Urinary system, development, developmental disorders

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Urinary system - *systema urinarium*
Kidney - *ren, nephros*
Renal pelvis - *pelvis renalis*
*Ureter*
Urinary bladder - *vesica urinaria*
Femal urethra - *urethra feminina*
Male urethra - *urethra masculina*
Development and congenital defects
Urinary system - organa urinaria, functions

Homeostasis (electrolyte and water balance), Excretion of metabolic products,

Production of urine – kidney 180 l/24 h primary urine – 1.8 l/24 h definitive urine
Transportation – pelvis, ureter, urethra
Accumulation – urinary bladder
Micturition
Endocrine functions (renin, erythropoietin)
Urinary tract of male is from prostate also part of genital tract
Structure of urinary tract organs – transitional epithelium (urothelium), smooth muscle layer, adventitia
Production of urine

180 l /24 h

primary urine –

1.8 l /24 h

definitive urine
Fetal renal function
Metanephros is functional since the second half of the prenatal period. The urine is excreted into the amniotic fluid and mixed with the fluid that the fetus swallows and resorbs.

Thus, the substances excreted in the urine go back into the bloodstream of the fetus and in the placenta they pass into the blood of the mother, which definitely excludes them. The excretion of the fetus thus fully depends on the function of the placenta of the mother.

Agenesis of the kidneys is manifested by reduced volume of amniotic fluid, but metabolic failure occurs after delivery.

(3 stages of the kidney development: pronephros, mesonephros (embryonic stages), metanephros (definitive kidney – in function from the week 20)
Kidney - ren (nephros) lateral + medial border, hilum, sinus, anterior + posterior surface, superior + inferior extremity
Position and the topography of the kidney

(Peritoneum, duodenum and pancreas were removed)
Position of the kidney in retroperitoneal Cavity of lumbar region (Th12 – L2)
Syntopy of the kidney
Syntopy of the anterior kidney surface (grey = peritoneum)
Syntopy of the posterior kidney surface

Subcostal n., iliohypogastric n., ilioinguinal n., diaphragm, iliopsoas, quadratus lumbum, transversus abdominis, costodiaphragmatic recessus
Syntopy of the kidney
Fibrous capsule, perinephric fat (capsula adiposa renis), renal fascia, paranephric fat (corpus adiposum pararenale)
renal cortex, medulla, lobi renales (pyramids) 5-14, renal papilla, cribiriform area, opening of papillary ducts (120 – 770)
Renal pelvis (ampullar x ramificate type), major (2-3) and minor (7-14) renal calices. Renal a., rami prepelvici, r. retropelvicus, segmental aa.
The renal arteries supply the kidneys. They include the right anterior (r. anterior), right posterior (r. posterior), segmental arteries (segmental aa.), and interlobar arteries (interlobar aa.).

The renal vascular segments include:
- Superior
- Anterior superior
- Anterior inferior
- Inferior
- Posterior

These segments are important for understanding the regional blood supply to the kidneys and for surgical or interventional procedures.
a. renalis, aa. segmentales, aa. interlobares, aa. arcuatae, aa. corticis radiatae, aa. rectae, arteriole afferentes, arteriole efferentes, peritubulare plexus (cortical. gl.), aa. rectae medullares (juxtamedullary gl.)
Uriniferous tubules: nephron = glomerular capsule + renal tubules (proximal convoluted, renal loop of Henle, distal convoluted tubule) glomerular filtration, selective tubular resorption (countercurrent multiplier and exchange system) tubular secretion, collecting duct papillary duct 180 l primary urine – 1.8 l definitive urine; 1 – 1.5 mio. of nephrons/kidney
Intrarenal vessels
arteries
segmental aa.
interlobar aa., arcuate aa.
cortical radiate aa.
afferent + efferent
glomerular aa.
intertubular capillary
plexuses x straight
medullar arterioles
veins
interlobar vv., arcuate vv.,
cortical radiate vv.
straight vv., stellate vv.
glomeruli, rete capillare peritubulare
Glomerular capillaries
Juxtaglomerular apparatus (JGA): dense macula (chemosensitive area of distal tubule), juxtaglomerulal cells of media of afferent a. producing renin, pole cushion (extraglomerular mesangium). JGA - feedback device regulating perfusion of glomerule by renin production.

Urinary filter: endothelium, basal lamina, podocytes
Renal pelvis, calices

Branching x ampullary type
Major + minor calices
Muscular layer (contraction waves),
mucous membrane, urothelium
X-ray of pelvis and ureter
Ureter
(25-30 cm)
Parts:
- abdominal
- pelvic
- intramural

3 constrictions

ureteric point

muscular layer
mucous layer
Transverse section of female pelvis
Peritoneal space of lesser pelvis in female

ureter
x a. uterina
Urinary bladder (vesica urinaria)
Apex, body, fundus, neck, uvula, trigon of bladder, ureteric orifice, internal urethral orifice, interureteric crest, serous coat, subserous layer, muscular layer, detrusor, trigonal muscle, submucousa, mucosa,
vesico-uterine pouch, recto-uterine pouch, pubovesical lig., retropubic space, vesico-vaginal septum, paracystium, recto-vaginal septum
Vessels + nerves: superior + inferior vesical artery, venous plexus, parasympathetic nerves (S2-4) activate detrusor, sympathetic nerves (L1-3) innervate sphincter in male, common and internal iliac nodes
Female urethra

Fibromuscular tube (4 cm) internal orifice, (filling, voiding) external orifice
Parts: intramural, pelvic, perineal, external urethral sphincter, urethral glands, (para-urethral ducts)
External urethral sphincter, Sphincter urethrovaginalis, Compressor urethrae
**Tractography** is a 3D modeling technique used to visually neural tracts is used to illustrate the course of muscle fibres using data collected by diffusion tensor imaging (DTI). It uses special techniques of magnetic resonance imaging (MRI), and computer-based image analysis. The results are presented in two- and three-dimensional images.

Fiber tractography representing the urethral sphincter complex from cranial (C) and posterior view (D).
External urethral sphincter consists of slow striated muscle fibres producing long lasting contraction

localization – urogenital diaphragm

innervated from nucleus of Onuff in spinal segments S2-3.

Axons arrive the muscle via inferior hypogastric plexus
Magnetic resonance image of female pelvis in plane of the urogenital hiatus (level 2 according to DeLancey)
Pelvic floor, perineum
levator ani, diaphragma urogenitale, perineal muscles
Levator ani, diaphragma urogenitale, perinealní svaly

1 – pubococygeus, 2 – iliococcygeus
3 – puborectalis, 4 – coccygeus
5 – obturatorius int.
Anatomy of the pelvic outlet (scheme based on MRI)

- Symphysis
- Tendinous arch of levator ani
- Urogenital hiatus
- Tendinous arch of pelvic fascia
- Urethra
- Vagina
- Anal canal
- Puborectal sling (levator ani)
- Hammock-like supportive layer
Urogenital hiatus
Urinary continence
The urethra lies on a supportive layer composed of the endopelvic fascia and the anterior vaginal wall. This layer gains structural stability through its lateral attachment to the tendineus arch of levator ani muscle.

Pressure from above compresses the urethra against this hammock-like supportive layer, and close its lumen. The stability of the suburethral layer depends on the intact connection of the vaginal wall and endopelvic fascia to the arcus tendineus fasciae pelvis and levator ani muscles. the urethra is compressed against a hammock-like supportive layer (J. DeLancey, 1994)

Urinary incontinence
also known as involuntary urination, is any leakage of urine. It is a common and distressing problem. Surgical therapy: tension-free vaginal tape, and bladder suspension
Hammock
Tendinous arch of levator ani

Tendinous arch of endopelvic fascia
New surgical technique for treatment of stress urinary incontinence: tension-free urethral suspension
Syntopy of the urinary bladder in male

Recto-vesical pouch, pubo-vesical lig., pubo-prostatic lig., retropubic space, recto-vesical septum, paracystium
Trigonum interampullare

Urinary bladder frontal section of pelvis at the level of prostate
Interampullar trigone
Male urethra
(ca 20 cm)
internal orifice,
parts: intramural, prostatic, seminal colliculus, prostatic sinus, internal urethral sphincter, membranous, external urtehral sphincter, bulbo-urethral gland spongy, urethral glands, urethral lacunae, external orifice navicular fossa
Development of the perineum and external genitalia; indifferent stage – female
Abnormal urethral orifices

Hypospadias
Development of urinary system
pronephros
mesonephros
mesonephric duct (Wolffian), ureteral bud
metanephros,
cloaca, urogenital sinus
The excretory system develops from the intermediate mesoderm.
Figure 16-8 Later changes in the development of the metanephros.
Signaling molecules and transcription factors on the beginning of nephrogenesis. Sprouts of the ureteric bud - yellow, nephrogenic blastema cells - brown.
NEPHROGENESIS is the result of Inductive interactions between branching ureteric bud and mesenchyme of nephrogenic blastema.

From ureteric bud develops the collecting system (collecting tubules, papillary ducts)
From nephrogenic blastema originates excretory unit (glomeruli, nephron tubules). Nephrogenic cells secrete VEGF, which is involved in the formation of glomerular capillary loops.
Figure 16-5 Stages in the development of a metanephric tubule.
Figure 16-9 A-C, Migration of the kidneys from the pelvis to their definitive adult level. D, Cross section of the pathway of migration of the kidneys out of the pelvis.
Figure 16-14 Migration defects of the kidney. A, Pelvic kidney. B, Crossed ectopia. The right kidney has crossed the left ureter and has migrated only part of the normal distance.
Figure 16-12 Common renal anomalies. A, Unilateral renal agenesis. The ureter is also missing. B, Unilateral renal hypoplasia. C, Supernumerary kidney. D and E, Complete duplication of ureter, presumably arising from two separate ureteric buds. F and G, Partial duplication of ureter, presumably arising from a bifurcated ureteric bud.
Sources of illustrations used:
Gray’s Anatomy,
Sobotta: Atlas der Anatomie des Menschen
Grim, Druga: Regional anatomy. Galén, Prague 2012
Benninghoff, Drenckhahn: Anatomie I., II.
Carlson, B.M.: Human Embryology and Developmental Anatomy

Recommended Textbooks:
or
and
Sobotta Anatomy Textbook, Waschke et al., edit. Elsevier 2019