Lecture #3

DEVELOPMENT OF UROGENITAL APPARATUS
## Urogenital apparatus

<table>
<thead>
<tr>
<th>Urine system organs</th>
<th>Genital system organs</th>
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</thead>
<tbody>
<tr>
<td>(organa urinaria)</td>
<td>(organa genitalia)</td>
</tr>
<tr>
<td>- Kidney – produce urine</td>
<td>- Organs:</td>
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<tr>
<td>- Ureter</td>
<td>- internal and external</td>
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<tr>
<td>- Urinary bladder</td>
<td>male and female genital organs</td>
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<tr>
<td>- Male and female urethras</td>
<td>transport and excrete urine</td>
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</table>
Urine system
(systema urinaria)
Functions of the kidney

• **1. Excretion with the urine:**
  - water-soluble metabolic products
  - xenobiotiks

• **2. Participate in the regulation:**
  - blood pressure and circulatory dynamics
  - water-salt and acid-base balance
  - osmotic pressure

• **3. Synthesis of bioactive substances:**
  - Erythropoietin
  - Renin
  - Prostaglandins

• **4. Enzymatic conversion (hydroxylation) and activation of vitamin D**
Uropoiesis (formation of the urine)

- Urine is formed from blood
- 3 main stages:
  1) **Filtration** of blood in glomerulus
  2) **Reabsorption** of substances and water in tubules and collecting ducts
  3) **Secretion** of substances from blood into proximal and distal tubules
Nephron – morphological and functional unite of the kidney

(From Thibodeau GA, Patton KT. Anatomy & physiology, ed 5, St Louis, 2003, Mosby.)
Filtration

- in glomerulus
- different diameter of afferent and efferent arterioles creates pressure between them and provides filtration
- Bowman's capsule is an extended blind end of the tubule
Filtration barrier
- endothelium of the glomerulus is fenestrated (with pores):
  - basal membrane
  - podocytes (with pores)

Result of filtration – primary urine, 170 L per day

Primary urine – is an ultrafiltrate of blood:
- water
- salts
- glucose
- small proteins (less than 30kDa)
- other small water-soluble substances
Glomerular filtration rate is destroyed

- by **glomerulonephritis** - in urine appear:
  • Proteins – *proteinuria*
  • Erythrocytes – *hematuria*

- by **decreased systolic blood pressure:**
  • less then 80mm Hg – *oliguria*
  • less then 60mm Hg – *anuria*
Reabsorption

- in proximal (85%) and distal tubules and Henle`s loop

- reabsorption of water, salts, glucose, amino acids, proteins and other components into blood (secondary capillary network of vas efference)

- H2O follows Na+

Nephron
Basic functional and structural unit of the kidney
Reabsorption is destroyed

- lesion of tubules and collecting ducts (pyelonephritis, interstitial nephritis, congenital pathology of the tubules)

- Urine:
  - contain not reabsorbed substances (small proteins)
  - increased volume (*polyuria*) and low concentration (low urine specific gravity - *hypostenuria*)
Where is it all reabsorbed?
– into secondary capillary network
Secretion

- Some substances (bilirubin, potassium ions, hydrogen, creatinine, histamine, xenobiotic and others) are excreted into the tubules by secretion.
Development of the kidney

- Amnioblasts
- Intraembryonic mesoderm
- Epiblast
- Primitive streak
- Intraembryonic mesoderm
- Endoderm
- Extraembryonic mesoderm
- Hypoblast being displaced laterally
Intraembryonic mesoderm plates:

- **Paraxial (dorsal) mesoderm** – axial skeleton (somites)
- **Intermediate mesoderm** – urogenital apparatus
- **Lateral mesoderm (somatic and splanchnic)** – appendicular skeleton and internal organs
The intermediate mesoderm forms a longitudinal elevation along the dorsal body wall – the **urogenital ridge**.

Part of the urogenital ridge forms the **nephrogenic cord** – give rise to the urinary system.
Nephrogenic cord develops into three sets of nephric structures:

1) **Pronephros** (forekidney)
2) **Mesonephros** (primary kidney)
3) **Metanephros** (hind kidney)

- form in cranial to caudal sequence
- Ancient fish
- Amphibian larvae
- Fishes
- Amphibia
- Mammals
- Human
Pronephros
3-5\textsuperscript{th} week
- mesoderm of the nephrogenic cord
- several glomuses, not connected with pronephric tubules
- no organized glomerules
- no urine formation
- 5\textsuperscript{th} week degenerate
Mesonephros (Wolffian body)

- 3–8th week (Th1-L3)
- S-shaped glomeruli
- One end of the tubule surrounds the aortic vessels
- Another end is connected with mesonephric duct
- Opens into cloaca
- Produces hypotonic urine
Mesonephros (Wolffian body)

Paramesonephral duct (Müllerian duct) is developed near to mesonephric one - develops into organs of reproductive system.

Gut
Metanephros

- is developed from two germs:

1) **metanephrogenic blastema** – condensation of mesoderm within nephrogenic cord

2) the **ureteric bud** – an outgrowth of the metanephric duct

- originates at the level of upper sacral segments

- 6th week – ascents from pelvic to lumbar position
- is a congestion of lateral mesoderm cells (caudal end of the embryo)
- all parts of the nephron will be formed
- capillary glomerulus is formed by vessels outgrowing from aorta
**Metanephric blastema** gives rise to the excretory components of the metanephros:

1) Bowman`s capsule
2) The proximal and distal convoluted tubules
3) The loop of Henle
**Ureteric bud** gives rise to the urine-collecting elements:
1) Collecting tubules within the kidney  
2) Papillary ducts  
3) Major and minor calyces  
4) Ureter
Kidney migration

- metanephros germ is below aortic bifurcation
- 9-10th week – kidney rises
- 90°Turn around vertical axis
Separation of cloaca (5-6th week)

Stages:
- development of septum urorectale
- posterior part – rectum
- anterior part – urogenital sinus

Urogenital sinus form:
- Bladder and urethra (male - partially)
- Inferior part of the vagina (female)
- Prostate (male)
Urinary tract
Digestive tract

Urorectal Septum
Cloaca

Loss of the Cloaca

Rectovaginal Fistula
Urorectal Fistula
Later this duct becomes **Urachus** (canal that drains the urinary bladder of the fetus) — *Plica umbilicalis mediana*

Allantois * — blind-ending hindgut diverticulum that projects into the umbilical cord
Congenital quantity abnormalities:
- Aplasia (absence of one or both kidneys)
- Accessory kidney
- Doubled kidney
- Fused kidney (horseshoe-, L-, S-shaped)
Congenital localization abnormalities:
- Pelvic kidney
- Lumbar kidney
- Iliac kidney
- Thoracic kidney
Congenital ureter openings abnormalities:

- into intestine
- into urethra
- into genital organs (seminal vesicals – male and uterine or vagina – female)
Congenital structure abnormalities:
- Polycystic kidney

Transcriptional misregulation

Mitotic orientation defects

Cl⁻ H₂O
Development of reproductive system
Gonads germ

- 5\textsuperscript{th} week
- genital ridge – columnar thickening of the splanchnomesoderm on the surface of the mesonephros (future stroma of the glands)
Primordial germ cells migrate from their primary germ in yolk sac endoderm (6th week).

Primordial germ cells are precursors of spermatogonia and oogonia.
The reproductive system at the indifferent stage

Chromosomal constitution + hormones = establishment of physical gender
**Sex-determining Region Y (SRY gene)**

*(this gene codes expression of TDF - testis-determining factor)*

![Diagram of the Y chromosome with the SRY gene highlighted.](image)

- **Short arm**
- **Centromere**
- **Long arm**

**Sex-determining region Y (SRY) gene**

- This gene is Y linked because it is found only on the Y chromosome.
Sex-determining Region Y (SRY gene)
**Wolffian duct (mesonephric):**
- Rete testis
- Efferent tubules of testis
- Epididymis canal
- Ductus deferens
- Seminal vesicles

**Urogenital sinus:**
- Prostatic part of urethra
- Prostate

**Müllerian duct (paramesonephric):**
- Fallopian tubes
- Uterine
- Vagina

**Urogenital sinus:**
- Vestibulum vaginae

**Wolff – Wolfgang**
- male name

**Frau Müller**
- female
Congenital abnormalities of female reproductive system:

- ectopy of the ovarian
- accessory ovarian
- hypoplasia of ovarian
- hermaphroditism
- aplasia of uterine, the fallopian tubes, vagina
Congenital Müllerian Anomalies

Normal uterus

Class I: Uterine hypoplasia and/or agenesis

Class II: unicornuate uterus

Class III: Uterus didelphys

Class IV: bicornuate uterus

Class V: septate uterus

Class VI: arcuate uterus

Class VII: Diethylstilbestrol (DES) drug related
**Wolffian duct (mesonephric):**
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Wolff – Wolfgang – male name

Frau Müller - female
Hormonal regulation of sex differentiation

Leydig cell

Testosterone

Epididymis
Vas deferens
Seminal vesicle

DHT

ANDROGEN RECEPTOR

Sertoli cell

AMH

AMH RECEPTOR

Uterus

UROGENITAL SINUS AND EXTERNAL GENITALIA

Dihydrotestosterone (Anti-Müllerian hormone)
**Leydig cells** produce androgens – determine development of organs of male reproductive system

**Sertoli cells** produce anti-Müllerian hormone
The testis develops as part of the urogenital ridge on the posterior body wall inside the abdominal cavity.

- The testis is attached to the scrotum by a band of connective tissue – gubernaculum testis.
- 3rd month – start to descend with concomitant shortening of the gubernaculum.
- The scrotum is merely an outpocketing of the body wall.
Congenital abnormalities of testis:

- Hypoplasia
- Retention (monorchism, criptorchism)
- Ectopy
- Inversion
- Synorchism, polyorchism
- Congenital herniation
- Hermaphroditism
**Female**
Glans area – clitoris  
Urogenital fold – labium minus  
Lateral buttress – labium majus

**Male**
Glans area – corpus cavernosum and glans penis  
Urogenital fold – corpus spongiosum and pars spongiosa urethrae  
Lateral buttress – scrotum
### Differences between male and female urethra

<table>
<thead>
<tr>
<th>Male urethra</th>
<th>Female urethra</th>
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<tr>
<td>• longer</td>
<td>• Shorter, without parts determination, but wider</td>
</tr>
<tr>
<td>• has 3 parts:</td>
<td>• Pelvic part is adjacent to cervix (danger of damage during surgical operation)</td>
</tr>
<tr>
<td>➢ Pars prostatica</td>
<td>• Easy infected</td>
</tr>
<tr>
<td>➢ Pars membranosa</td>
<td>• Conducts urine only</td>
</tr>
<tr>
<td>➢ Pars spongiosa</td>
<td></td>
</tr>
<tr>
<td>• Conducts urine and spermatozoa</td>
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Congenital abnormalities of male urethra:
- Hypospadia
- Epispadia
- Doubled urethra
- Narrowed urethra
Boundaries of the perineum

- Anterolateral: Ischiopubic ramus
- Anteriorly: Pubic symphysis
- Anterolateral: Ischiopubic ramus

- Laterally: Ischial tuberosity
  - Laterally: Ischial tuberosity

- Posterolateral: Sacrotuberus lig.
- Posterolaterally: Sacrotuberus lig.
- Posteriorly: sacrum/coccyx
Perineum

G 5.73, inferior view
1 - symphisis pubica;  
2 - os sacrum et os coccygis;  
3 - vesica urinaria;  
4 - rectum;  
5 - m. transversus perinei profundus;  
6 - m. bulbospongiosus;  
7 - m. ischiocavernosus;  
8 - m. levator ani;  
9 - m. gluteus maximus;  
10 - fascia glutea;  
11 - fascia diaphragmatis pelvis inferior;  
12 - fascia diaphragmatis urogenitalis superior;  
13 - fascia diaphragmatis urogenitalis inferior;  
14 - lig. transversum perinea;  
15 - fascia pelvis et m. sphincter urethrae;  
16 - fascia diaphragmatis pelvis superior;  
17 - lamina visceralis fasciae pelvis; 18 - m. transversus perinei superficialis;  
19 - fascia superficialis perinea;  
20 - fascia subcutanea;
1) **Fascia superficialis perinea** (common subcutaneous fascia) – (19)
2) **Fascia diaphragmatic pelvis inferior** (from m.gluteus maximus till posterior border of m.transversus perinei profundus) – (11)
3) **Fascia diaphragmatic pelvis superior** (above m. levator ani – continuation of fascia pelvis) – (16)
1) Fascia superficialis perinea (common subcutaneous fascia) – (19)
2) Fascia diaphragmatis urogenitalis inferior (below m. transversus perinei profundus = between deep and superficial muscles of perineum) – (13)
3) Fascia diaphragmatis urogenitalis superior (above m. transversus perinei profundus) – (12)
4) Fascia pelvis – (15)
Between Fascia diaphragmatis urogenitalis inferior and Fascia diaphragmatis urogenitalis superior:
- sphincter externus uretherici
- m. transversus perinei profundus
- bulbourethral glands (male)/vestibular gland (female)
Walls:
**Anterior** – transverse muscles of perineum;
**Posterior** – posterior border of m.levator ani and m.coccygeus
**Medial** – external surface of m.levator ani
**Lateral** – m.obturator internus, covered by its own fascia, and medial surface of tuber ischiadicum
Additional slides
Coronal section: anterior view

- Rectum
- Sigmoid colon
- Levator ani m.
- Ischio-anal fossa
- Anal canal
- Ischio-anal fossa
- Obturator Internus m.
- Pudendal (Alcock’s) canal
  - Internal pudendal a. & v.
  - Pudendal n.

sphincter

Netter6: 370
**Epididymis canals**

- control and regulation of semen secretion
- remove damaged sperm
- preservation of semen and stimulation of its maturation
**Funiculus spermaticus**

- Pampiniform plexus of testicular veins
- Testicular artery
- Ductus deferens + artery
- Smooth muscle cells
- Lyphatic vessels
- Nerves:
  - n. ilioinguinalis
  - n. genitofemoralis
Seminal vesicles
- tubes 15sm
- alkaline liquid with fructose, ascorbic acid, enzymes and prostaglandins (95%)
- maturation of spermen

Bulbourethral glands
- Liquid for neutralization of urine acidity
Prostate

- slightly acidic liquid with cytrate, enzymes, prostate-specific antigen (PSA)
- hypertrophy in adults – compression of urethra- risk of kidney infection
- prostate cancer – second place after lung cancer in males