Development of the Urinary System

''every things is written in this sheet so u don’t have to go back to the slide.
'' I write everything and I hope everything will be clear ,, if some note doesn’t clear to u ,please listen to record , I think u will understand well.
'' please when u read this sheet, look at the picture,,it’s useful to understand.
'' GoOd Luck And lets start ..

Lecture Objectives

• Understand the development of the kidney and related organs of the urinary system.
• Define the pronephrons, mesonephrons and metanephrons.
• Understand the major and common congenital abnormalities in the urinary system.

**Urinary system and reproductive system developed from the same region ,,and closely related (structurally & developmentally).
**In development of embryonic disc ,,we have ectoderm,mesoderm and endoderm and mesoderm has differentiate to paraxial , intermediate, and lateral mesoderm( look at the picture) , lateral part have 2 parts >>^somatic mesoderm (attach to abdominal wall) and splanchnic mesoderm ( related to viscera or splanchnic structures).

Development of Urogenital System

** review : inside intermediate mesoderm will be mysenchymal cell.
• Urogenital system develop from the intermediate mesoderm >> during development, within intermediate mesoderm , mysenchymal cell in certain area in mesoderm will proliferate and condense and finally reflected internally toward abdominal cavity between splanchnic and somatic mesoderm as ridge >>Urogenital ridge is a longitudinal elevation of the mesoderm lateral to the dorsal aorta)>> again look at the picture.
>> inside these ridge( urogenital ridge) there will be condensation and differentiation of some of mysenchymal cell and form cord like structure ,,from this cord Nephrogenic cord (ridge) appears >> nephrogenic cord developed all over the body of embryo ( intermediate mesoderm)from the Ending or beginning of cervical region up down To the tail ( caudal region) ..inside Nephrogenic cord there will be differentiate of some cell to Gives rise to part of the urinary system.

** Note : later on there will be development of another cord Genital (gonadal) ridge which arise from swelling externally of Nephrogenic cord .
** Genital (gonadal) ridge develop close to the nephrogenic cord and will Gives rise to part of the genital system ,,this we will talk about it in reproductive lecture).
**Development of Kidneys & Ureters**

- **Three sets of kidneys** develop sequentially in the **nephrogenic cord**. 
  - The first kidney will be developed (**Pronephros**) Nonfunctional (rudimentary) kidney just form the bases of other kidney (mesonephros and metanephros).
  - Then **Mesonephros** functional but Temporary kidney, work until first semester then **metanephros** will be functional, mesonephros stopped as functional part and part of its will disappear and the rest will be used as developed part of genital system. we will talk about this in detail in this lecture.
  - Finally **metanephros** - The permanent kidney and adult kidney

**Firstly >>**

**Pronephros**, because it’s Nonfunctional (rudimentary) kidney so the functional part (nephrons) will be not developed and duct will develop.

**Appears in the neck region at the beginning of the 4th week**

Development >> inside **nephrogenic cord** all over intermediate mesoderm, mesenchymal cell will differentiate and condense to form canal like structure >> Pronephros will form >> pronephric duct run all over intermediate mesoderm and end inferiorly in (drained into) cloaca (cloaca form from folding of wall caudal)

**Note:** distal part of gi and distal part of the urinary system developed from cloaca.
• Contains
• Tubular structure - Disappear
• Pronephric duct - Run caudally & open in the cloaca
• Most of it utilized by other kidneys - Mesonephric duct

In the picture there is overlapping between different part of the kidney.
Pronephros form then part of its become rudimentary and at the same time mesonephron form.

**when mesonephros beginning to development,. tubular structure of pronephros disappears almost ( isn’t important)”Pronephric duct remain and drained finally to cloaca. after pronephros part of duct beginning to disappear, „remaining part of pronephric duct converted to mesonephron duct (basis of mesonephros)
** mesonephrus just caudal to pronephrous .use pronephric duct to make mesonephrotic duct.
** The only important thing of pronephrus is pronephrotic duct which will converted to mesonephric duct.
**all of Nephrogenic cord drop in intermediate mesoderm just lateral to dorsal aorta, from dorsal aorta there will be branching, (group of artery from dorsal aorta) direct branching to kidney.
**group of artery from dorsal aorta because mesonephros is large kidney so it need large number of artery work as interlobular artery or as afferent artery.

Secondary >> Mesonephros
• Interim kidney - temporary functional kidney
• Appears late in the 4th week caudal to the pronephros
• Disappear by the end of 1st trimester ,, during development of metanephrous.
  in second half of embryonic development >> Interim kidney is working ,,filtration of blood and secretion of urin
Ether Disappear or Gives rise to other structures( reproductive system ) >>
Become the efferent ductules of the testes
  • Content
  • Glomerulus
  • Mesonephric tubules - from mesonephric vesicle
  ** we talked previously, „pronephric duct give rise to mesonephric duct and mesonephric duct within Nephrogenic cord ( there will be number of myenchymal cell which will condense to each other and will form mesonephric vesicle.
Look at the picture,,
mesonephric vesicle>> there will be branche from dorsal aorta ,,and dorsal aorta will form glomerular and glomerular will make induction in mesonephric vesicles ,,and mesonephric vesicles will differentiate to mesonephric tubule and will drain to mesonephric duct ..
** mesonephric tubule contact to mesonephric vesicles and glomerulus ( branches from dorsal aorta) and these structures will drain to duct and then to cloaca .
**mesonephric vesicle more than one**
**there will be duct all over intermediate mesoderm beside them mesonephric vesicle in the same cord,,and branching of dorsal aorta to mesonephric vesicles .

**after first trimester,( actually after embryonic period) interim kidney will stop working,,
Finally >>
Metanephros
• Permanent kidney
• Begin development of metanephros in the 5th week during mesonephros is working,, & start functioning in the 9th week( the end of embryonic period and beginning of fetus life) in this period mesonephros beginning to degenerate or converted to another structure of reproductive system and become disfunction ,,,
• Develops from:
• Metanephric diverticulum (uretricbud) >> Developed from mesonephric duct( end of distal part) near cloaca >> formation of diverticulum will induce mesenchyme in intermediate mesoderm to differentiate and condense and convert to mass surrounding diverticulum we called it >> Metanephric mass of intermediate mesoderm (metanephric blastema)
So diverticulum will be inside the mass.

In general; Metanephricblastema will give rise to parenchyma of the kidney and uretric bud will give rise to the rest (collecting duct down to ureter)

**Metanephros: Derivatives**

- **Metanephric diverticulum (uretric bud)** —> Gives rise to Ureter + Drainage system (renal pelvis & calices) + Collecting tubules —> Induce formation of metanephricvesicle
- **Metanephric mass**
  - Gives rise to the nephron (parenchyma of the kidney)
  - inside metanephric mass,, metanephric vesicles will form —> from induction of

![Diagram](image)

1) elongation of diverticulum And branching inside the mass and form major and minor cavities —> from minor cavities, collecting duct will appear and collecting duct will branch —> from the branch of collecting duct and branching of end of connecting duct or junctional tubule —> there will be induction from myshenma inside the mass so every end of tubule of collecting duct, the area which will face them there will be differentiate to form Metanephric vesicle —> differentiation to form metanephric tubule —> nephron

>> later on when it becomes functional, the blood vessels will enter —> in this stage blood vessels doesn't yet enter the kidney.

blood vessels must enter the kidney and glomerulus formation when it's become functional and this will be in the end embryonic period.

Note: up to the end of 8 weeks >> embryonic period, after that >> fetal period,, collectively(All the development of the fetus)>> conceptes period

**Position of the Kidney**

- **At the beginning** —> Kidneys are close to midline and Located on pelvis anterior to sacrum (at the end of the distal part of mesonephric duct) And Hilum faces ventrally (because it's appear from posterior bud of mesonephric duct)
  **We know that the adult kidney present at upper part of the abdomen,, so the kidney in the beginning will be in the pelvis then will migrate toward adult position.**
- With development of the embryo caudal to the kidneys, they have: (reposition of the kidney to form adult position)
• Rostral position
• Move laterally
• Rotated medially
• Hilum faces medially
• Kidneys come to their adult position & orientation by the 9th week
• They contact the adrenal gland (the adrenal gland remain at the same position which it’s developed from and kidney will move upward and migrate until it’s reach the adrenal gland and contact with it)
• Kidneys change their blood supply while changing position (to be functional must be blood supply, so must take blood supply to be functional at 9th week or at the end of 8th week)
• ** At beginning - renal aa. branch from common iliac aa then enter the kidney and supplying it. At the migration of the kidney these artery will disappear and there will be another branch from distal part of abdominal aorta it’s self, when it’s reach adult position, there will be another branch from proximal part of abdominal aorta (Permanent renal aa. branch from aorta at their adult level), these are version
Another version said that renal artery arise from common iliac and migrate with kidney. So there is 2 versions, the most acceptable one is that degenerate of artery and another one will rise until reach adult position and will supply from proximal part of abdominal aorta.
• if kidney remain in the pelvic will be functional and blood supply will be from common iliac,

Development of the Urinary Bladder
Ureter of the kidney will drain in the end of mesonephric duct and mesonephric duct will drain into cloaca.
- **Cloaca divided by (cord like structure from splanchnic mesoderm>> urorectalseptum)**
  Urorectalseptum from behind will separate cloaca to 2 parts posterior and anterior parts
  Posterior part will continue with gi tract and form distal part of gi tract and anterior part
  will form distal part of urinary tract so **Rectum - dorsally And Urogenital sinus (form urinary and genital structure also) - ventrally**
  **previously mesonephric duct will drain in cloaca, now will drain in urogenital sinus.**
- Urogenital sinus parts will elongate and divide to 3 parts from rostral to caudal
  1) **Vesical part - cranially >> rostral ,,mesonephric duct drain to it .**
  2) **Pelvic part - middle**
  3) **Phalic part- most caudal part**
- **Most of the bladder develop from the vesical part and will be distention**
- **Epithelium of urinary bladder from endothelium which originates from endoderm but of the origin of the kidney from intermediate mesoderm because urinary bladder originate from cloaca and cloaca from folding of splanchnic mesoderm and inside them endoderm so epithelium of urinary bladder from endoderm and connective tissue and muscular tissue From splanchnic mesoderm.**
- **Other layers - splanchnic mesenchyme**
- **Trigone connective tissue develop from mesonephric ducts(attach to urinary bladder from behind)**

**distal part of mesonephric duct (from uretric bud area) and distaly to urinary bladder>> will be part of urinary bladder and form the wall of urinary bladder..and proximal of mesonephric duct will separate from it and migration.
**ureter will drain directly to urinary bladder.
**ureter will form the end of the trigon and the origin of tigon is different from the origin of the rest of urinary bladder ((from mesonephric duct from intermediate mesoderm and as we talked previously urinary bladder from splanchnic mesoderm) so different histologically.
• Bladder continuous with allantois anteriorl,, converted to urachus which attach to umbilical cord (duct like structure) with new born baby will obliteration and becomes median umbilical ligament
  ** apex of urinary bladder connected to umbilicus through median umbilical ligament.

Development of the Ureters
• Ureters separate from mesonephric ducts and open directly into the bladder
• Reposition superolaterally
• Have oblique bath within wall of bladder(entrance) because of the repositioning of kidneys >>rostrally stretch the ureters (the tension during migration)

^^Distal part of mesonephric ducts move caudally to urethra & become ejaculatory ducts>> In female they degenerate.
^^we will talk about it in reproductive system.

Development of the Urethra
Urogenital sinus from cloaca from splanchnic mesoderm has 3 parts: 1) Vesical part >> urinary bladder
2) Pelvic part >> urethra of female and prostatic and membranous urethra of male
3) Phalic part >> part of vestibule of female and penis( spongy) urethra of male.

• Epithelium - endoderm
• Other layers - splanchnic mesenchyme
• spongy) urethra of male >> Distal part (navicularfossa) ← glandular (urethral)
  Plate ← glans penis (ectoderm)

Ectoderm >> contact to the rest of urethra >> formation of navicular fossa( last part of urethra of male and epithelium will be stratified squamous epithelium and from ectoderm not endoderm.
Development of Adrenal Gland
- **Cortex** - from mesothelium which attach to intermediate mesoderm
- **Medulla** - sympathetic ganglion - neural crest

** Development will be migration of neural crest to the cortex of mesothelium

- Begin at 6th week between root of mesentery and developing gonads
- Develop from mesothelium lining of posterior abdominal wall - form fetal cortex
- More mesothelial cells cover the fetal cortex and form the permanent cortex

**different layers** layers of cortex later on will develop, part of them development during fetal life and another during childhood later on
- Layers differentiate in late fetal life
- Zona glomerulosa & fasciculata present at birth
- Zona reticularis - end of 3rd year

Urinary Tract Anomalies
- **Duplication of upper urinary tract (renal pelvis or ureter)**
- **Renal agenesis**
  - 1/1000
  - There is one kidney and another one doesn’t form because *Absence of uretric bud* because uretric bud will make induction of mesoderm to form functional part or vesicles.
- **Abnormal rotation**
  - Hilum faces anterior, lateral or posterior

- **Horseshoe kidney**
  - 1/500
  - Kidney fusion and form one large kidney
  - Stay low (below inferior mesenteric a.), gonna be stuck in branching of abdominal aorta, so will be inferior to inferior mesenteric artery. in lower part of abdomen
  - **Congenital polycystic disease** instead of parenchymal cell will be tubular part of kidney, we will talk about it in pathology.

- **Exstrophy of the bladder**
  - 1/10000-40000>> not rare, present alot
  - Posterior wall of bladder is exposed
  - bladder rise from cloaca and cloaca from folding of splanchnic of lateral mesoderm, so if Failure of fusion of inferior part of anterior abdominal wall (anterior abdominal wall and bladder will be open and >> Exstrophy of the bladder

- **Urachus anomalies**
  - apex of urinary bladder will contact with amilicus, in the beginning will be duct before it's converted to ligament, and part of this duct will remain opening so will be exposed to infection >> converted to Cyst, sinus, vesicoumbilical Fistula>> if there isn't be complete obliteration of Urachus
Done by: marah saeed

# Good luck