Development of the Urinary System
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.
Development of Urogenital System

• Both the urinary & reproductive systems are closely related (structurally & developmentally)

• Urogenital system develop from the intermediate mesoderm

• Urogenital ridge is a longitudinal elevation of the mesoderm lateral to the dorsal aorta

• Nephrogenic cord (ridge) develop in the urogenital ridge
  • Gives rise to part of the urinary system

• Genital (gonadal) ridge develop close to the nephrogenic cord
  • Gives rise to part of the genital system
Development of Kidneys & Ureters

- Three sets of kidneys develop sequentially in the nephrogenic cord
  - Pronephros - Nonfunctional (rudimentary) kidney
  - Mesonephros - Temporary kidney
  - Metanephros - The permanent kidney
Pronephros

• Nonfunctional (rudimentary) kidney
• Appear in the neck region at the beginning of the 4th week
• Contains
  • Tubular structure - Disappear
  • Pronephric duct - Run caudally & open in the cloaca
    • Most of it utilized by other kidneys - Mesonephric duct
Mesonephros

• **Interim kidney** – temporary functional kidney
  • Appears late in the 4th week caudal to the pronephros
  • Disappear by the end of 1st trimester

• **Content**
  • **Glomerulus**
  • **Mesonephric tubules** – from mesonephric vesicle
    • Become the efferent ductules of the testes
  • **Mesonephric duct** – from pronephric duct
    • Gives rise to other structures
Metanephros

• Permanent kidney
• Begin development in the 5th week & start functioning in the 9th week
• Develops from:
  • Metanephric diverticulum (uretic bud)
    • Develop from mesonephric duct near cloaca
    • Induce formation of metanephric mass
  • Metanephric mass of intermediate mesoderm (metanephric blastema)
Metanephros: Derivatives

- Metanephric diverticulum (ureteric bud)
  - Gives rise to
    - Ureter
    - Drainage system (renal pelvis & calices)
    - Collecting tubules
      - Induce formation of metanephric vesicle

- Metanephric mass
  - Gives rise to the nephron
    - Metanephric vesicle → metanephric tubule → nephron
Position of the Kidney

• At the beginning
  • Kidneys are close to midline
  • Located on pelvis anterior to sacrum
  • Hilum faces ventrally

• With development of the embryo caudal to the kidneys, they have:
  • Rostral position
  • Move laterally
  • Rotates medially
    • Hilum faces medially

• Kidneys come to their adult position & orientation by the 9th week
  • They contact the adrenal gland
Position of the Kidney

- Kidneys change their blood supply while changing position
  - At beginning - renal aa. branch from common iliac aa.
  - Then branch from distal aorta
  - Permanent renal aa. branch from aorta at their adult level
Development of the Urinary Bladder

- Cloaca divided by urorectal septum
  - Rectum – dorsally
  - Urogenital sinus – ventrally
- Urogenital sinus parts
  - Vesical part – cranially
  - Pelvic part – middle
  - Phallic part – caudally
Development of the Urinary Bladder

- Most of the bladder develop from the vesical part
  - Epithelium – endoderm
  - Other layers – splanchnic mesenchyme
- Trigone connective tissue develop from mesonephric ducts
- Bladder continuous with allantois → urachus → median umbilical ligament
Development of the Ureters

• Ureters separate from mesonephric ducts and open directly into the bladder

• The repositioning of kidneys rostrally stretch the ureters
  • Reposition superolaterally
  • Have oblique bath within wall of bladder

• Distal part of mesonephric ducts move caudally to urethra & become ejaculatory ducts
  • In female they degenerate
Development of the Urethra

- Epithelium – endoderm
- Other layers – splanchnic mesenchyme
- In female – all develop from pelvic part of urogenital sinus
- In male
  - Prostatic & membranous urethra – pelvic part
  - Spongy urethra – phallic part
    - Distal part (navicular fossa) ← glandular (urethral) plate ← glans penis (ectoderm)
Development of Adrenal Gland

• Cortex – mesoderm
  • 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
  • Layers differentiate in late fetal life
    • Zona glomerulosa & fasciculata present at birth
    • Zona reticularis – end of 3rd year
• Medulla – sympathetic ganglion – neural crest
Urinary Tract Anomalies

• Duplication of upper urinary tract (renal pelvis or ureter)
  • Division of uretric bud

• Renal agenesis
  • 1/1000
  • Absence of uretric bud

• Abnormal rotation
  • Hilum faces anterior, lateral or posterior

• Horseshoe kidney
  • 1/500
  • Kidney fusion
  • Stay low (below inferior mesenteric a.)

• Congenital polycystic disease
Urinary Tract Anomalies

• Exstrophy of the bladder
  • 1/10000-40000
  • Posterior wall of bladder is exposed
  • Failure of fusion of inferior part of anterior abdominal wall

• Urachus anomalies
  • Cyst, sinus, vesicoumbilical fistula