a patent urachus:**

- ***Urachal fistula:*** persistence of the whole urachus patent.
- ***Urachal sinus:*** persistence of the distal part.
- ***Urachal diverticulum:*** persistent proximal part of urachus
- ***Urachal cyst:*** persistence of an isolated segment of the urachus patent.

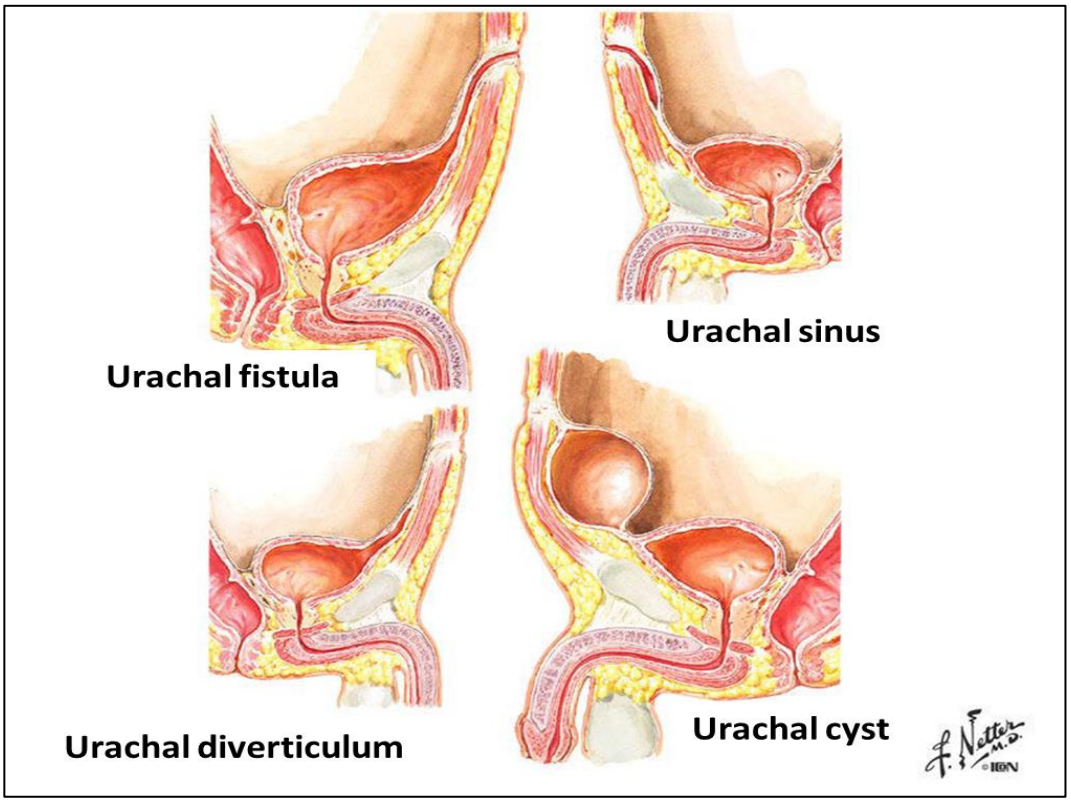


Fig. (38): **showing anomalies of the urachus.**

3) **Ectopia vesicae (Exstrophy of the bladder):**

- Ventral body wall defect in which the bladder mucosa is exposed
- Due to defectiveformation of the infraumbilical part of the anterior abdominal wall, usually associated with epispadius.

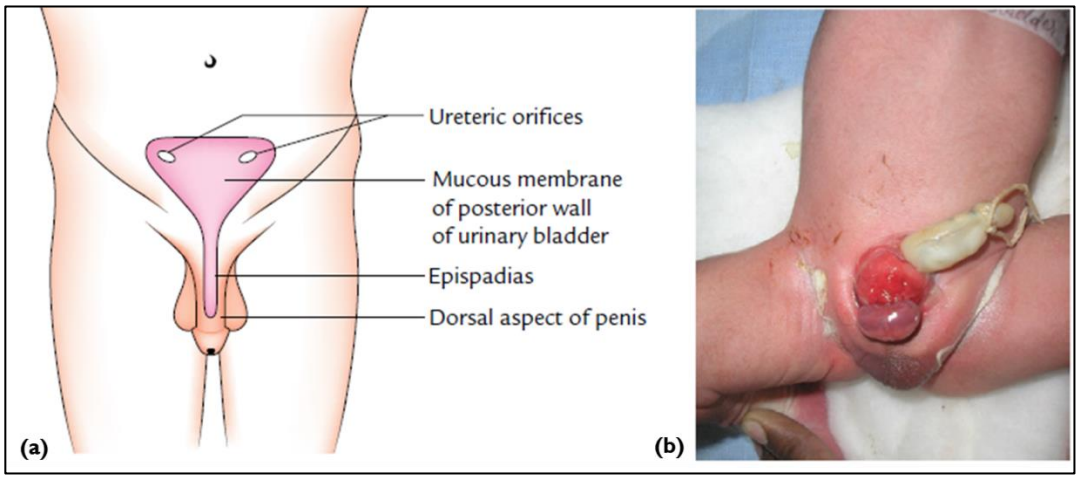


Fig. (39): **ectopia vesicae. (a) Line diagram. (b) Actual clinical photograph.**

Development of the urethra

Urethra	Embryonic source of development
Female urethra	• Caudal part of vesicourethral canal **except** its dorsal wall that is mesodermal in origin, derived from absorption of mesonephric ducts.
Male urethra ***1. Prostatic part*** (a) Above the level of opening of ejaculatory ducts (colliculus seminalis) (b) Below the level of openings of ejaculatory ducts	• Caudal part of vesicourethral canal **except** its dorsal wall that is mesodermal in origin, derived from absorption of mesonephric ducts. • Pelvic part of definitive urogenital sinus
2. Membranous part	• Pelvic part of definitive urogenital sinus
3. Penile part	• Phallic part of definitive urogenital sinus
4. Terminal part (which occupies the glans penis)	• Surface ectoderm

N.B. Only the lining epithelium of the urethra is derived from endoderm of urogenital sinus. Connective tissues and smooth muscles of urethra are derived from surrounding splanchnopleuric layer of intraembryonic mesoderm.

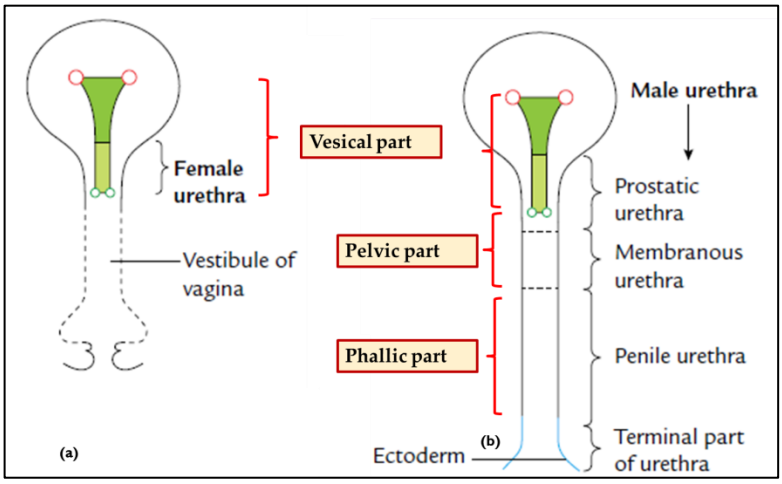


Fig. (40): **Development of the urethra. (a) Female urethra. (b) Male urethra.**

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