# EMBRYOLOGY OF URINARY SYSTEM

Dr Shahab

# Urogenital System

**Embryologically and Anatomically urinary system and genital system are intimately interwoven.**

- **Both develop from** a common mesodermal ridge (**intermediate mesoderm)** **along** the posterior wall of the abdominal cavity,
- Initially the excretory ducts of both systems enter a common cavity, **the cloaca.**

# Urinary System

## KIDNEY SYSTEMS

1. **Pronephros, (rudimentary and nonfunctional).**
2. **Mesonephros, (function for a short time during the early fetal period).**
3. **Metanephros, (forms the permanent kidney)**

# Pronephros

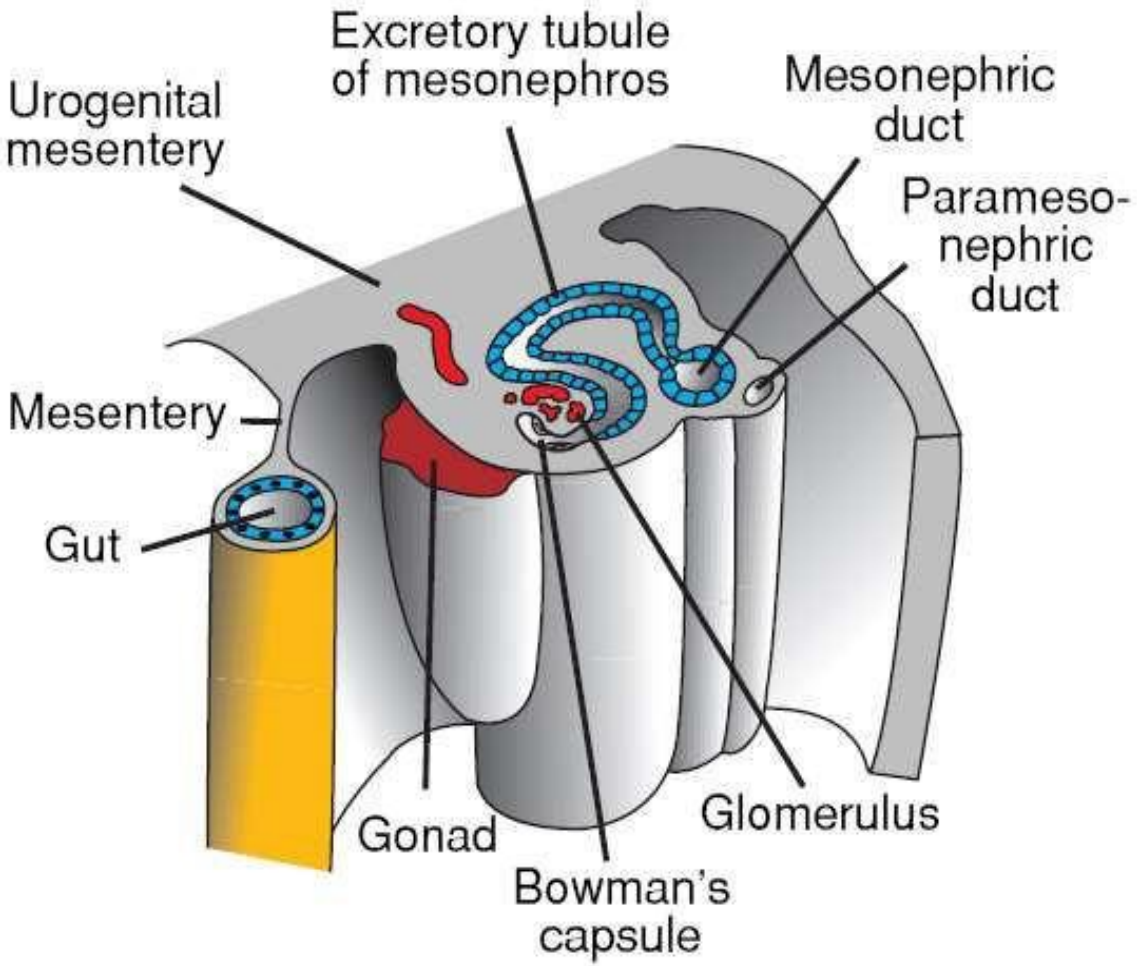
**Fourth week**

**7 to 10 solid cell groups** ……cervical region.

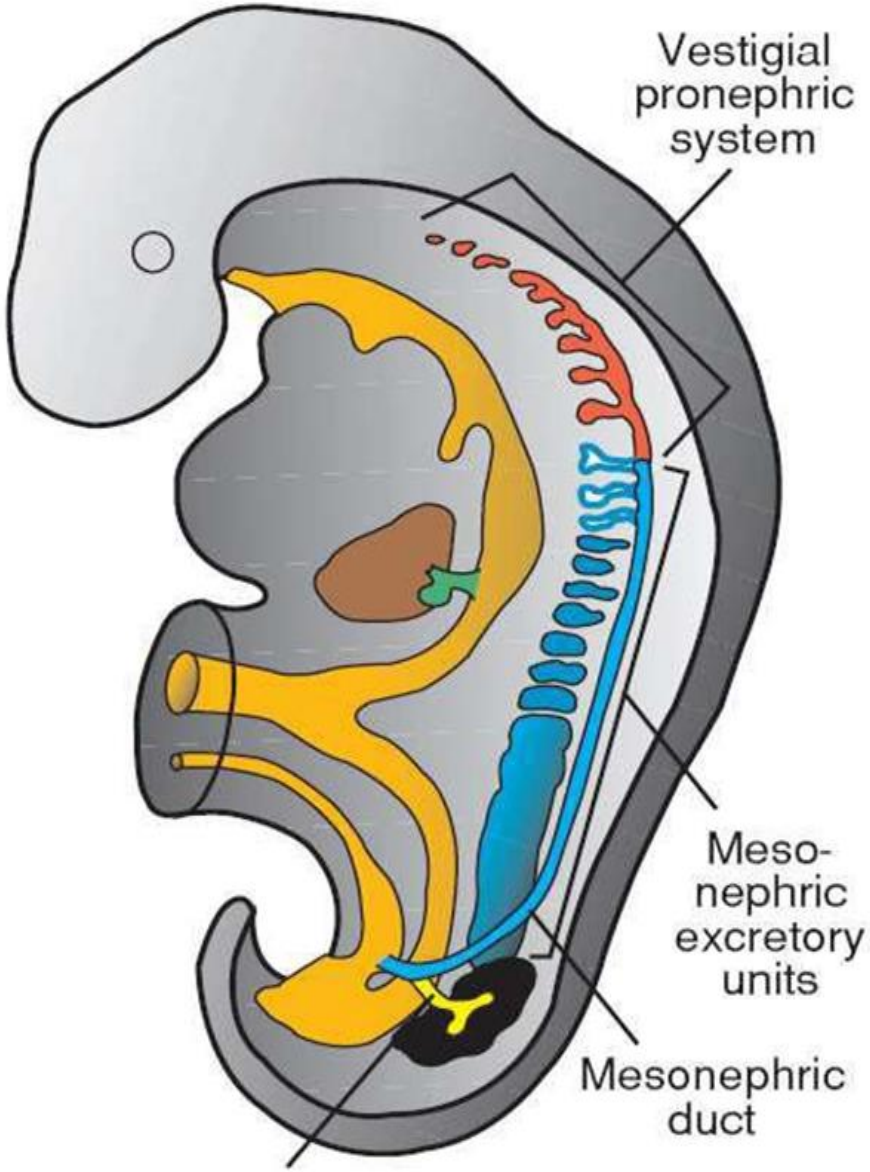
- vestigial excretory units, **nephrotomes**
- **By the end** of the **fourth week**, all indications of the pronephric system have **disappeared**.

# Mesonephros

- Derived from intermediate mesoderm from upper thoracic to upper lumbar (L3) segments.
- Early in the fourth week, the first excretory tubules of the mesonephros appear.
- They lengthen rapidly, form an S-shaped loop, and acquire a tuft of capillaries that will form a glomerulus at their medial extremity.
- *Around the* glomerulus the tubules form **Bowman's capsule, and together these structures** constitute a **renal corpuscle.**
- **Laterally the tubule enters the longitudinal** collecting duct known as the **mesonephric or wolffian duct**.




**Excretory tubules of the pronephric and mesonephric systems in a 5-week-old embryo.**




Ureteric bud

# Mesonephros

- In the middle of the second month **The cranial** tubules and glomeruli show degenerative changes, and by the end of the second month the majority have disappeared.
- **In the male a few of the caudal tubules and the mesonephric duct persist and participate in formation of the genital system, but they disappear in the female.**

# Metanephros

## The Definitive Kidney

2 sources

(1)The ureteric bud (metanephric diverticulum)

(2)The metanephrogenic blastema

•fifth week.

•**ureteric bud starts as out pouching from caudal part of mesonephric duct**

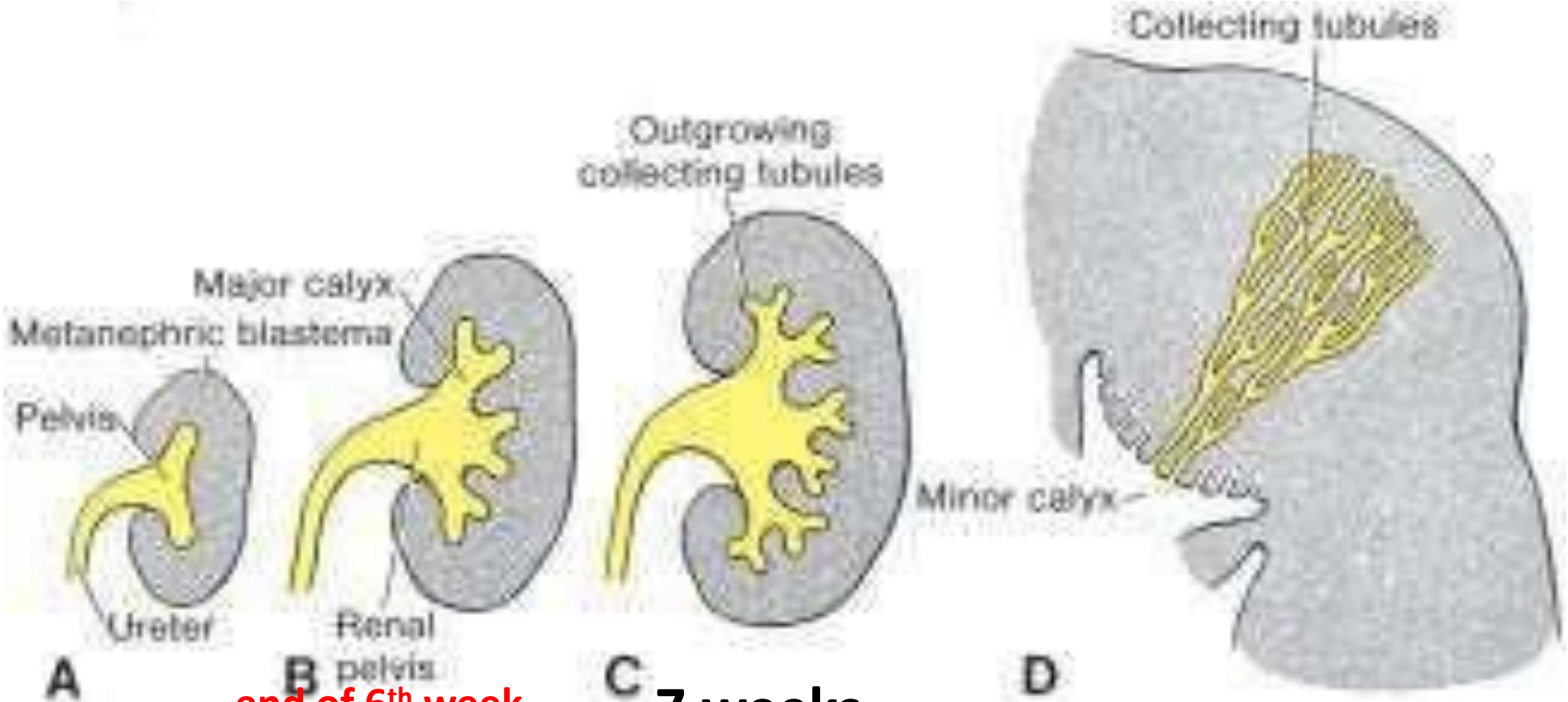
•**The bud penetrates** the metanephric tissue.

•These **buds continue to subdivide until 12 or more generations of tubules have formed.**

•The first four generations of tubules enlarge and become confluent to form the **major calyces**, and the second four generations coalesce to form the **minor calyces**.

•Collecting tubules of the fifth and successive generations form the

**renal pyramid.**



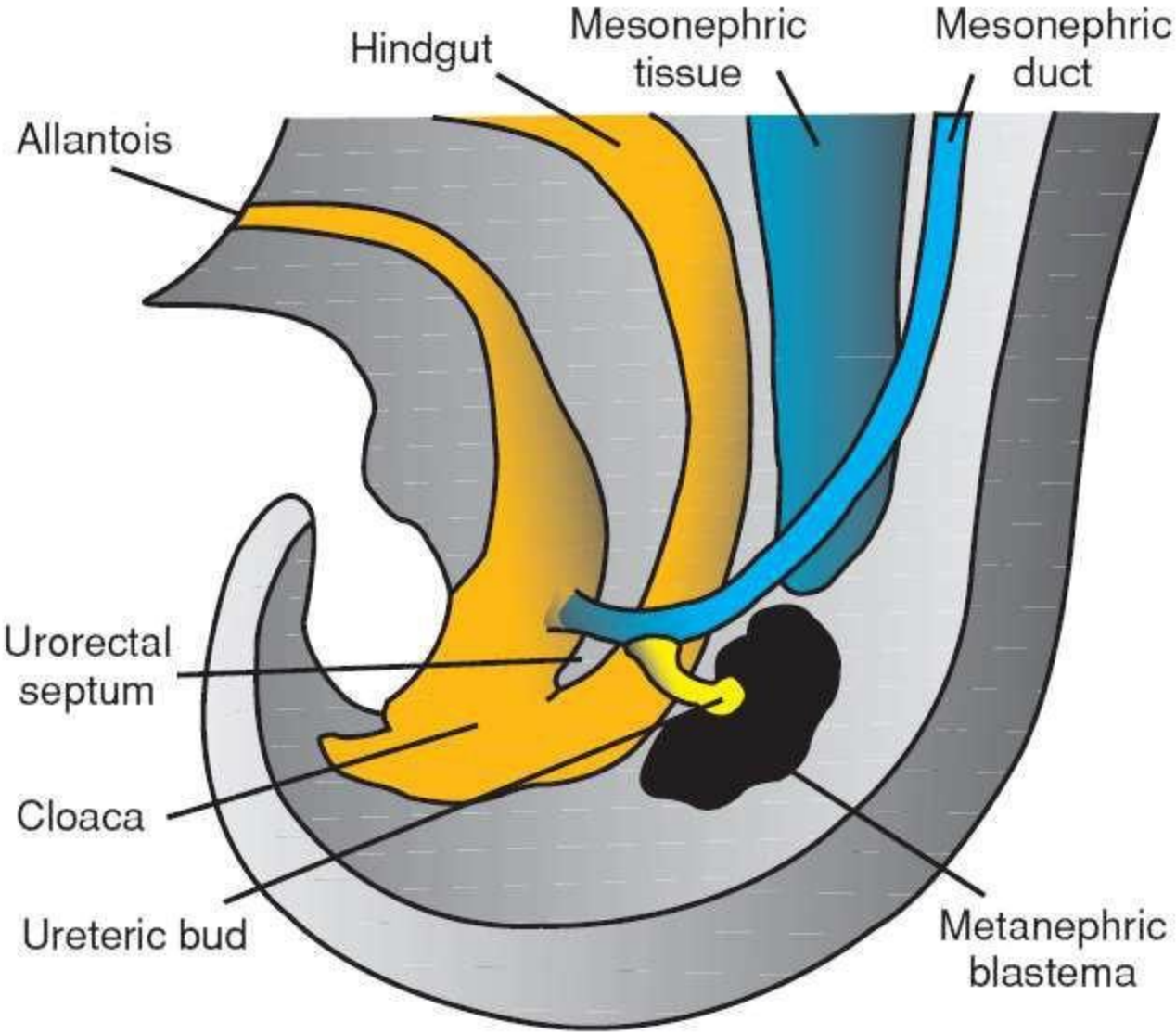

6 weeks

end of 6th week

7 weeks

Newborn

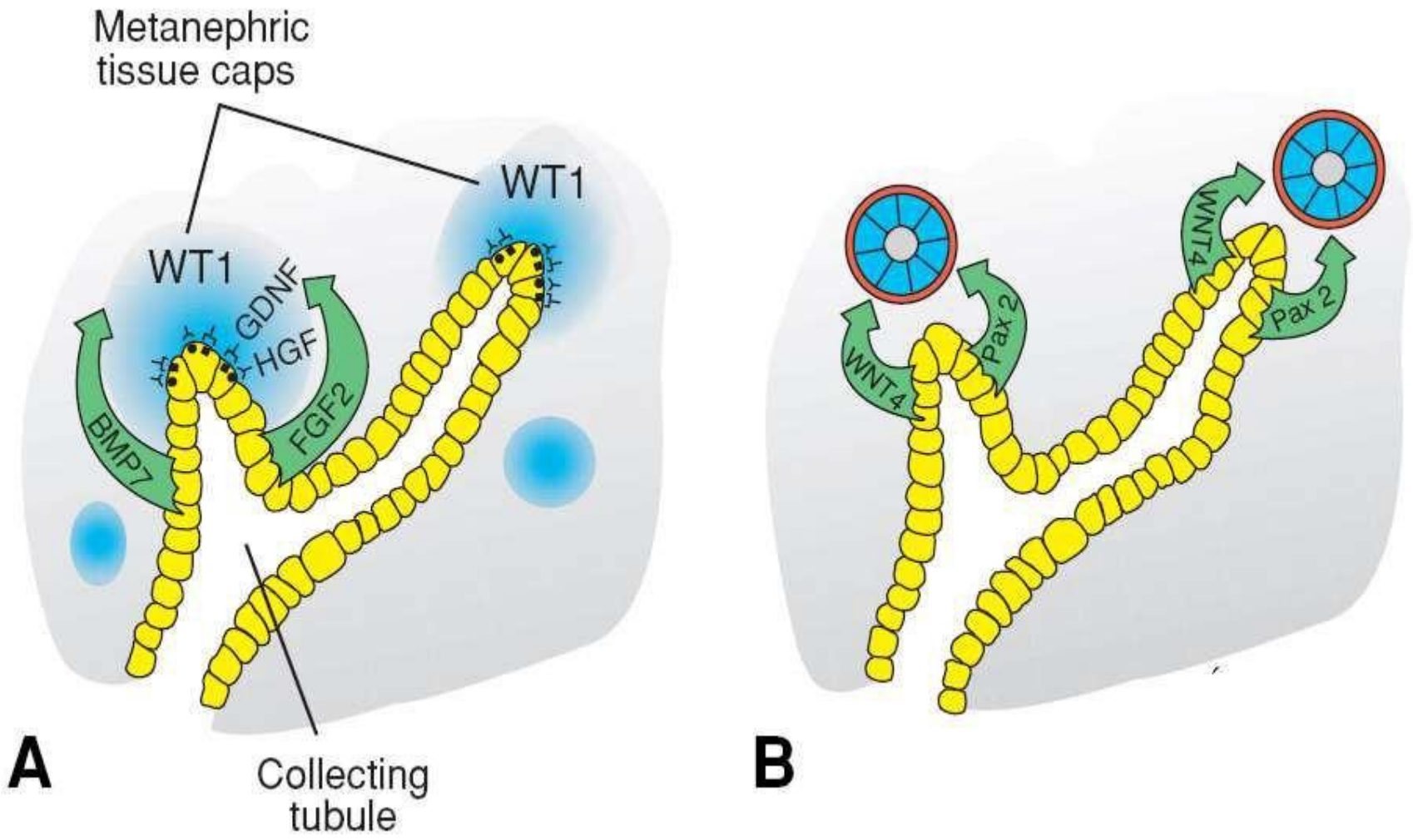
**Relation of the hindgut and cloaca at the end of the 5th week.**




**The ureteric bud penetrates the metanephric mesoderm (blastema).**

# Excretory System

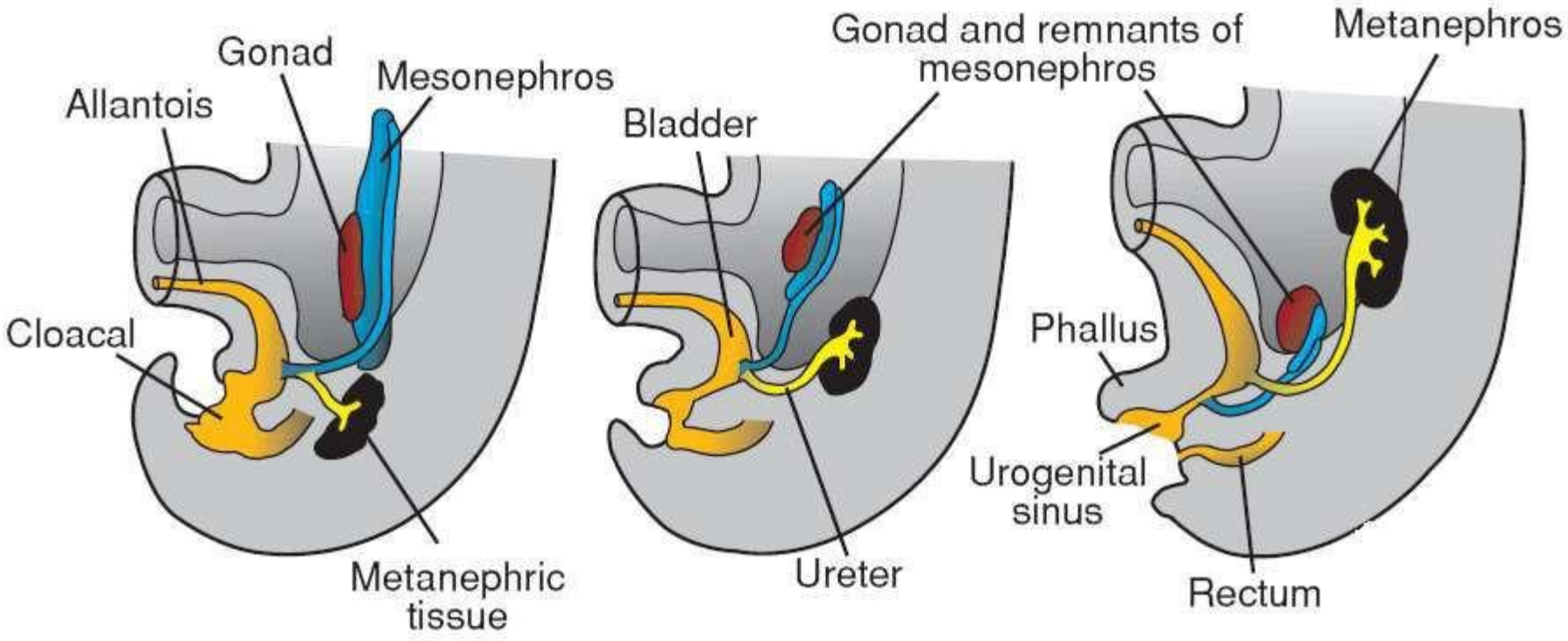
- **Each newly formed collecting tubule is covered at its distal** end by a **metanephric tissue cap.**
- Cells of the tissue cap form small vesicles, the ***renal vesicles*****,**
- **Renal vesicles** give rise to small S-shaped tubules.
- *Capillaries grow* into the pocket at one end of the S and differentiate into **glomeruli.**
- **These** tubules, together with their glomeruli, form **nephrons, or excretory units.**
- **The** proximal end of each nephron forms **Bowman's capsule.**
- The distal end *forms an open* connection with one of the collecting tubules, establishing a passageway from Bowman's capsule to the collecting unit. Continuous lengthening of the excretory tubule results in formation of the **proximal convoluted tubule, loop of Henle, and distal convoluted tubule.**




# Genes involved in differentiation of the kidney

# POSITION OF THE KIDNEY

- The kidney, initially in the pelvic region,
- later shifts to a more cranial position in the abdomen.
- This **ascent of the kidney is caused by diminution of** body curvature and by growth of the body in the lumbar and sacral regions.
- **In the pelvis** the metanephros receives its arterial supply from common iliac arteries.
- **During its ascent** to the abdominal level, it is vascularized by arteries that **originate from the aorta at continuously higher levels.**
- **The lower vessels** **usually** **degenerate**, **but** some may remain.




# Ascent of the kidneys

# FUNCTION OF THE KIDNEY

- The definitive kidney formed from the metanephros becomes **functional near the 12th week.**
- **Urine** is passed into the amniotic cavity and **mixes** with the amniotic fluid.
- The **fluid is swallowed** by the fetus and recycled through the kidneys.
- **During fetal life**, the kidneys are **not responsible for excretion** of waste products,
- **The placenta serves this function.**

# BLADDER AND URETHRA 1/2

- **the fourth to seventh weeks** of development the **cloaca divides into** the **urogenital sinus anteriorly and the anal canal posteriorly**.
- The **urorectal septum is a layer of mesoderm between the** primitive anal canal and the urogenital sinus.
- **The tip of the septum will form the perineal body.**
- **Three portions of the urogenital sinus** can be distinguished:
  1. The **urinary bladder ,** (the upper and largest part).
  2. The **pelvic part of the urogenital sinus,** (narrow canal)
  3. The **phallic part of the urogenital sinus,**(flattened from side to side).

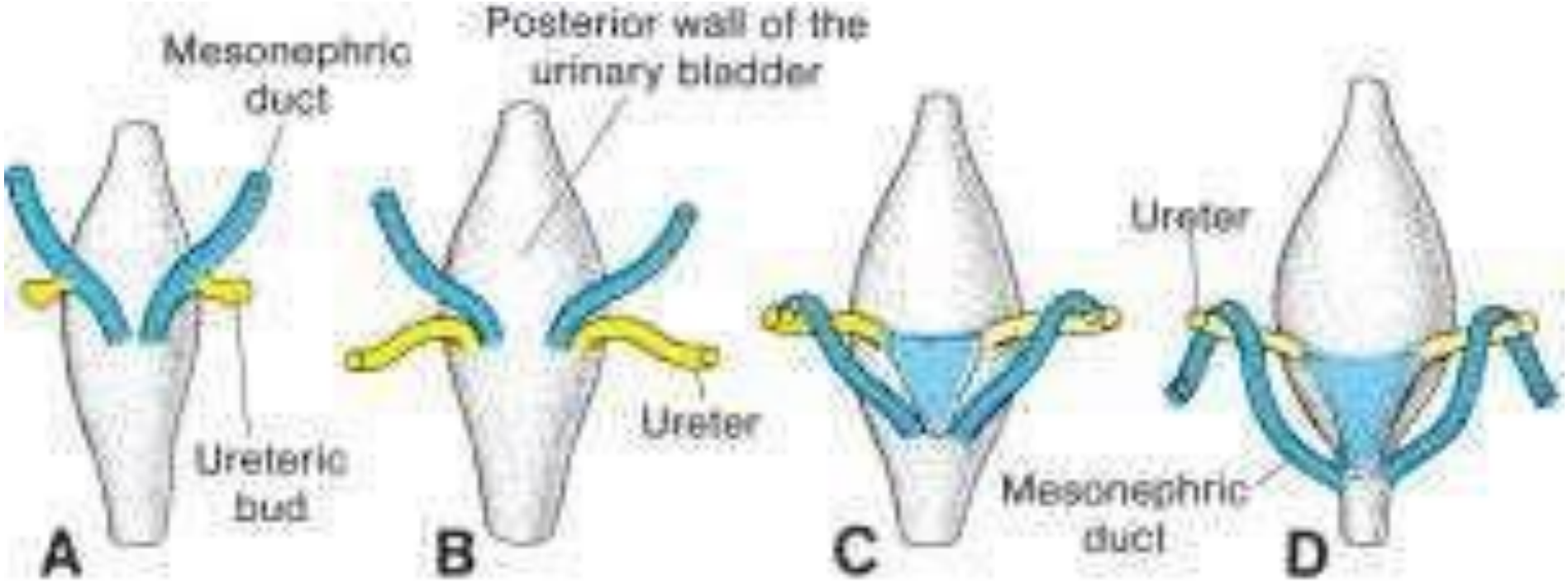
# BLADDER AND URETHRA 2/2

- Initially the bladder is continuous with the allantois,
- **but** when the lumen of the allantois is obliterated, the **urachus, remains and connects** the apex of the bladder with the umbilicus.
- **In the adult**, it is known as the **median umbilical ligament.**

- the **pelvic part ,**
  - **In the male gives** rise to the **prostatic and membranous parts of the urethra. And whole of urethra in females.**
- the **phallic part of the urogenital sinus.**
  - **It is flattened from side to side, and contributes in formation of genital system.**

# During Differentiation of the Cloaca

- The caudal portions of the mesonephric ducts are absorbed into the wall of the urinary bladder.
- **The ureters enter the bladder separately.**
- *As a result of ascent of the kidneys, the* orifices of the ureters move farther cranially;
- **The mesonephric ducts move close together to enter the prostatic urethra and in the male become the ejaculatory ducts.**
- The mucosa of the bladder formed by incorporation of the ducts (the **trigone of the bladder) is also mesodermal.**
- **With time** the mesodermal lining of the trigone is replaced by endodermal epithelium, **so that finally the inside of the bladder is completely lined with endodermal epithelium.**



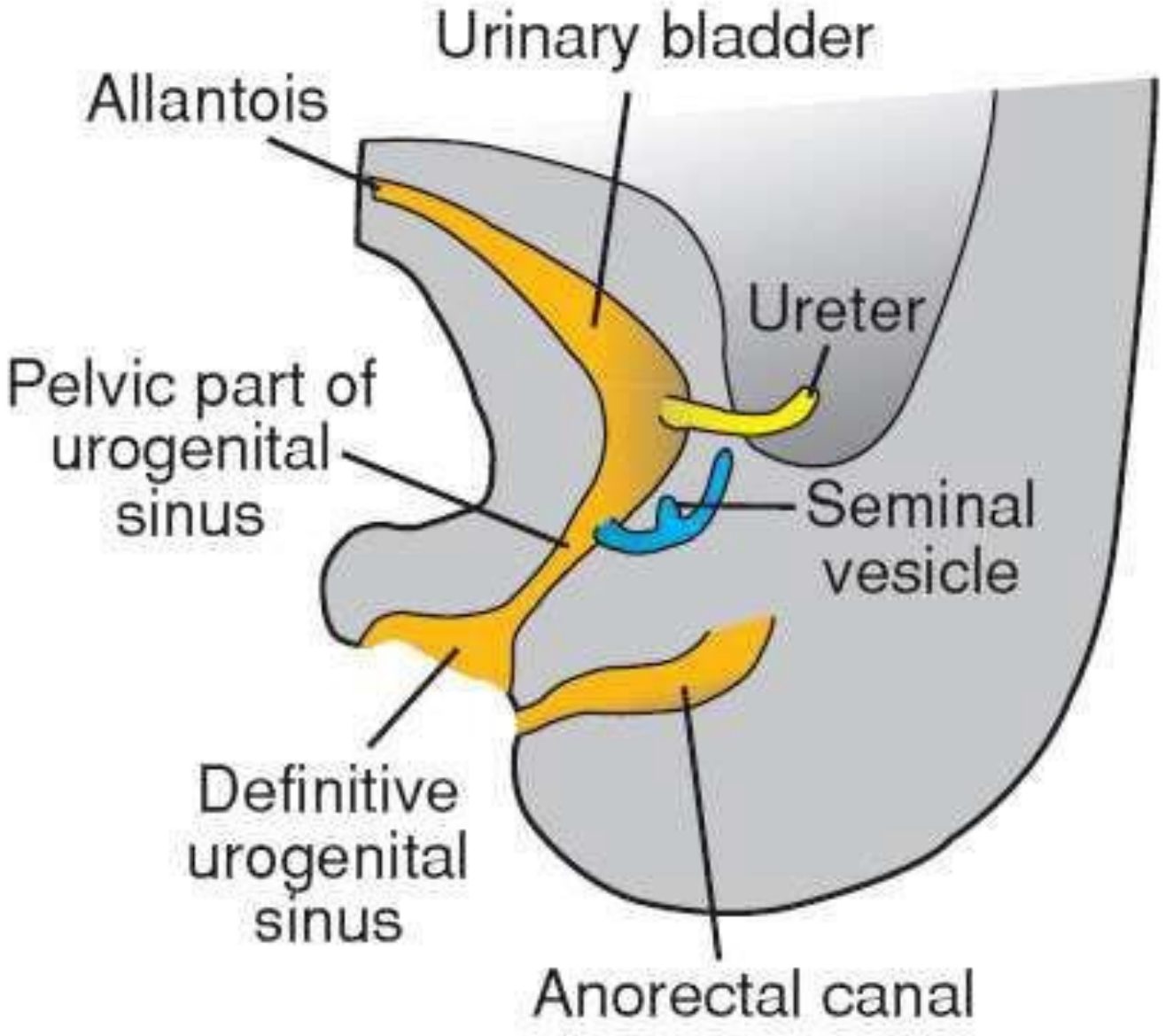

**Dorsal views of the bladder showing the relation of the ureters and mesonephric ducts during development**

**(A) Initially the ureters are formed by an outgrowth of the mesonephric duct**

**(C and D)the trigone of the bladder formed by incorporation of the mesonephric ducts.**

# URETHRA

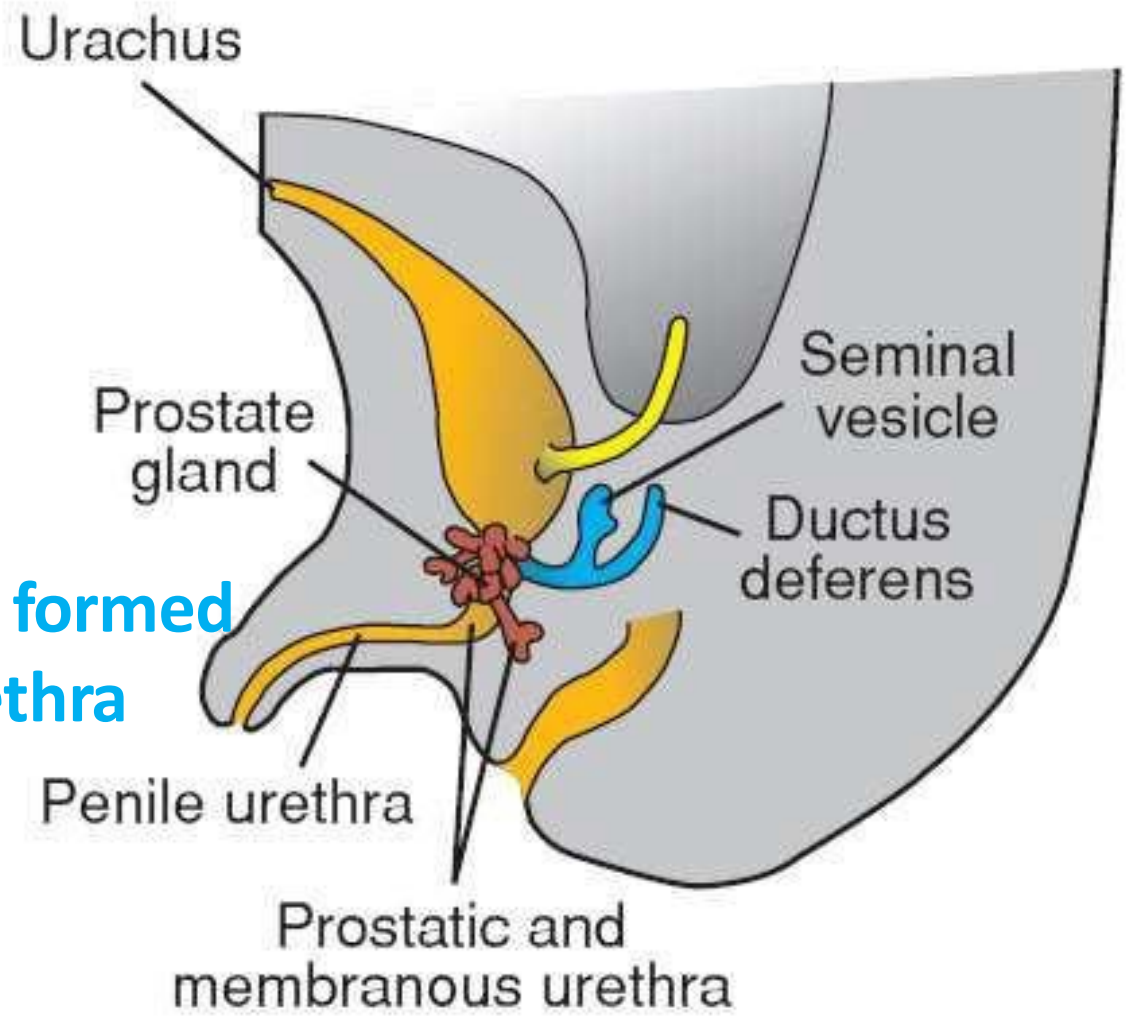
- The epithelium of the urethra in both sexes originates in the endoderm;
- Penile urethra formed by inward migration of ectodermal cells through glans meeting the endodermal cells of spongy urethra.
- *At the end of the third month, epithelium of the prostatic urethra begins to proliferate and forms a number of outgrowths that penetrate the surrounding mesenchyme*.
- In the male, these buds form the **prostate gland** .
- *In the female, the cranial part of the urethra gives rise to the* **urethral and paraurethral glands.**




**Development of the urogenital sinus into the urinary bladder and definitive urogenital sinus.**

**In the male the definitive urogenital sinus develops into the penile urethra.,**

**The prostate gland is formed by buds from the urethra**



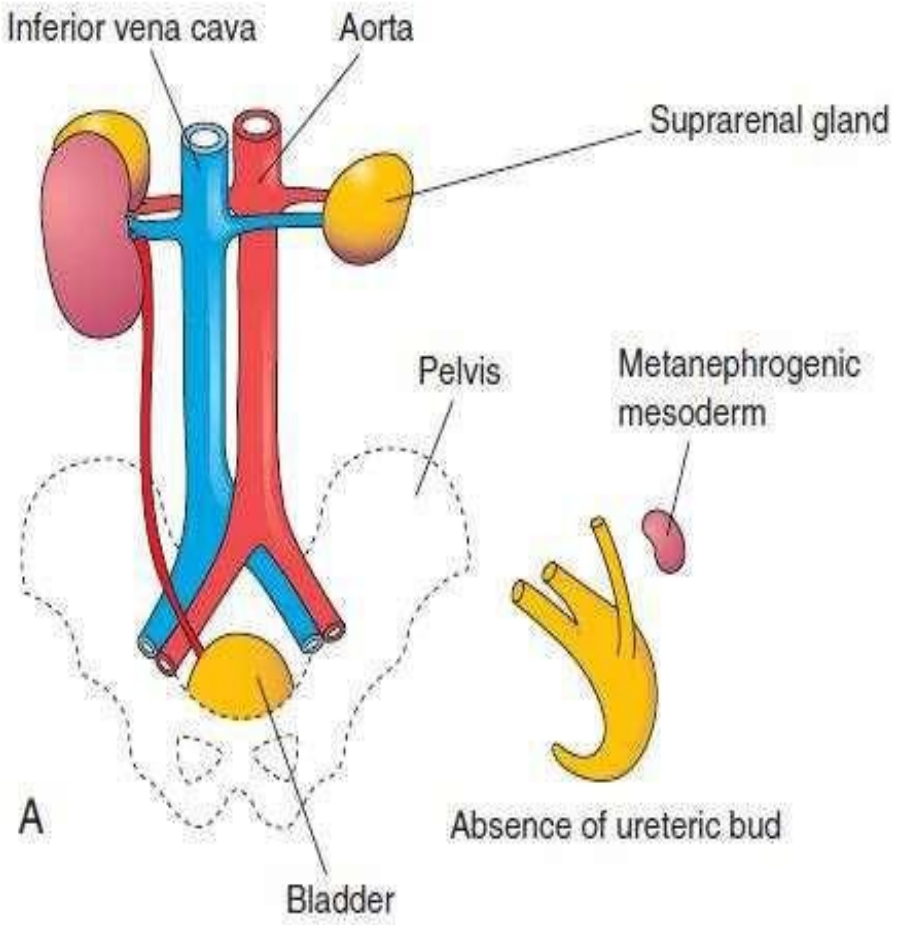
# CONGENITAL ANOMALIES OF KIDNEY

- Ectopy and hypoplasia associated with facial maldevelopment
- Ectopy , malrotation and renal agenesis associated with scoliosis and kyphosis

## AGENESIS

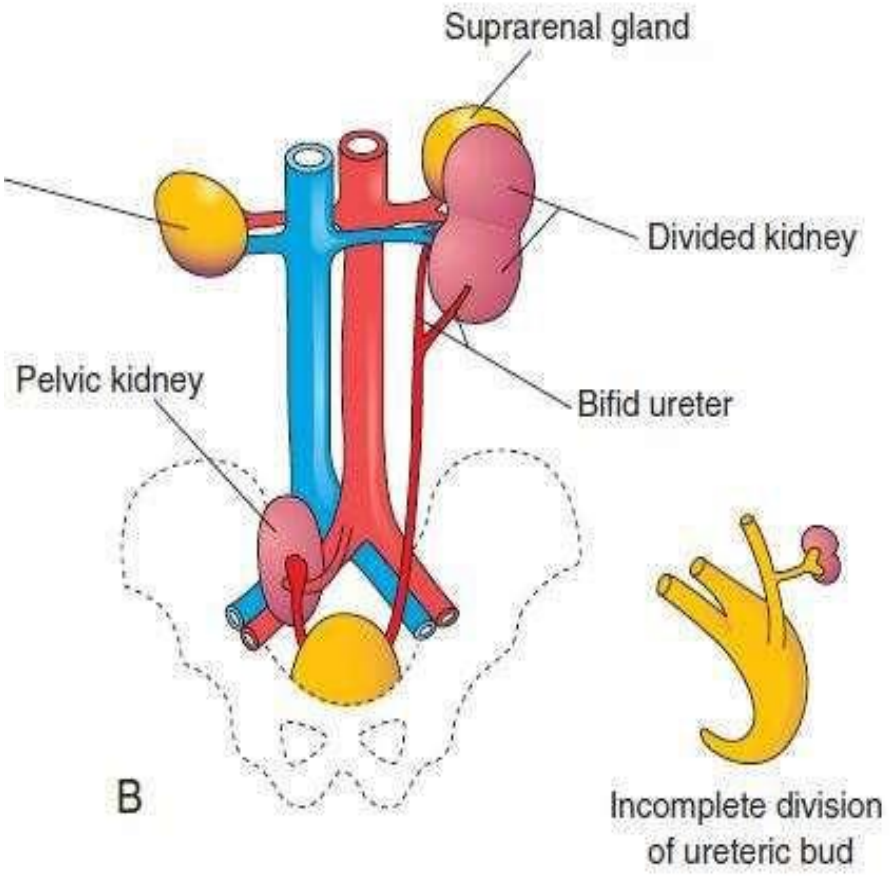
- Rare less than 400 cases
- Bilateral … 50%... incompatible with life
- Unilateral ….compatible with life
  contralateral kidney hypertrophied
- Oligohydromnios
- Defect: ureteric bud fail to develop or fail to reach metanephric tissue
- Diagnosis: …ultrasound
….CT scan
…cystoscopy.. Ureteric oriffice not seen

Complications… infection, stone, HDN



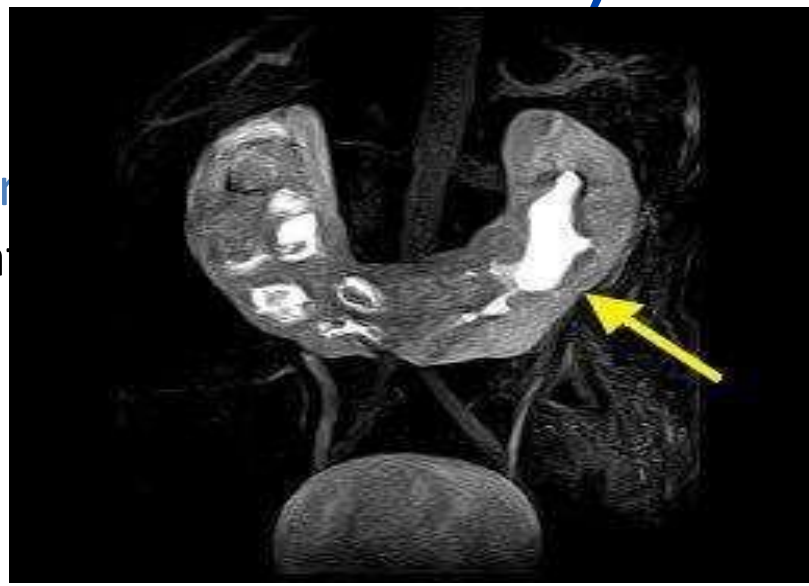
# Renal Ectopia / pelvic kidneys

- Kidney Doesn't ascend, formed near pelvic brim
- Usually asymptomatic
- Present with pain or mass which one may tempt to remove as **unexplained** pelvic mass
- May be source of stone, infection
- Liable to trauma
- TREATMENT: Treat the complication



# RENAL FUSION

## Horse shoe kidney (Most common)



•Lower poles fused in mid line in front of 4th lumber vertebra – ascent impeded by inferior mesenter

•Symptoms /signs. usually asypmtoma flank Pain, hematuria, fever

•Exam : fixed mass below umbilicus

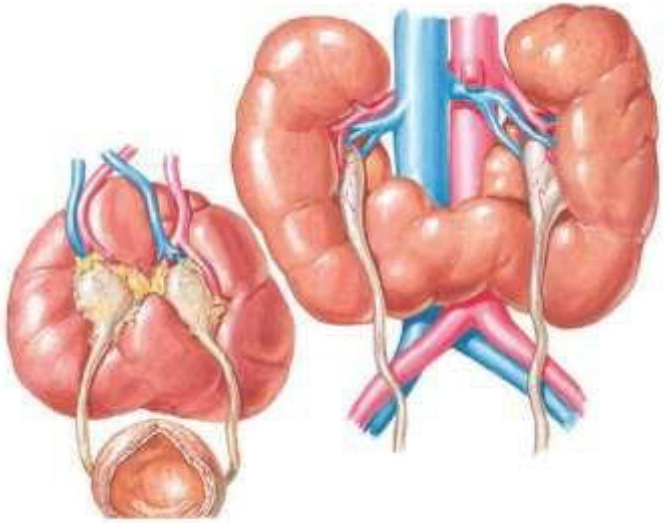
•Diagnosis: U/S IVU . Pelvis on anterior surface

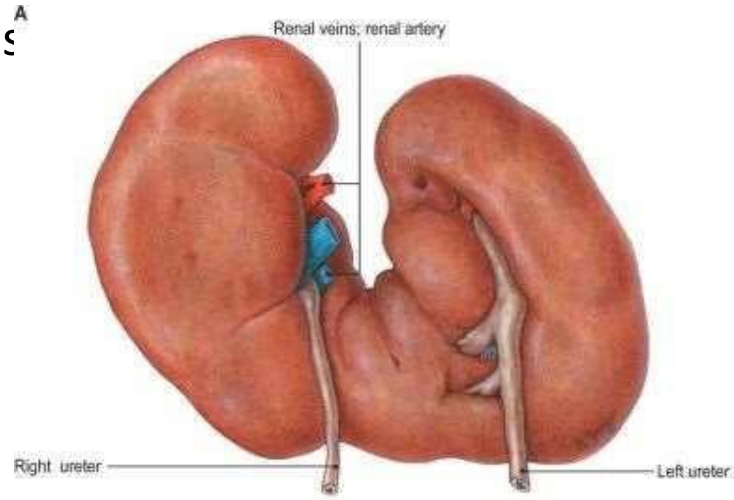
•complications: Liable to disease

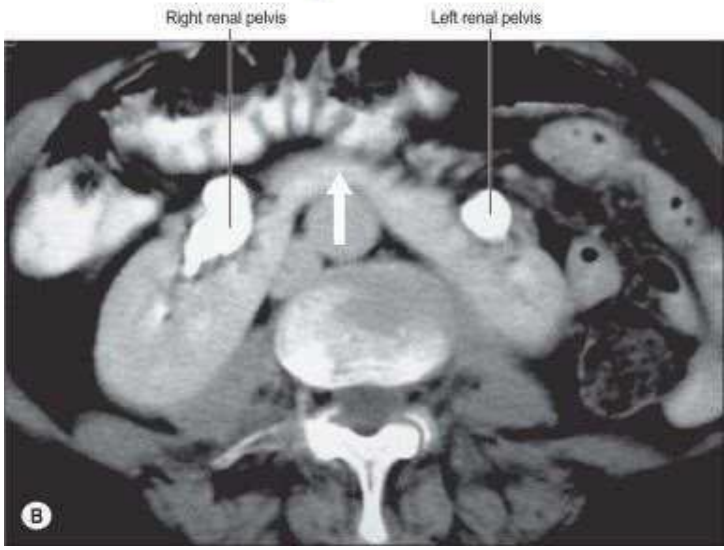
– angulated ureters + PUJ obstruction→ urinary stasis → stones, infection & obstruction →CRF.

- Treatment
  - Asymptomatic = no treatment
  - Mild sypmtoms = treat accordingly
  - PUJ or ureteric obstruction, recurrent infection
  - Stones

  → surgery (pyelolithotomy + /-reconstruction)
  - ISTHEMECTOMY with straightening of ureters
  - less commonly done.

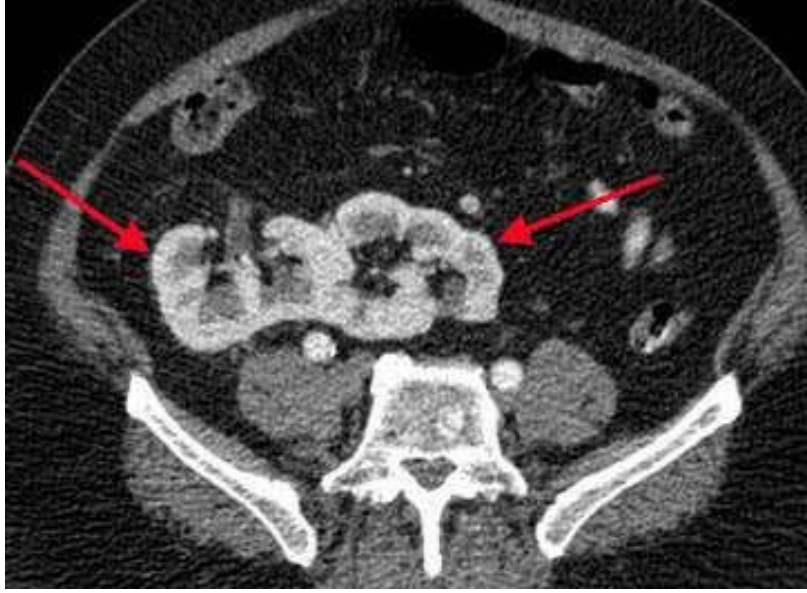




**Pancake / Discoid Kidney :**

-Bilateral fused pelvic kidneys , usually near the aortic bifurcation

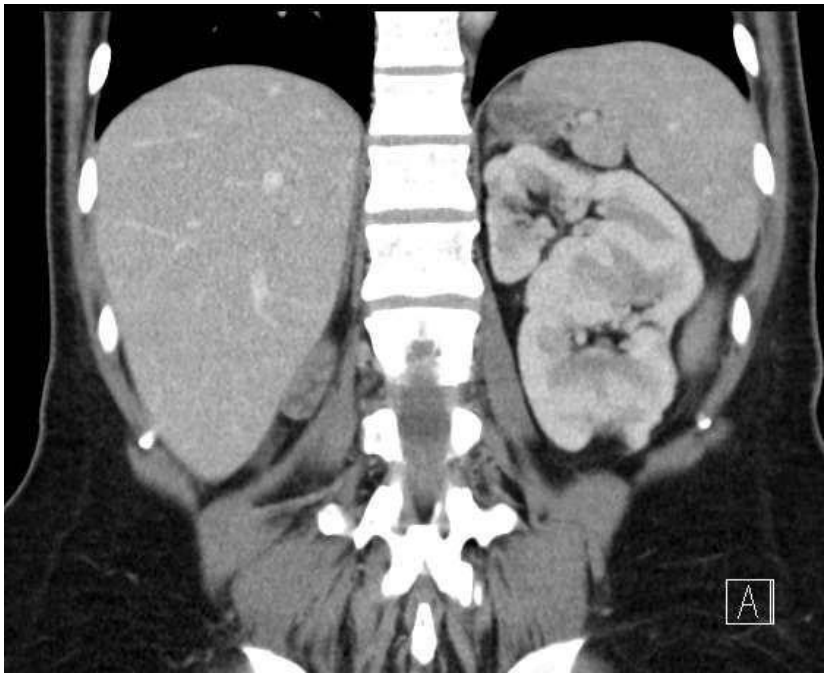


**Crossed Renal Ectopia :**

-Both kidneys are found in the same side

-In 85-90 %of cases , the ectopic kidney will be fused to the other side

-The upper pole of the ectopic kidney is usually fused to the lower pole of the other kidney , although fusion may occur anywhere



# Adult Polycystic kidneys

- Hereditary – autosomal dominant
- 95% bilateral
- Not manifested before 40
- Kidneys enlarged, studded with cysts
- Unyeilding capsule compresses

renal parenchyma causing atrophy

- Liver,lungs and pancreas may be affected
- CAUSE: defect in development of tubules.
- Cyst contents: Amber color fluid but may be hemorrhagic

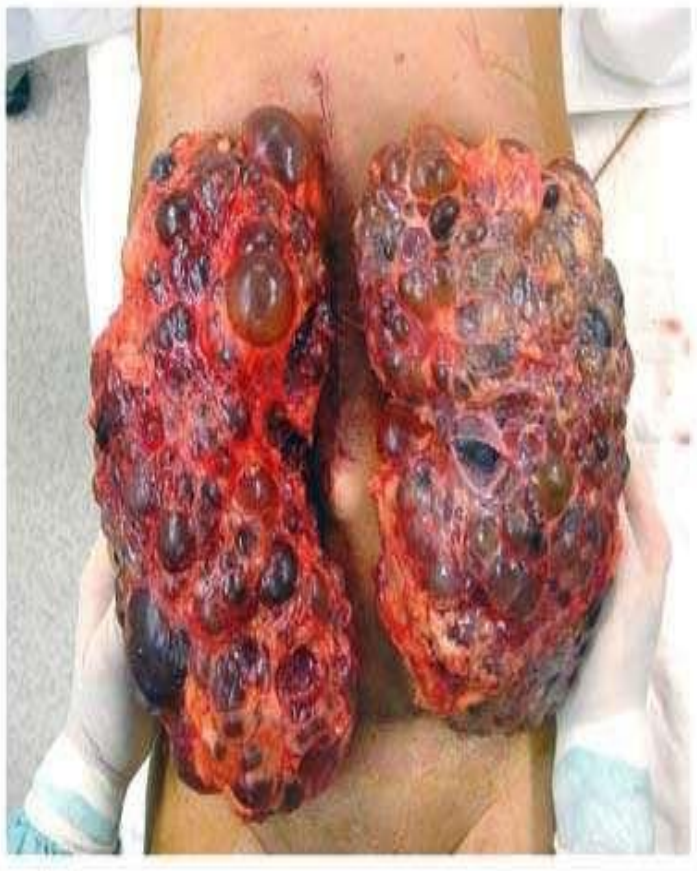


**Figure 6** - The incision of much smaller size than the kidney, with no emptying of the cyst and no morcellation of the kidney required

Signs / symptoms:

- Loin pain- weight dragging upon peddicle or capsule stretch, hemorhage in cyst, stone
- abdominal mass- confused with cystic tumor
- hematuria- cyst rupture in pelvis,moderate, episodic.
- hypertention, infection, & uremia/CRF.
- Nonspecific symptoms: anorexia, headache, vague abdominal discomfort, →vomiting, drowsiness, anemia.

LABS:

Urine R/E.. Pyuria, microscopic hematuria

Deranged RFT's, anemia

XRAYS: enlarged renal shadows > 16cm

bizarre calyceal system( spider deformity)

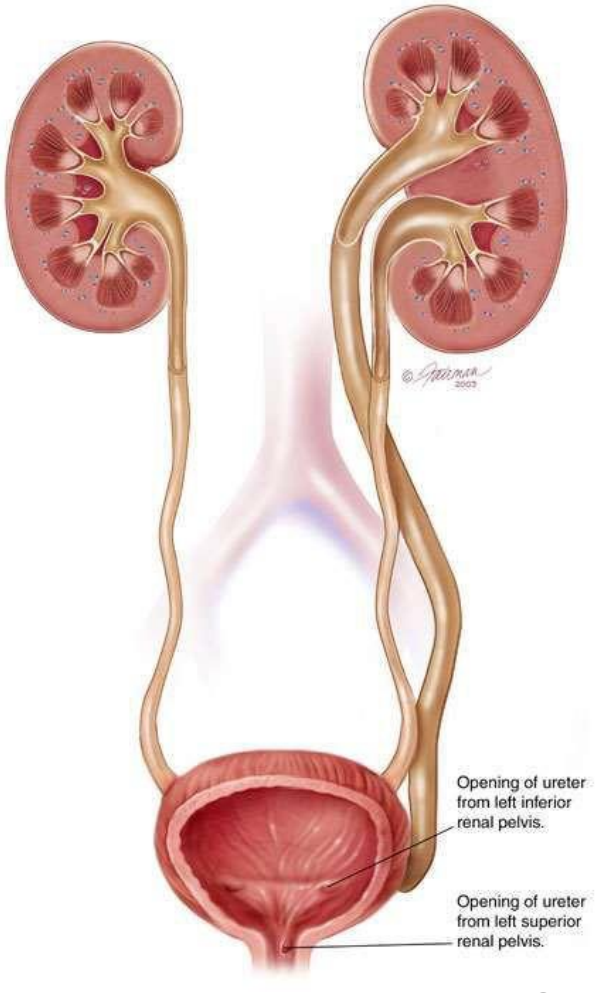
# Infantile polycystic kidneys

- Rare
- Inheritance- autosomal recessive
- Enlarged kidneys – may obstruct labour, Many stillborn
- Die of renal failure in in early childhood

# Abnormalities of renal pelvis and ureter

- Most common, harmless, asymptomatic

- <u>DUPLICATION OF RENAL PELVIS</u>
  - Common, usually unilateral – left
  - Upper pelvis – small, drains upper calyx
  - Asymptomatic no treatnment
  - If one moity severly damaged – partial nephrectomy



# DUPLICATION OF URETER

Often join before reaching bladder, suffer obstruction ( esp from stones) & reflux

May open independently, ureter from upper moity opens distal and medial to its fellow.

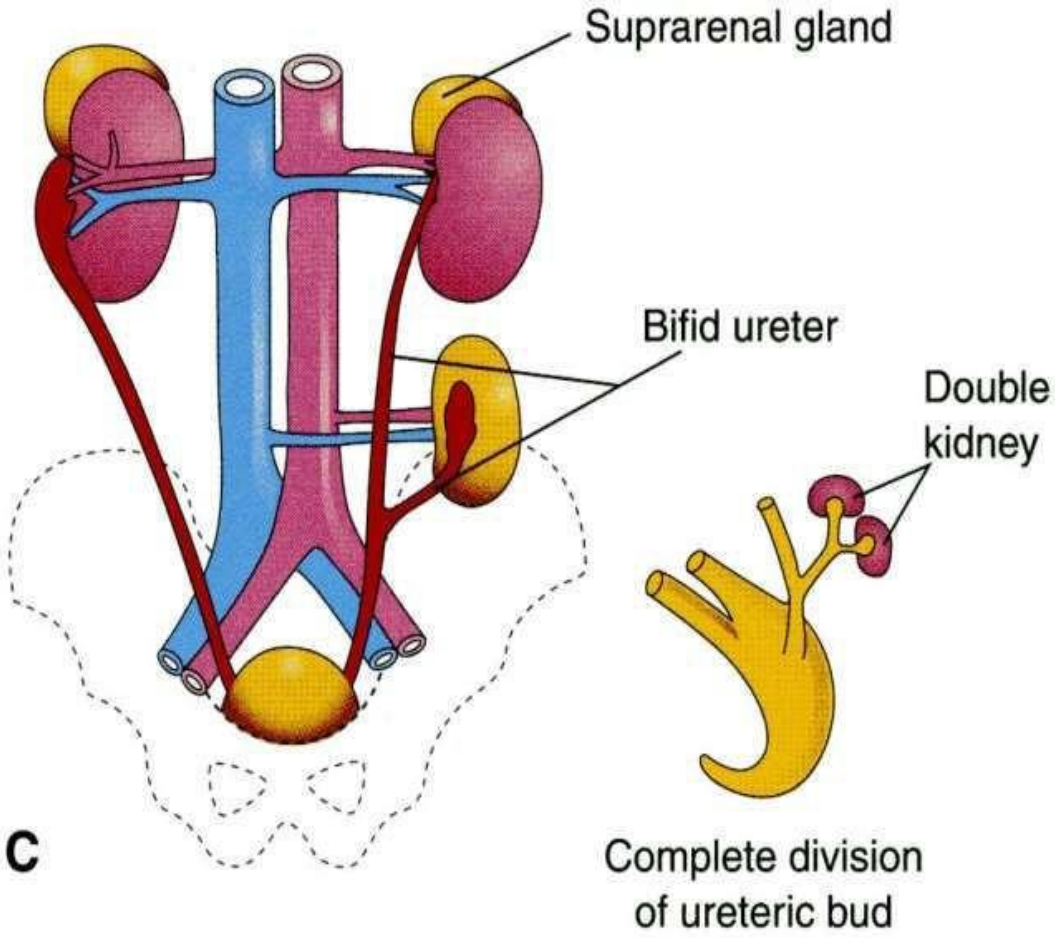
Upper ureter suffers ureterocele.

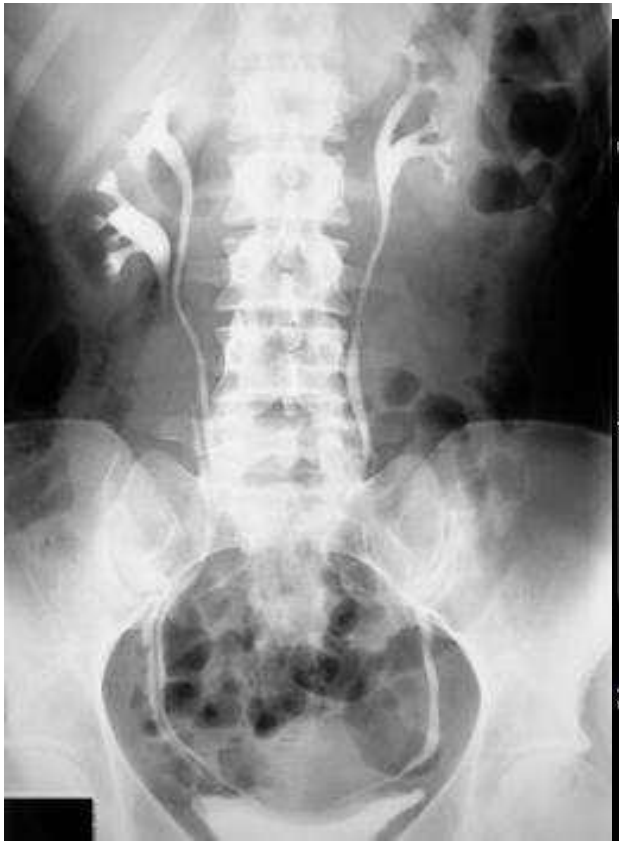
Lower ureter suffers VUR

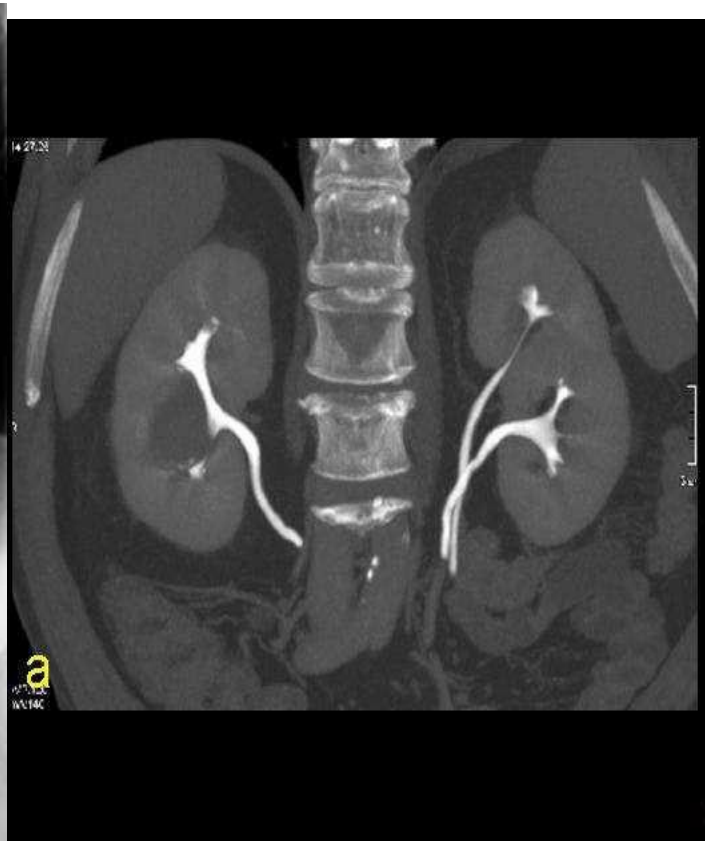
Infection, calculus formation,

PUJ

obst and VUR, ectopic opening



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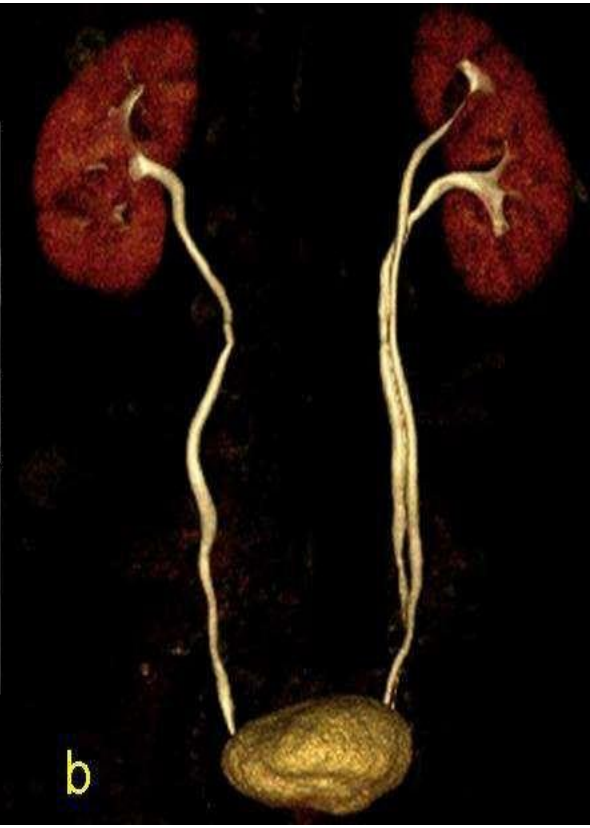
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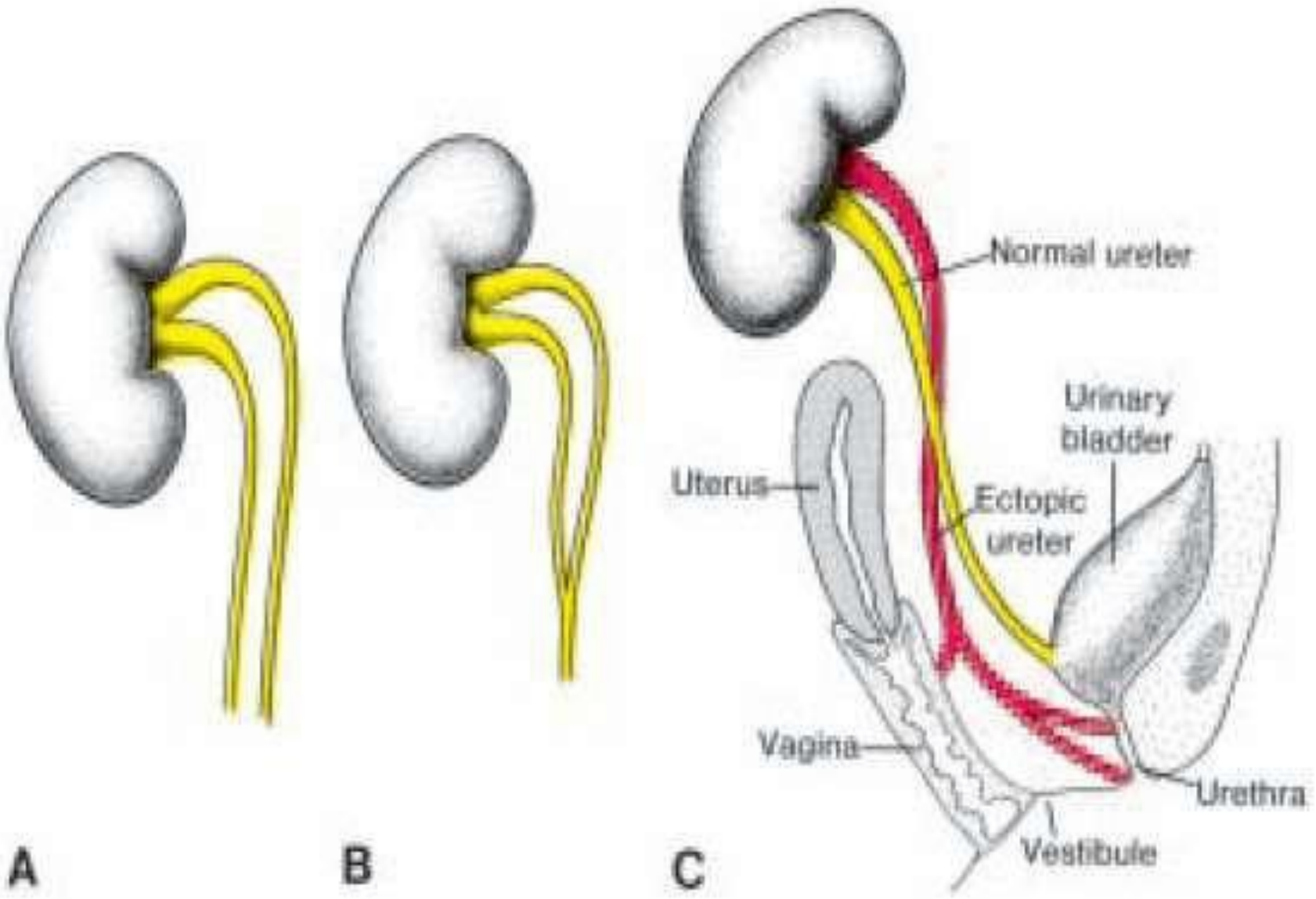
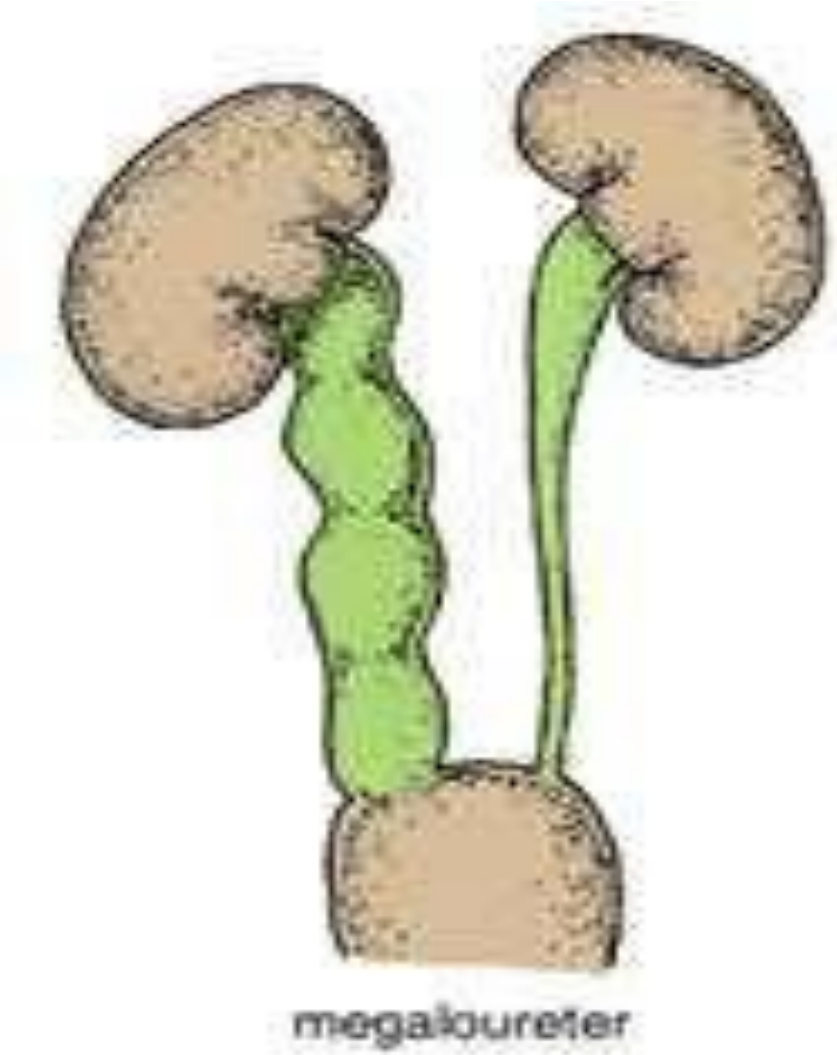
# Ectopic uretric opening

– Female – into urethra below sphincter on vagina = incotinence since childhood with desire and passage of urine normally as well.
  - IVU and cystoscopy
– Male.continent as opening is above sphincter
  - Opening in trigone apex, post. Urethra, seminal vesical or ejaculatory duct
– functionally abnormal, infection common
– Treatment:
  - Frequently ectopic ureter drains hydronephrotic, chronically infected kidney --- best excised - nephrectomy
  - Incontinence can be cured and renal function preserved by implanting ureter into bladder ( tunneling) or joining its fellow. (URETERO-NEOCYSTOSTOMY, URETERO-URETEROSTOMY)


Normal ureter
Urinary bladder
Uterus
Ectopic ureter
Vagina
Urethra
Vestibule
A
B
C

# CONGENITAL MEGA URETER

– Uncommon, bilateral
– FUNCTIONAL obstruction at lower end → dilatation & infection
– Ureteric orifices normal, ureteric cath passes easily
– Reflux not feature till opened endoscopically
– Treatment: refashioning and tunneled reimplant



# Aberrant vessels

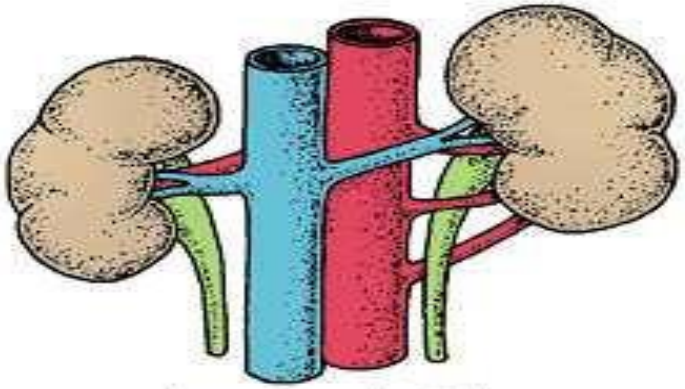
-As the kidney ascends during embryologic development , it derives its blood supply from the aorta at successively higher levels with regression of the lower level vessels

-If the lower level vessels persist

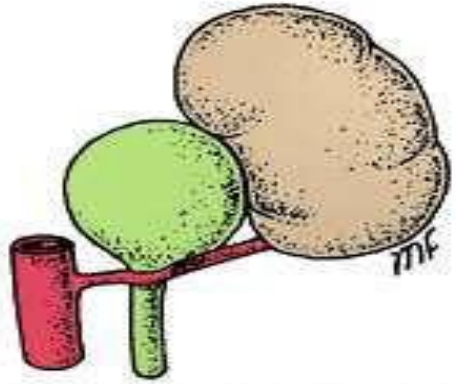
, aberrant renal arteries will be present

-Aberrant vessels can compress the ureter anywhere along its course , giving rise to obstruction

-With color Doppler , aberrant vessels may be seen crossing the ureter at the level of ureteric obstruction



aberrant renal arteries



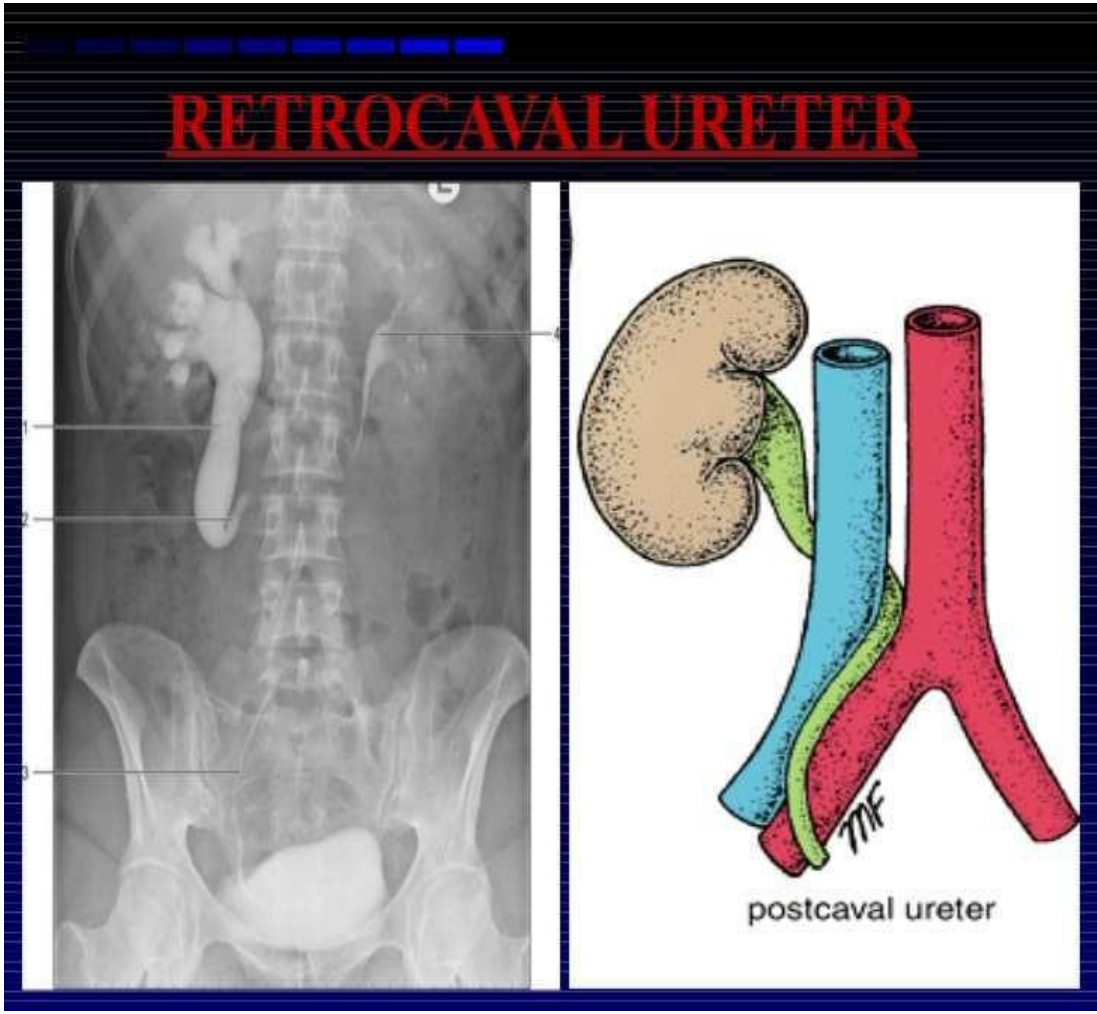
aberrant renal artery causing urinary obstruction

# POST (retro) CAVAL URETER

– Right ureter passes behind

IVC instead of lying to the right of it (laterally)

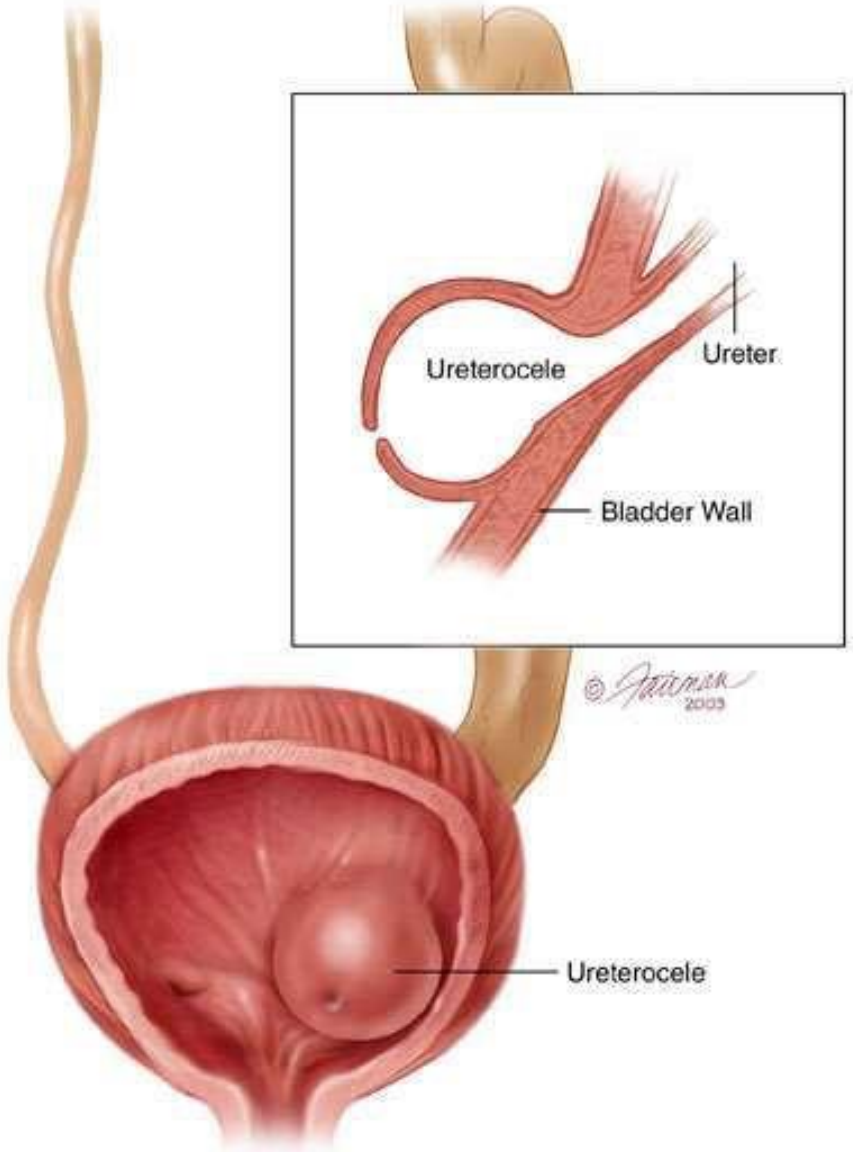
– If causing obstruction, can be devided and joined in front of cava – long oblique anastomosis



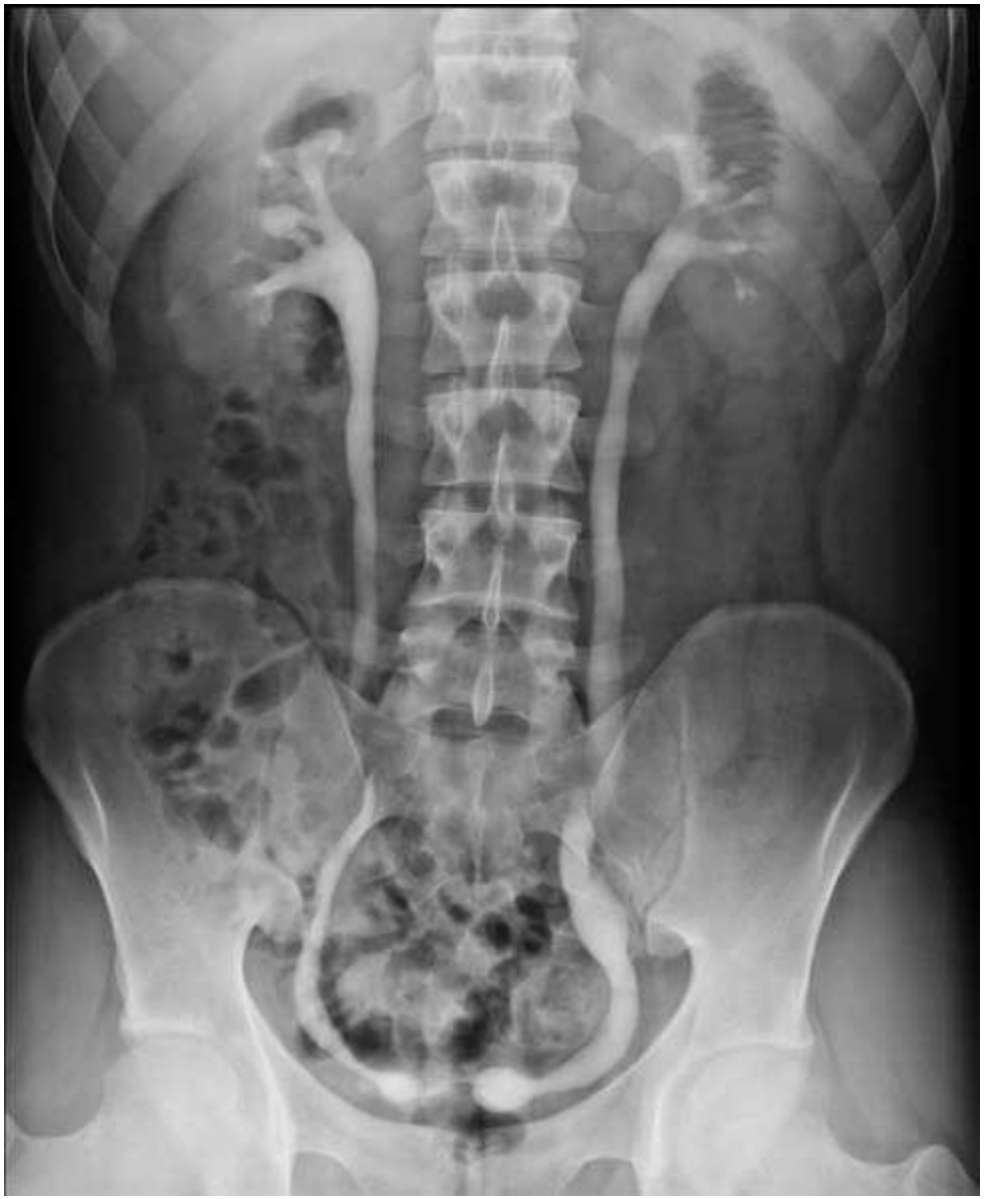
# URETEROCELE

– Cystic enlargement of intramural portion of ureter
– Thought to result from congenital atresia of ureteric orifice
– Though present since childhood, unrecognised till adulthood
– More common in female, cause BOO by obstructing/ prolapsing into internal urinary meatus. May even prolapse out of urethra

- Adder head on IVU
- Cyst wall composed of urothelium only
- confirmed on cystoscopy
  - Translucent cyst, enlarging and collapsing as urine flows
- Treatment avoided unless symptoms of infection / stone
- Endoscopic diathermy incision / deroofing
  - Postoperative MCUG to see VUR
- Ureteral reimplant
- Sever hydronephrosis, pyonephrosis→ nephrectomy



# ureterocele



# EXSTROPHY OF BLADDER

- 3.3 per 100,000 births.
- Male to female 1.5:1ratio.
- incomplete median closure of the inferior part of the wall.
- the inferior parts of the rectus muscles is absent and the external and internal oblique and the transversus abdominus muscles are deficient.

## Signs and symptoms

Exposure and protrusion of the mucosal surface of the anterior wall of the bladder characterize this defect.

- The trigone of the bladder and the ureteric orifices are exposed, and urine dribbles from the everted bladder.
- Epispadias
- Anus and vagina anteriorly located.
- UTI and HDN common

# Bladder Diverticula

-Outpouchings from the bladder wall, whereby mucosa herniates through the bladder wall

-solitary or multiple in nature and can vary considerably in size

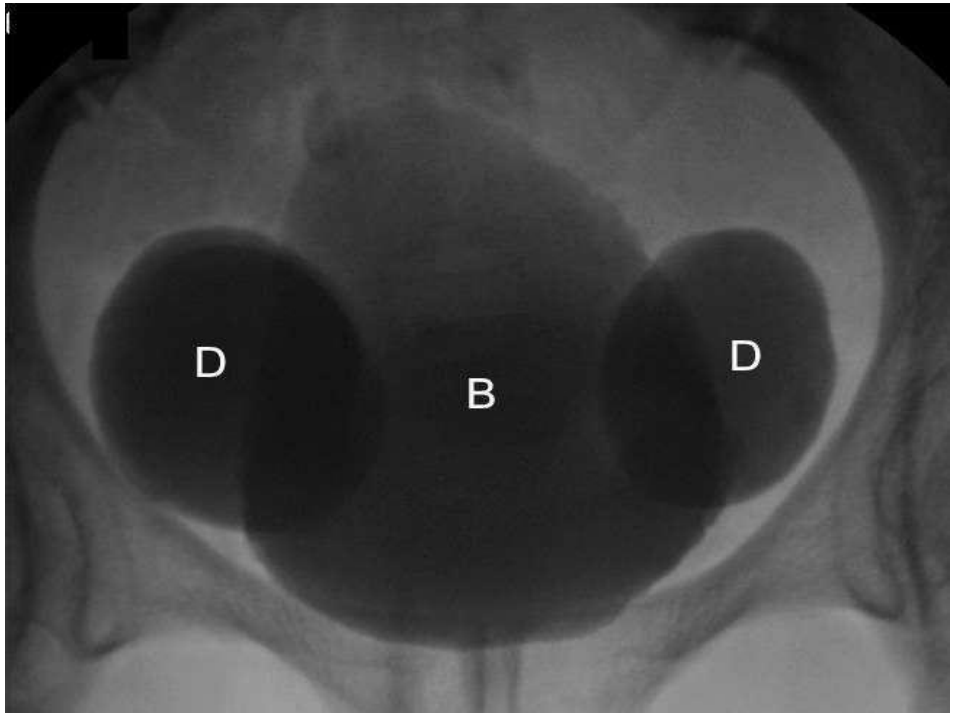
-May be congenital (primary) or acquired (secondary)

-A Hutch diverticulum is a congenital bladder diverticulum, seen at vesicoureteric junction

Usually asymptomatic but can cause bladder outlet obstruction and UTI

-Treatment: symptomatic

- MCUG showing bladder diverticula



# Urachal anomalies

-Normally, the urachus closes in the last half of fetal life

-There are 4 types of congenital urachal anomalies :

a)Patent urachus (50 %)

b)Urachal cyst (30 %), forms if the urachus closes at the umbilical and bladder ends but remains patent in between, the cyst is usually situated in the lower one third of the urachus

c)Urachal sinus (15 %), forms when the urachus closes at the bladder end but remains patent at the umbilicus

d)Urachal diverticulum (5 %), forms if the urachus closes at the umbilical end but remains patent at the bladder

-There is 2:1 predominance in males

## Treatment:

-- Excision

-- Radical excision if evidence of adenocarcinoma .


Thank
you