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Department of Anatomy

ANATOMY OF THE UROGENITAL SYSTEM

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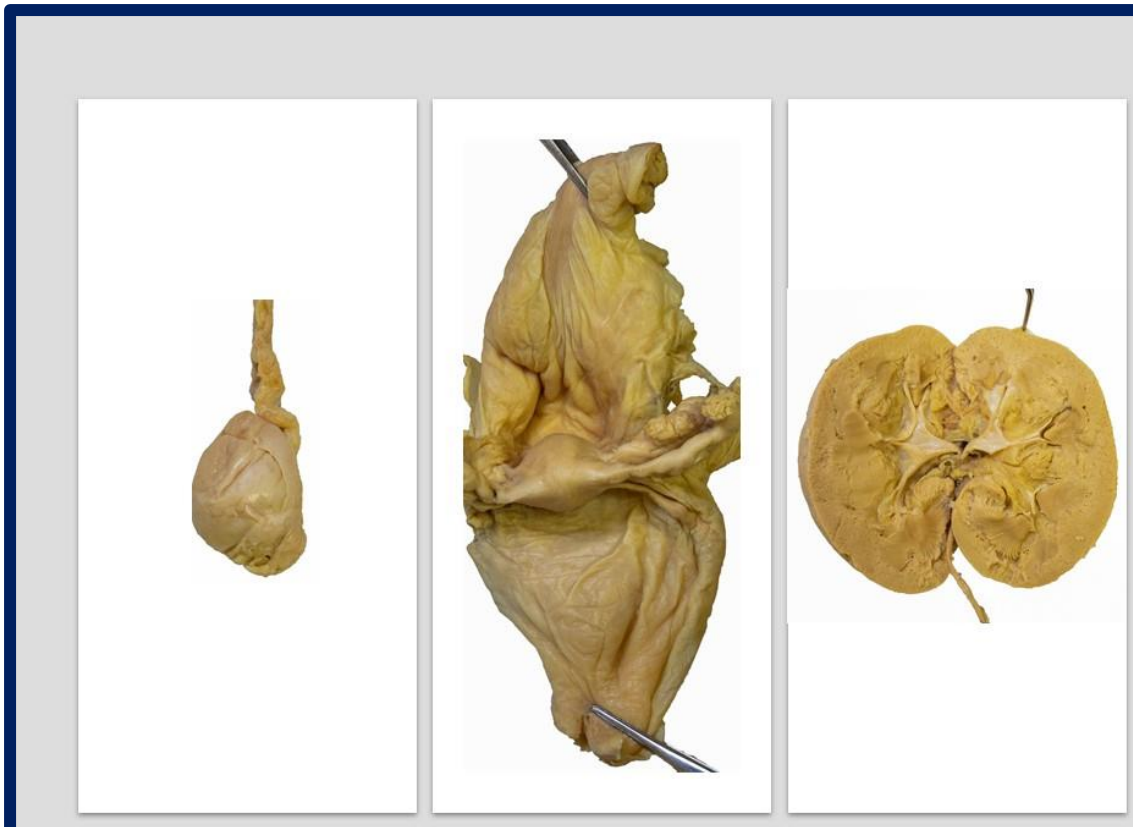

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Preface

The textbook was composed for the pre graduate medical students as the basic educational material. It contains the solid theoretical basis of the anatomy of the urogenital system with a focus on clinical application.

The textbook has four chapters. The first chapter describes the organs of the urinary system, the second and the third deals with the male and female genital system, respectively. Each organ is described as for the position and relations, external description, internal structure (or the wall), blood supply, lymph drainage, and innervation. The theoretical parts are completed by clinical columns. The fourth chapter contains the review questions that may help students verify their knowledge. Although the textbook contains schemas, photographs of formalin-fixed cadaveric specimens and modified figures from public domain, Henry Gray 'Anatomy of the Human Body' (Philadelphia: Lea & Febiger, 1918), it is necessary to use the anatomical atlas, too (Sobotta's, Gilroy's, Netter's or Gray's atlas of human anatomy). Only parallel usage of the textbook and the atlas is effective and may lead to the optimal study result.

We believe that students will find this textbook to be valuable material for their study and review of anatomy.

Authors

1 URINARY SYSTEM

The urinary system consists of **the kidneys** and **organs of the efferent urinary tract: renal calices, renal pelvis, ureter, urinary bladder and urethra**.

1.1 KIDNEY (REN in Latin, NEPHROS in Greek)

The **kidneys** are indispensable organs due to their excretory, regulatory and endocrine functions.

The kidneys filter the blood to excrete (eliminate) waste products such as urea, uric acid, or foreign substances along with water, creating urine.

They also maintain balance between fluids and electrolytes and regulate acid – base homeostasis.

The kidneys also perform the following endocrine functions:

- *renal interstitial fibroblasts produce the erythropoetin that influences the production of erythrocytes in the bone marrow*
- *in the kidneys, hydroxycholecalciferol is hydroxylated to hormonally active calcitriol (1,25 - dihydroxycholecalciferol) involved in the regulation of calcium absorption and mineral metabolism*
- *renal juxtaglomerular cells convert prorenin into renin, the important enzyme for the regulation of blood pressure.*

Position and relations of the kidneys

Both kidneys are situated at the posterior abdominal wall on the sides of the vertebral column. They are located within the fatty tissue behind the parietal peritoneum that lines the posterior abdominal wall. They are **retroperitoneal in position**.

The kidneys extend from the level of TXII to the level of LII – LIII.

The right kidney is below the liver and, therefore, slightly lower than the left one. The superior pole of the right kidney extends to the level of the rib XII.

The superior pole of the left kidney reaches to the rib XI (see Fig. 1).

Kidneys move around 2 – 3 cm upward and downward during the deep respiration.

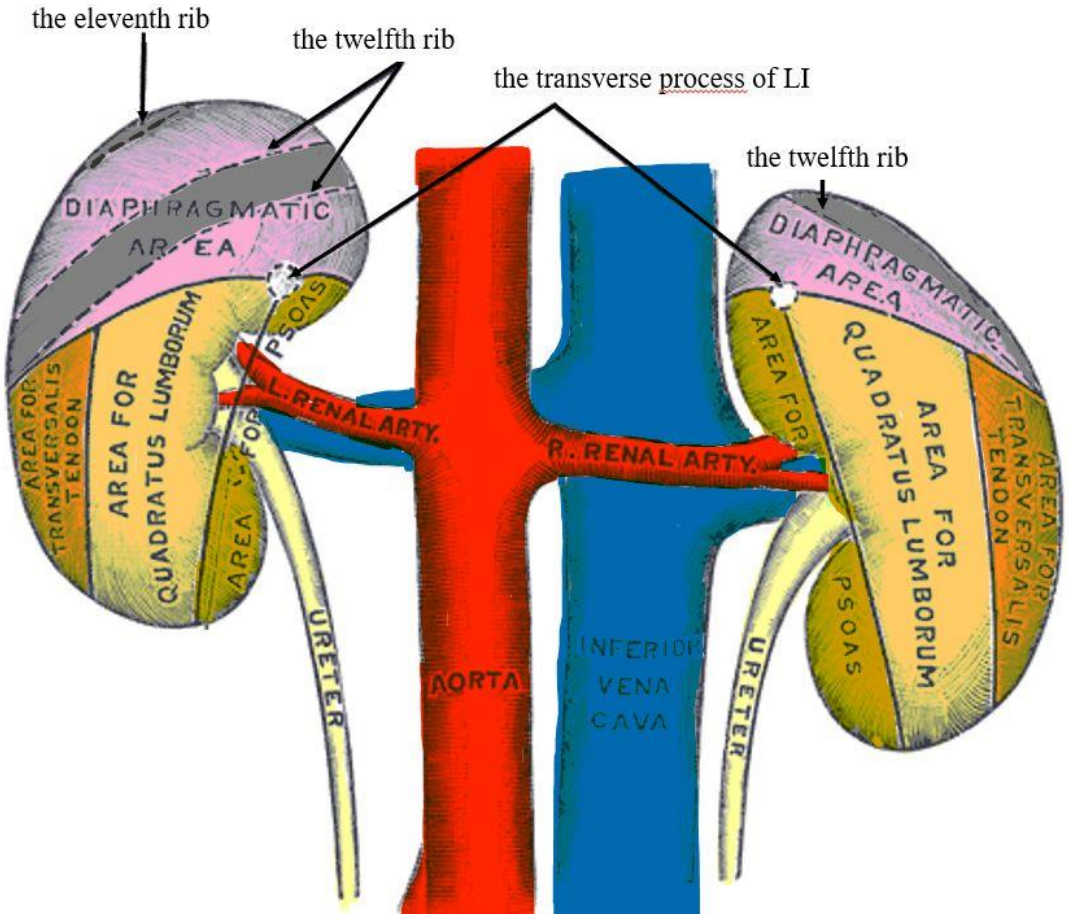

Fig. 1 Posterior surface of the kidneys. Areas of the muscle relations.

Original diagram from Gray's anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the Human Body. Philadelphia: Lea & Febiger, 1918. Available online: at Bartleby.com, 2000. www.bartleby.com.
Modified by additional colorization and labeling.

The posterior surface of both kidneys is related to **the ribs** (rib XI and rib XII), **muscles and nerves** (see Fig. 1).

The upper part of the posterior surface of both kidneys is **related to the diaphragm**. The lowermost part of the pleural cavity, the costodiaphragmatic recess, extends behind the upper half of the kidney.

The lower half of the posterior surface is related to **the transversus abdominis muscle** (laterally), **the quadratus lumborum muscle** (in the middle) and **the psoas major muscle** (medially).

There are three **nerves** running in close proximity behind the kidneys: **subcostal, iliohypogastric and ilioinguinal nerves.**

The subcostal nerve is the uppermost one. It is accompanied by the subcostal vessels.

The iliohypogastric nerve and **the ilioinguinal nerve** (both arising from the lumbar plexus) run behind the kidney more inferiorly.

*This **relation is clinically important** because the pathological process, e.g. inflammation or tumours, may affect these nerves. **Nerve irritation** results in the typical symptom of '**radiating pain**' corresponding to the sensory distribution of nerve fibers. Radiating pain in the area above the inguinal ligament reflects irritation of the iliohypogastric, radiation in the inguinal region, and in the skin of the scrotum or labia majora when the ilioinguinal nerve is affected.*

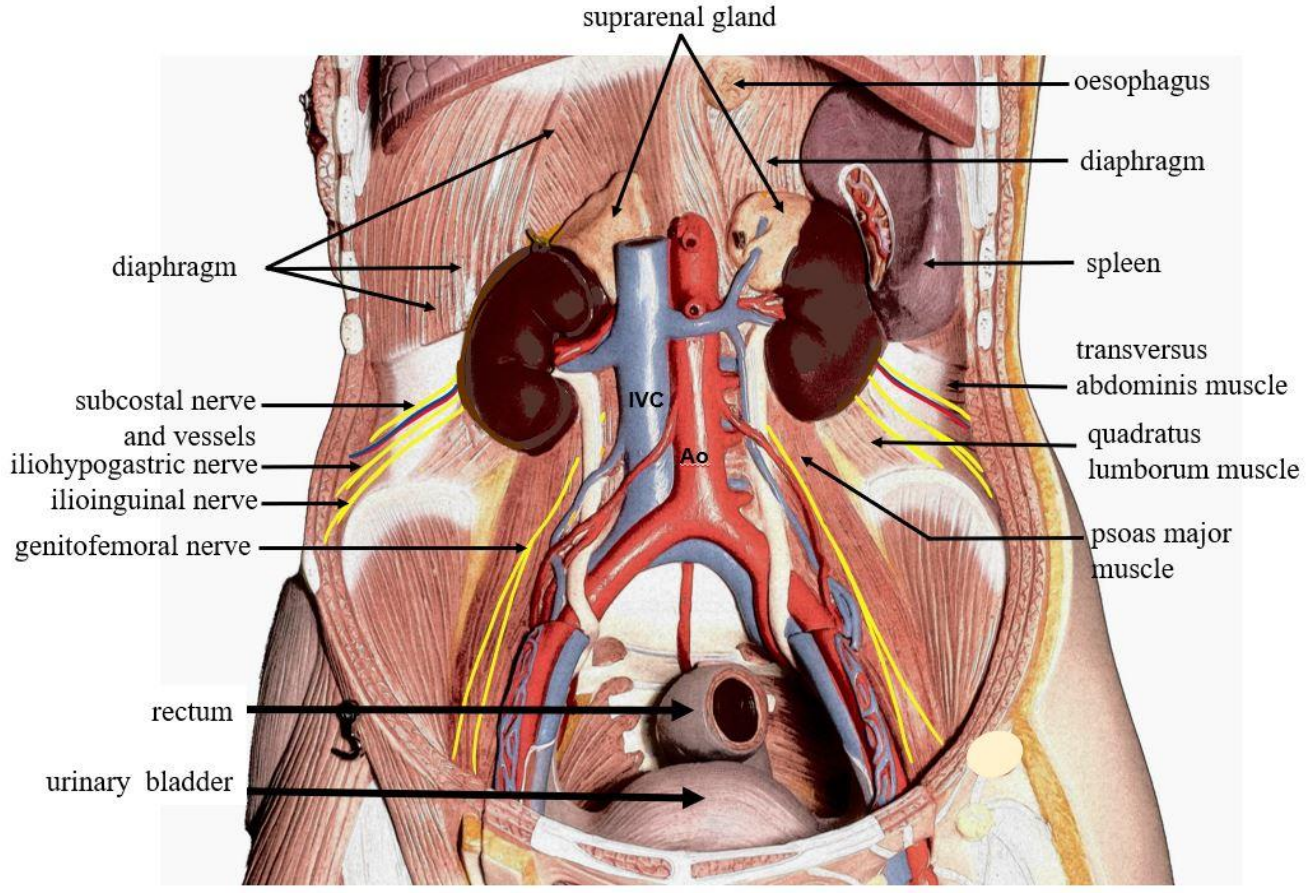

Fig. 2 Posterior abdominal wall with the kidneys relations.

Phototography of SOMSO model, modified by additional drawing, labeling and colorization.

The superior pole (extremity) of both kidneys is related to **the suprarenal (adrenal) gland**, **the inferior pole** (extremity) **to the coils of the jejunum**.

The anterior surface of the kidneys is related to **the abdominal organs**.

The anterior surface of the right kidney is related to the visceral surface of the **liver**, the descending part of the **duodenum**, **right colic flexure** and **the coils of the jejunum**.

The anterior surface of the left kidney is in relation to the visceral surface of **the spleen**, the posterior wall of **the stomach**, the body of **the pancreas** , **the left colic flexure** and **the coils of the ileum** (see Fig. 2).

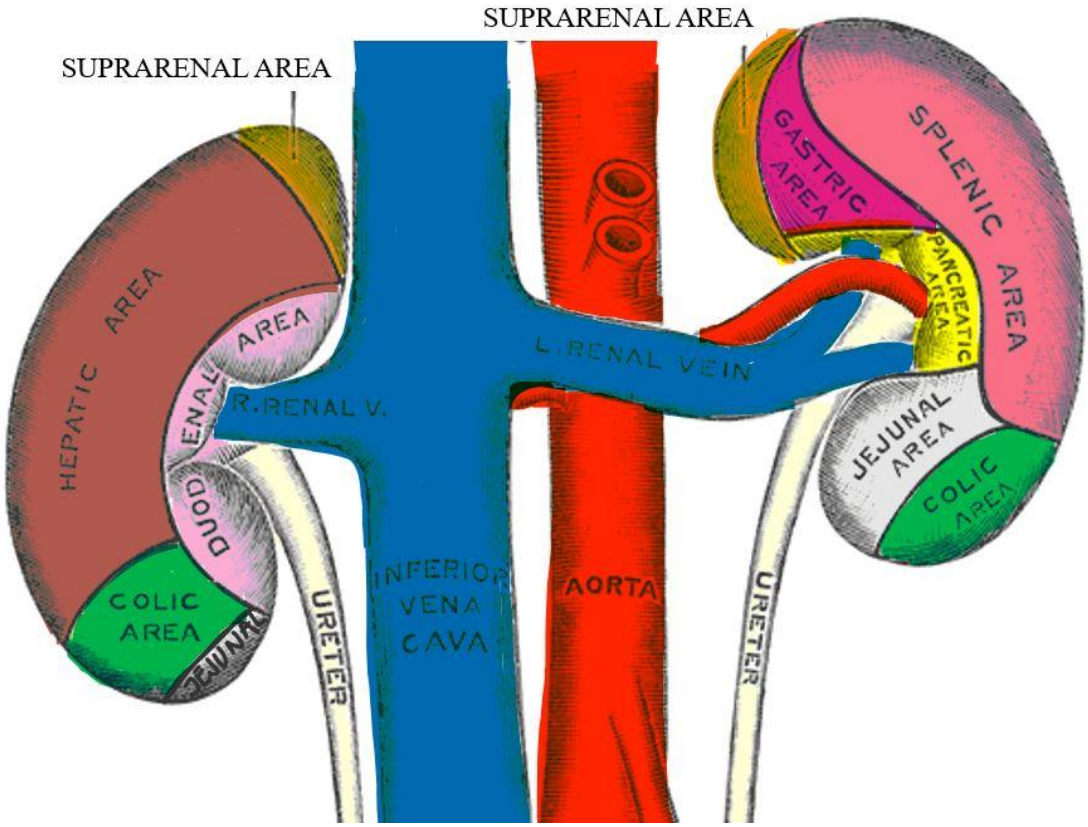

Fig. 3 Anterior surface of the kidneys. Areas of the organ relations.

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Modified by additional colorization and labeling.

Palpation of the kidneys *is usually very difficult. The left kidney is not palpable under physiological conditions. It may be felt when it is enlarged or ectopic. The inferior pole of the right kidney may be palpated, especially in thin persons. A bimanual examination in a lying person is usually used. The left hand presses the back (right flank) in the area between the 12th rib and the iliac crest. The right hand deeply palpates immediately below the right costal margin, while the examined person deeply inhales.*

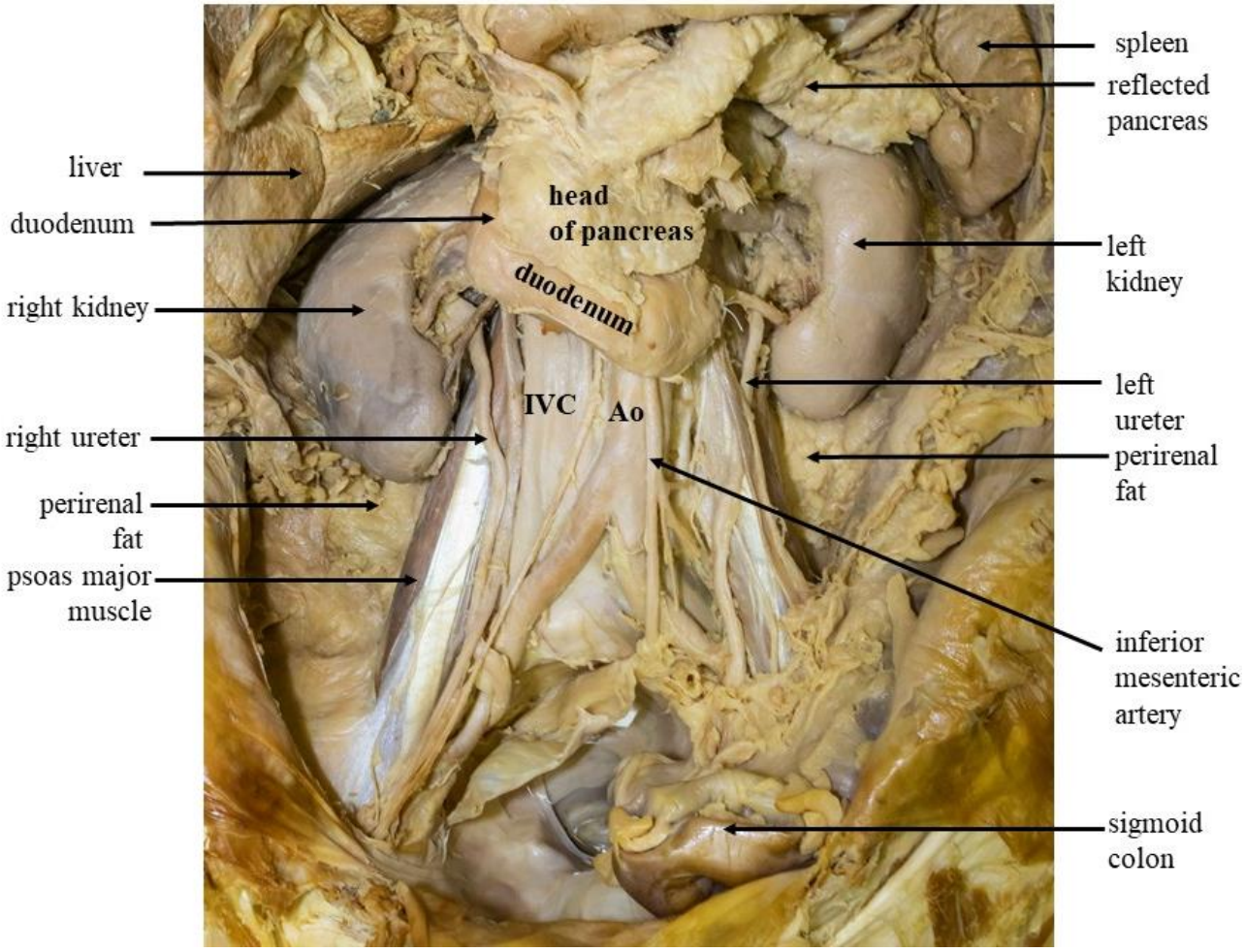

Fig. 4 Kidneys at the posterior abdominal wall 1.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

External description of the kidney

The kidneys are **redbrown bean - shaped** organs. They are slightly **ventrodorsally flattened**.

The average weight of each kidney is 140 – 150 g. Its length is approximately 11 cm, transverse dimension 6 cm, and ventrodorsal dimension 3 cm.

The left kidney is slightly longer and slender. In the frontal plane, the long axis of each kidney is not parallel to the vertebral column; however, it is directed inferolaterally.

Each kidney is ventrodorsally flattened and shows **the anterior and posterior surfaces, the superior and inferior poles (extremities).**

The surfaces of the kidney meet at a convex **lateral border** (margin) and a concave **medial border** (margin).

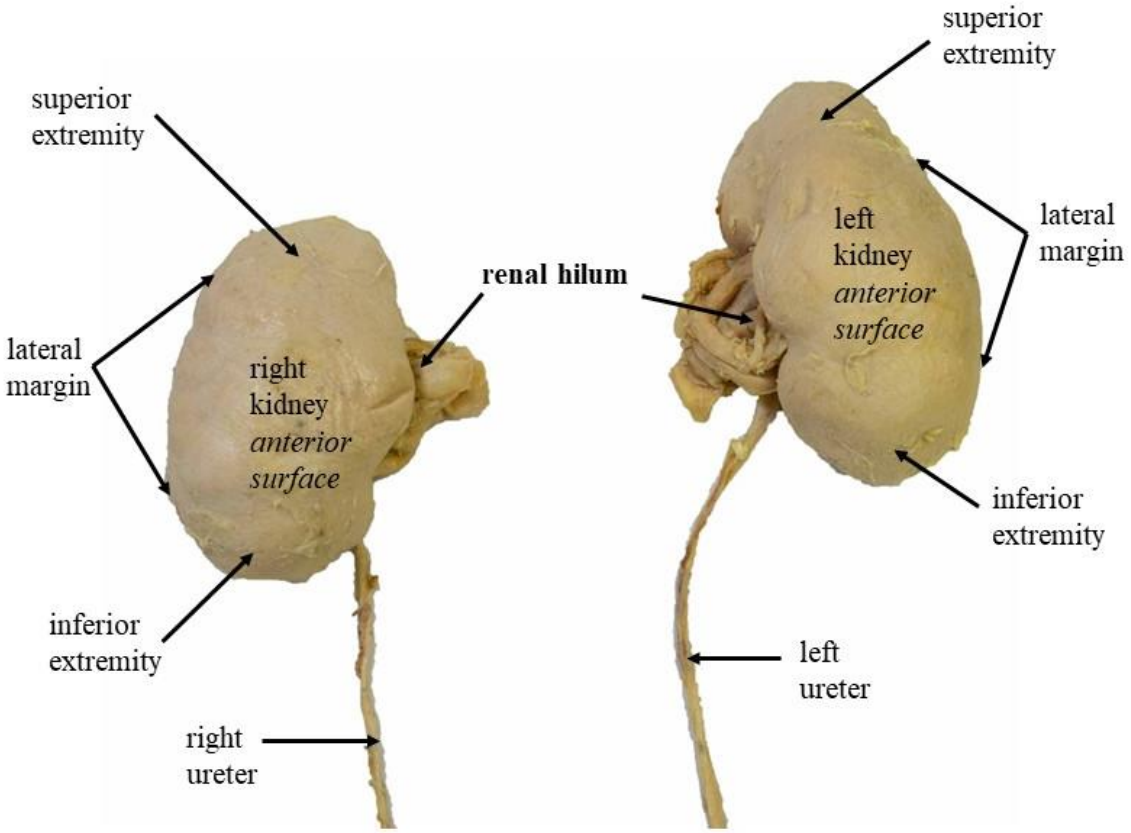

Fig. 5 Kidneys.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

The renal hilum continues into the renal sinus, which is usually described as the cavity or pocket in the kidney. *The renal hilum is „the door into the space - the renal sinus"*. In the middle part of the medial border there is a vertical slit, **the renal hilum (renal hilus)**. It is the site where the renal vessels and nerves and the renal pelvis enter and exit the kidney. The common arrangement of the structures in the renal hilum in ventrodorsal direction is : the renal vein, the anterior branch (ramus) of the renal artery, the renal pelvis and the posterior branch (ramus) of the renal artery. **The right renal hilum** projects to the level of LI – LII and **the left renal hilum** to the level of LI.

The renal sinus contains the renal calices, the renal pelvis, renal vessels and nerves. All structures contained in the renal hilum and the renal sinus are **surrounded by the perirenal (perinephric) fat.**

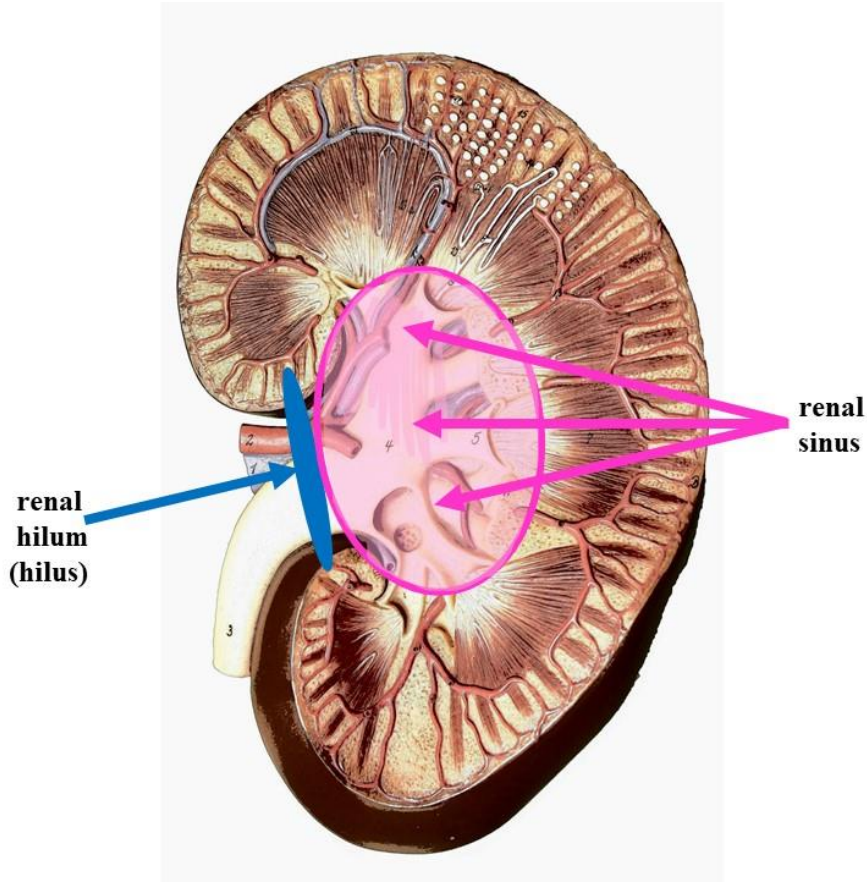

Fig. 6 The renal hilum and the renal sinus.

Phototography of SOMSO model, modified by additional drawing, labeling and colorization.

During embryonic development, the kidneys first differentiate in the pelvis and subsequently ascend to the final position. In some cases, the ascent may be absent or incomplete and the ***ectopic kidney can be found,*** *most often in the pelvis. Sometimes both kidneys may be found on the same side as crossed ectopic kidneys. The most common developmental anomaly is the* ***horseshoe kidney*** *when the kidneys fuse through a transverse ridge or isthmus between the inferior extremities (poles).*

Transplatation of the kidney *is usually the treatment of choice for patients with a severe renal failure. Due to the longer left renal vein, the left kidney of the donor is preffered. The kidney is implanted into the iliac fossa below the peritoneum (surgeons do not open the peritoneal cavity but detach the peritoneum more medially), the renal vessels are connected to the external iliac vessels and the ureter to the urinary bladder.*

Internal structure of the kidney

The surface of the kidney (parenchyma of the kidney) is covered by the dense connective tissue (collagen rich tissue), **the fibrous capsule** (see Fig. 7).

It can be easily removed from the kidney during the dissection under the physiological conditions. However, in some renal diseases, e.g. inflammation of the renal parenchyma, the fibrous capsule may adhere tightly to the renal cortex.

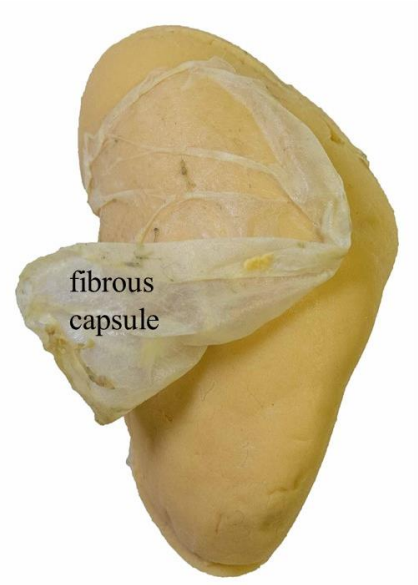

Fig. 7 Fibrous capsule of the kidney.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

The parenchyma of the kidney forms **the renal cortex** and **the renal medulla**.

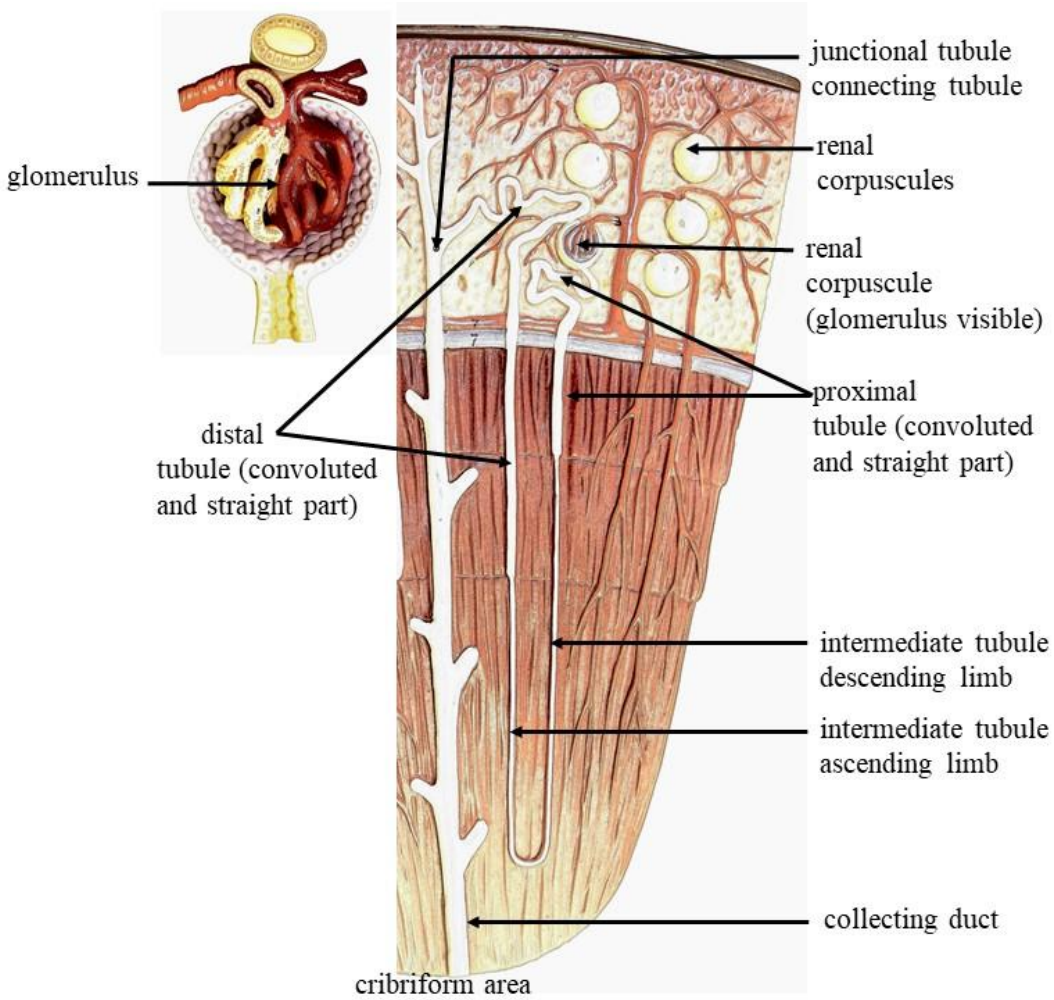

Fig. 8 Renal lobe and nephron.

Phototography of SOMSO model, modified by additional drawing, labeling and colorization.

The functional unit of the kidney is the microscopic structure, the nephron (see Fig. 8).

The human kidney contains around one million nephrons. Each nephron consists of the renal corpuscule, proximal, intermediate and distal convoluted tubules. The loop of Henle consists of the straight part of the proximal tubule, intermediate tubule and the straight part of the distal tubule. The renal corpuscule contains the network or cluster of capillaries (glomerulus) surrounded by a double – layered Bowman's capsule. The loop of Henle consists of the straight part of the proximal tubule,the intermediate tubule and the straight part of the distal tubule.

In the renal corpuscule, primary urine (approximately 150-180 l per day) is formed by filtration of blood in glomerular vessels. The ultrafiltrate, the primary urine, enters the Bowman's space and

then it continues to **the proximal convoluted tubule, intermediate tubule and distal convoluted tubule**.

In this system of tubules, some substances, especially water, Na^+, Ca^{2+},Cl^-, Mg^{2+}, HCO_3^-, glucose, lactate, amoinoacids, vitamins, etc., are reabsorbed into the blood of the peritubular capillary network. Other substances such as ammonium, uric acid, creatinine, or drugs are secreted to the tubules. The reabsorption and secretion of some molecules in the tubules are under the control of hormones (e.g. aldosteron, antidiuretic hormone, natriuretic peptide or parathormone). The distal convoluted tubules open into the collecting duct that opens at the renal papilla and releases the final urine to the minor renal calyx.

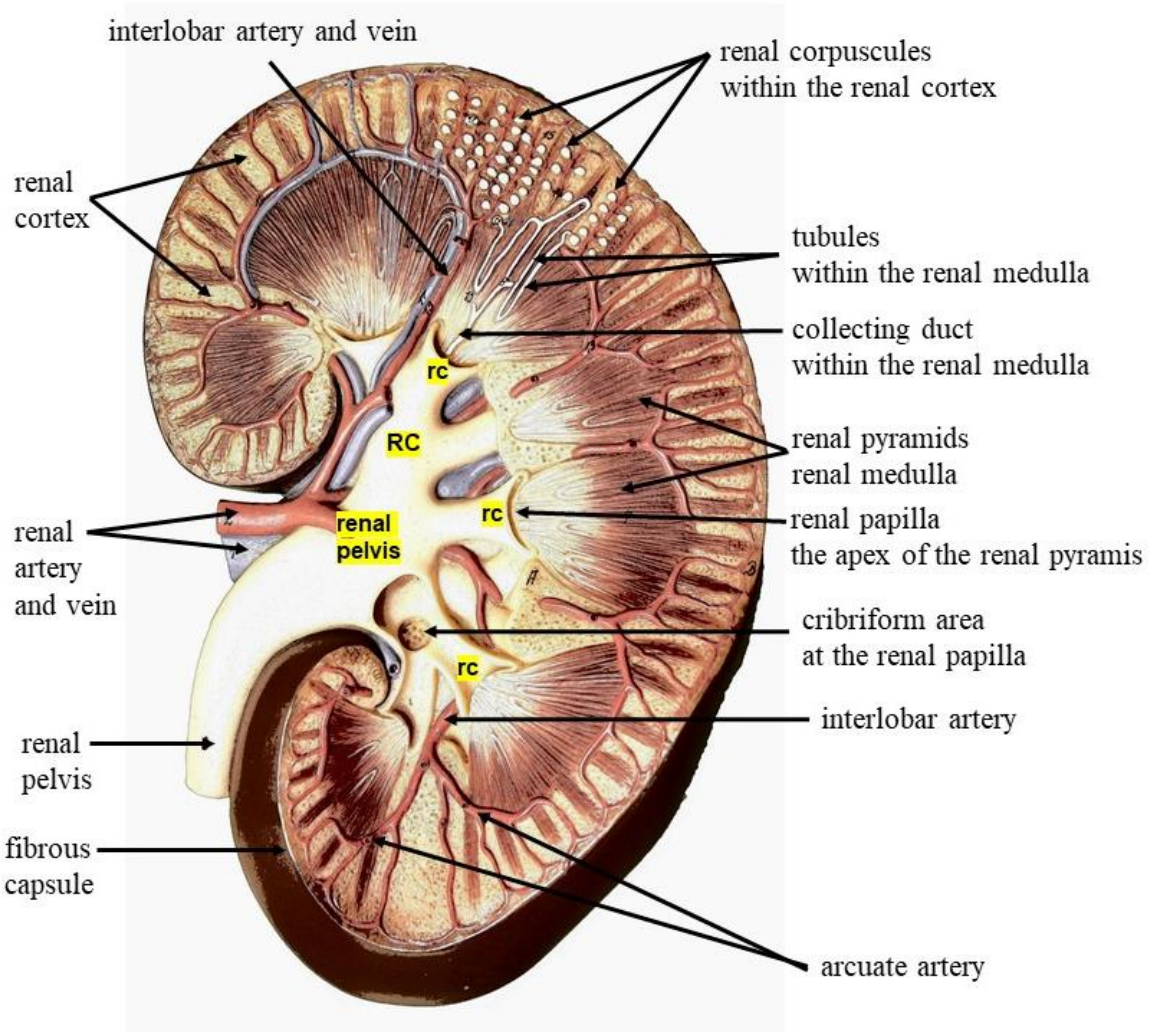

Fig. 9 Frontal section of the kidney.

Rc – minor renal calyx, RC – major renal calyx

Phototography of SOMSO model, modified by additional drawing, labeling and colorization.

The renal cortex is a layer situated immediately **below the fibrous capsule.** It is pale (lighter than the medulla) and has a grainy appearance due to the content of the renal corpuscules. The cortex extends deeper, forming the renal columns between the pyramids. As for the position of the nephron parts, there are the renal corpuscules, proximal and distal tubules, and cortical parts of collecting ducts within the renal cortex (see Fig. 9).

The renal medulla is deeper and forms **the renal pyramids**.
There are usually 10 – 14 renal pyramids in each kidney.

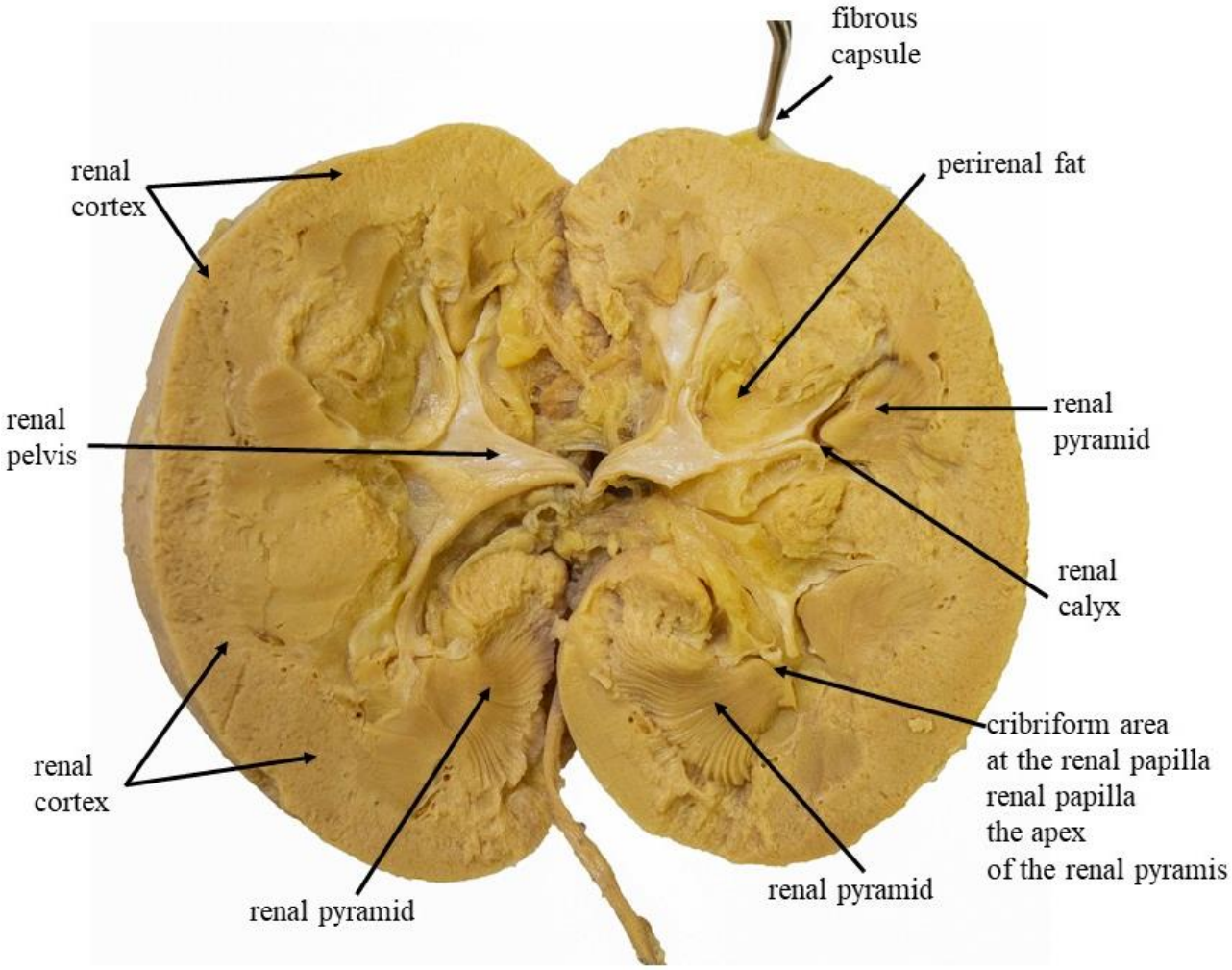

Fig. 10 Frontal section of the kidney.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

The renal pyramids contain the loops of Henle and the medullary parts of the collecting ducts. The bases of the renal pyramids direct to the cortex and outward surface of the kidney. The apices of the pyramids, **renal papillae**, project to the minor calices within the renal sinus. **Each renal papilla** (apex of the pyramid) is **surrounded** by **the minor calyx** (see Fig. 9).

The renal papilla, is a sievelike area (cribriform area). The collecting (papillary) ducts open on the renal papilla **as papillary foramina**. Through the papillary foramina, urine enters the minor calyx, the initial part of the urinary tract.

The pyramid with the adjacent cortex form **the renal lobe**.

The kidneys are subdivided into **the renal segments** with respect to the branching of the renal artery: **superior segment, anterior superior segment, anterior inferior segment, inferior segment and posterior segment**.

Envelopes of the kidneys

The kidneys are embedded in fatty tissue, **perirenal (perinephric) fat,** or **adipose capsule** (see Fig. 11).

The perirenal fat also surrounds the suprarenal glands and the renal vessels. It enters the renal sinus, where it surrounds the renal calices and renal vessels.

Perirenal fat has an important mechanical protective function, it secures the kidney when it moves during the respiration and it also contributes to the fixation of the kidneys in their position. This fat dissapears only at extreme weight loss.

The kidney in perirenal fat is enclosed by dense connective tissue, **renal (perirenal) fascia.** It also encloses the suprarenal glands (see Fig. 11 and Fig. 12).

*The **suprarenal gland** is enclosed by the renal fascia, however, it is situated in its own fascial compartment tightly connected to the diaphragm. Therefore, during the nephroptosis (dropped kidney), the suprarenal gland separates from the kidney and remains in its original position.*

The renal (perirenal) fascia consists of anterior and posterior layers that **fuse superiorly and laterally**. Superiorly the fascia fuses with the diaphragmatic fascia. Laterally both fused layers may reach the transversalis fascia. **Medially and inferiorly the anterior and posterior layers do not fuse and the perirenal space remains open**.

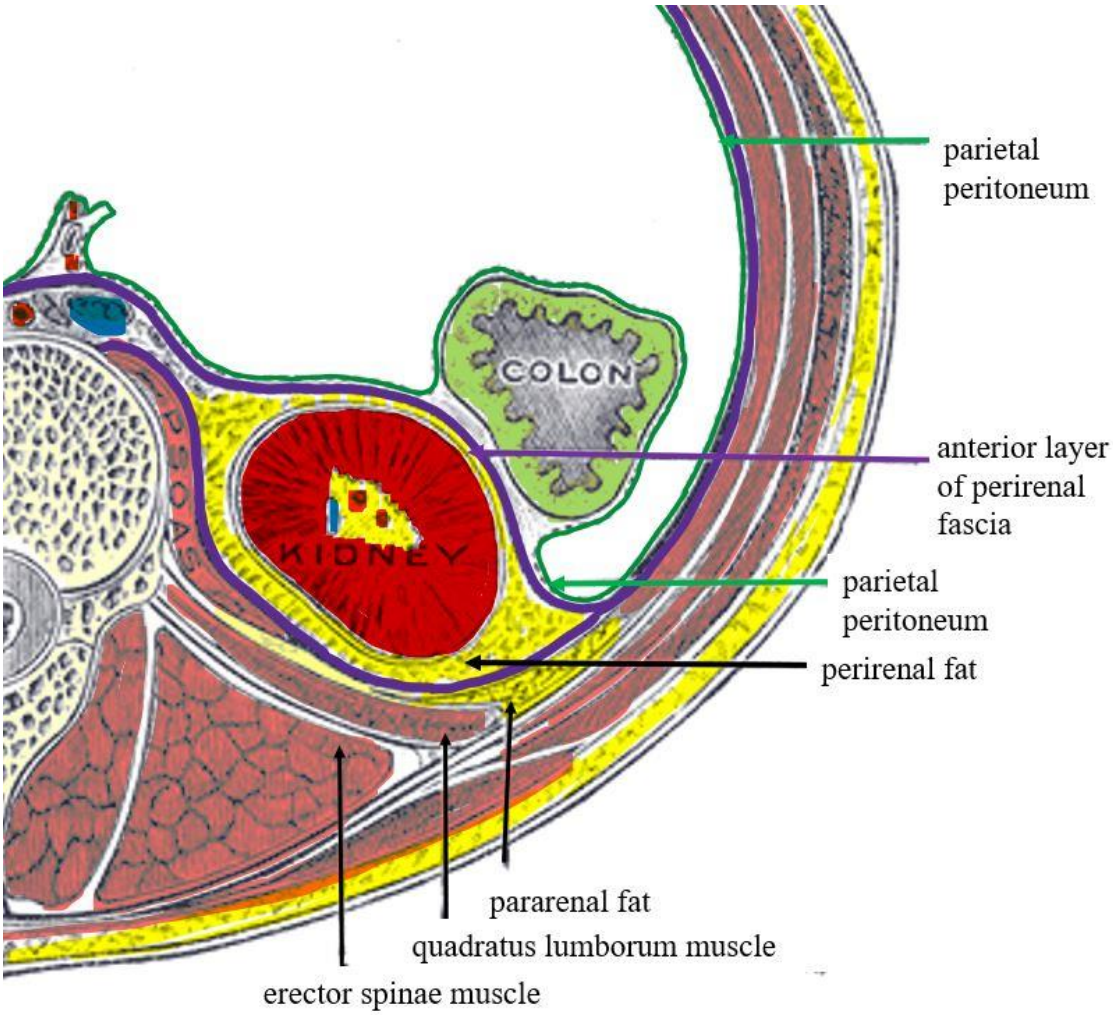

Fig. 11 Envelopes of the kidney. Transverse section of the trunk.

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Modified by additional colorization and labeling.

The anterior layer of the renal (perirenal) fascia continues medially and covers the renal vessels and pelvis passing through the renal hilum and finally fuses with the connective tissue around the abdominal aorta and the inferior vena cava.

The posterior layer of the renal (perirenal) fascia fuses with the fascia of the quadratus lumborum muscles and more medially with the fascia of the psoas major muscle. Inferiorly the anterior and posterior layers do not fuse and the perirenal space opens to the iliac fossa. Inferomedially, the layers of renal fascia fuse with the connective tissue around the ureters.

The pararenal (paranephric) fat is the fatty tissue accumulated posteriorly and posterolaterally behind the kidney immediately outside the renal fascia (see Fig. 11).

These envelopes of the kidney, together with the apposition of neighbouring organs and renal vessels, are crucial for the physiologic position of the kidneys.

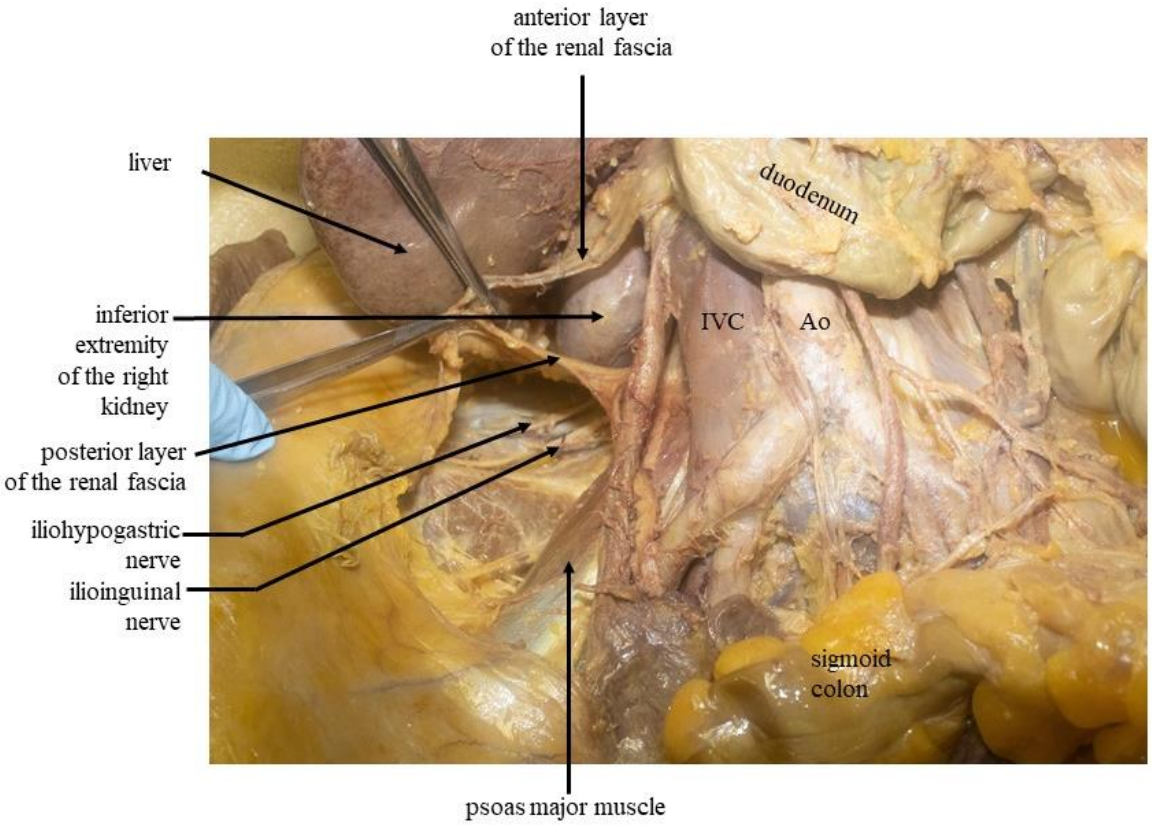

Fig. 12 Envelopes of the kidney. Posterior abdominal wall 2.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

Blood supply, lymph drainage and nerve supply of the kidneys

The renal arteries arise **from the abdominal aorta**.

The right renal artery arises from the aorta slightly lower than the left renal artery (the right kidney is lower than the left one). The right renal artery has a longer course than left one, passing behind the inferior vena cava. Each renal artery continues to the hilum and divides into the **anterior and posterior ramus**. These rami give off the **segmental arteries** that supply the renal segments.

*Sometimes, the **accessory renal arteries** can be found. They do not enter the renal parenchyma through the renal hilum however outside it, e.g. superior polar artery or inferior polar artery that enters the superior or inferior renal pole (extremity).*

Inside the renal parenchyma the segmental arteries divide to **the lobar arteries** continuing to the interlobar arteries that run along the pyramids. At the medulla - cortex interface, the interlobar arteries supply the arcuate arteries and these give off the interlobular arteries radiating into the renal cortex.

The above - mentioned intrarenal arteries have accompanying veins. **Venous blood** from the peritubular plexuses is drained to the interlobular veins and then the blood continues to the arcuate veins, interlobar veins and finally the blood empties into the renal veins.

The left renal vein runs in front of the aorta and behind the superior mesenteric artery. It receives the left suprarenal vein, left gonadal vein and left inferior phrenic vein. The corresponding veins on the right side are drained directly into the inferior vena cava.

The renal veins run ventrally in front of the renal arteries and open into the inferior vena cava. **The right renal vein** is three times shorter than the left one due to the position of the inferior vena cava, which lies more on the right side.

Aneurysms of the aorta or superior mesenteric artery in this area can be the reason for the compression of the left renal vein or left renal vein entrapment syndrome.

*The **long left renal vein** is the reason why the left kidney is predominantly taken from a living donor for transplantation.*

The lymph from the kidneys is drained into the **lumbar lymph nodes** and then into the **lumbar trunks**.

The renal nervous plexus consists of **the sympathetic, parasympathetic, and sensory fibers.** Majority of the fibres are **the sympathetic fibres** coming from the aortic plexus, coeliac ganglion and coeliac plexus. These fibers are vasomotor efferents to the afferent and efferent arteriols responsible for the vasoconstriction, and in this way they affect the blood flow through the glomeruli. **Parasympathetic fibers** are renal branches of **the vagus nerve**. **Sensory fibers** come from the fibrous capsule through spinal nerves to segments T10 a T11. The parenchyma of the kidney is practically without sensory afferents. It is supposed that some sensory fibres run within the vagus nerve what may explain nausea and vomitus accompanying the renal pain.

1.2 THE ORGANS OF THE EFFERENT URINARY TRACT

The organs of the efferent urinary tract transport urine out of the body. The urine is revealed from the papillary foramina at the apices of the renal pyramid to **the minor calices**. From the minor calices the urine continues to **the major calices**, then the **renal pelvis** and through the ureter to the **urinary bladder,** where it is stored. The **urethra** is the terminal part of the urinary tract.

1.2.1 RENAL CALICES AND RENAL PELVIS (PYELOS)

The renal calices and **the renal pelvis** form the **proximal part of the urinary tract**.

External description and position of the calices and renal pelvis

Each renal papilla is surrounded by **a minor calyx**. There are usually 7-14 minor renal calices, their number is similar to the number of renal pyramids. Usually, one minor calyx is attached to one renal papilla, only rarely one calyx surrounds two or three papillae. The minor renal calices receive the urine drops from the papillary foramina that are the openings of the collecting ducts.

From the minor renal calices, the urine continues to the **major renal calices and to the renal pelvis.** There are usually **three major renal calices**: superior, middle and inferior. Sometimes only the superior and inferior major calyx can be found.

All **renal calices are located in the renal sinus.**

The renal pelvis (in Greek pyelos) is a funnel shaped ventrodorsally flat organ.

It is **situated in the renal sinus (intrarenal part)**, then leaves the sinus through the renal hilum, and after that narrows and continues inferomedially as **the extrarenal part of the renal pelvis.**

Because the length, width and volume of the renal calices and the renal pelvis may vary, we can recognize the **dendritic and ampular type of the renal pelvis**.

The **dendritic (branching) type** shows a smaller and narrower pelvis with longer calices. The **ampular type** has a large pelvis with short calices (see Fig. 13).

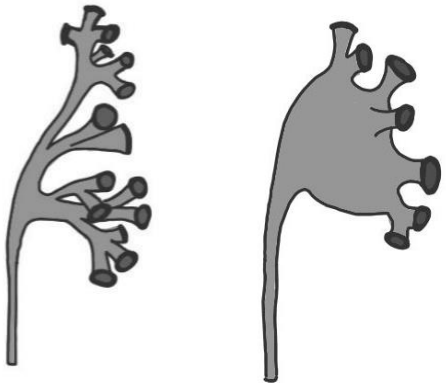

Fig. 13 Dendritic and ampular type of the renal pelvis with calices.

Redrawn from Čihák, R. (2016). Anatomie 2. Třetí, upravené a doplněné vydání. Grada Publishing, a.s.

Relations of the renal pelvis

The right renal pelvis is related to the **descending part of the duodenum**,

the left renal pelvis to the **body of the pancreas** and **both are related to the renal vessels**.

The renal pelvis projects to the same level as the renal hilum (right LI– LII; left LI).

The continuation of the renal pelvis to the ureter is in the **pelviureteric junction** that lies in the midpoint of the distance between the renal hilum and the inferior pole (extremity) of the kidney.

Internal structure – the wall

The wall of the renal calices and the renal pelvis is formed by **three layers**.

Externally, there is **the advetitia** formed by the connective fibroelastic tissue that blends with the areolar tissue in the retroperitoneum.

The muscular layer is made up of **smooth muscle cells**. In the minor and major calices and the renal pelvis, there is a special internal layer of atypical smooth muscle cells. In the minor calices, these cells form the connections between adjacent calices traversing the renal parenchyma. This thin layer of atypical cells descends from the minor calices, where they reach the highest density, to the major calices and to the renal pelvis, where they are less in number. They disappear in the peviureteric junction. These atypical smooth muscle cells are supposed to have the ability to contract spontaneously and within the minor calices they initiate the peristalsis that continues to the ureter.

The internal layer forms the **mucous coat**.

Blood supply, lymph drainage and nerve supply of the renal calices and pelvis

The renal calices and renal pelvis are blood supplied by small **wavy branches from the renal artery**.

Venous blood is drained by **the tributaries to the renal vein**.

Lymph is drained similarly as the kidney to the **lumbar lymph nodes**.

Nerves come from **the renal plexus**.

1.2.2 URETER

Ureters are the tubes that transport urine to the urinary bladder (trigone of the bladder)

External description and position of the ureter

The average length of the ureter is 25 – 32 cm, the outside diameter is 8 – 9 mm, and the internal diameter (lumen) is around 3 mm.

*Evaluation of the ureteric diameter is important for the diagnostics. The **dilation of the ureter** can be the sign or result of various urological diseases, e.g. recently passed kidney stone, chronic vesicoureteral reflux, and infections that negatively affect the ureteric peristalsis. Interestingly, the ureter may be dilated during the pregnancy due to the compression of the urinary tract by the growing gravid uterus.*

Depending on the position, we recognize **three parts of the ureter:**

abdominal, pelvic, and intramural.

In the abdominal part, the ureter is **retroperitoneal in position** and runs on the anterior surface of the psoas major muscle. The abdominal part is the longest part of the ureter.

Entering the pelvis ureter curves slightly posterolaterally and then continues anteromedially to enter the fundus (base) of the urinary bladder. It runs **subperitoneally in the pelvic part**.

The intramural part, the part where the ureter pierces the wall of the urinary bladder, is the **shortest** (1,5 – 2 cm) and **the narrowest** part.

The ureters open into the trigone of the urinary bladder (trigonum vesicae) in the fundus (base) of the bladder.

The ureter has **three constant constrictions** (see Fig. 14).

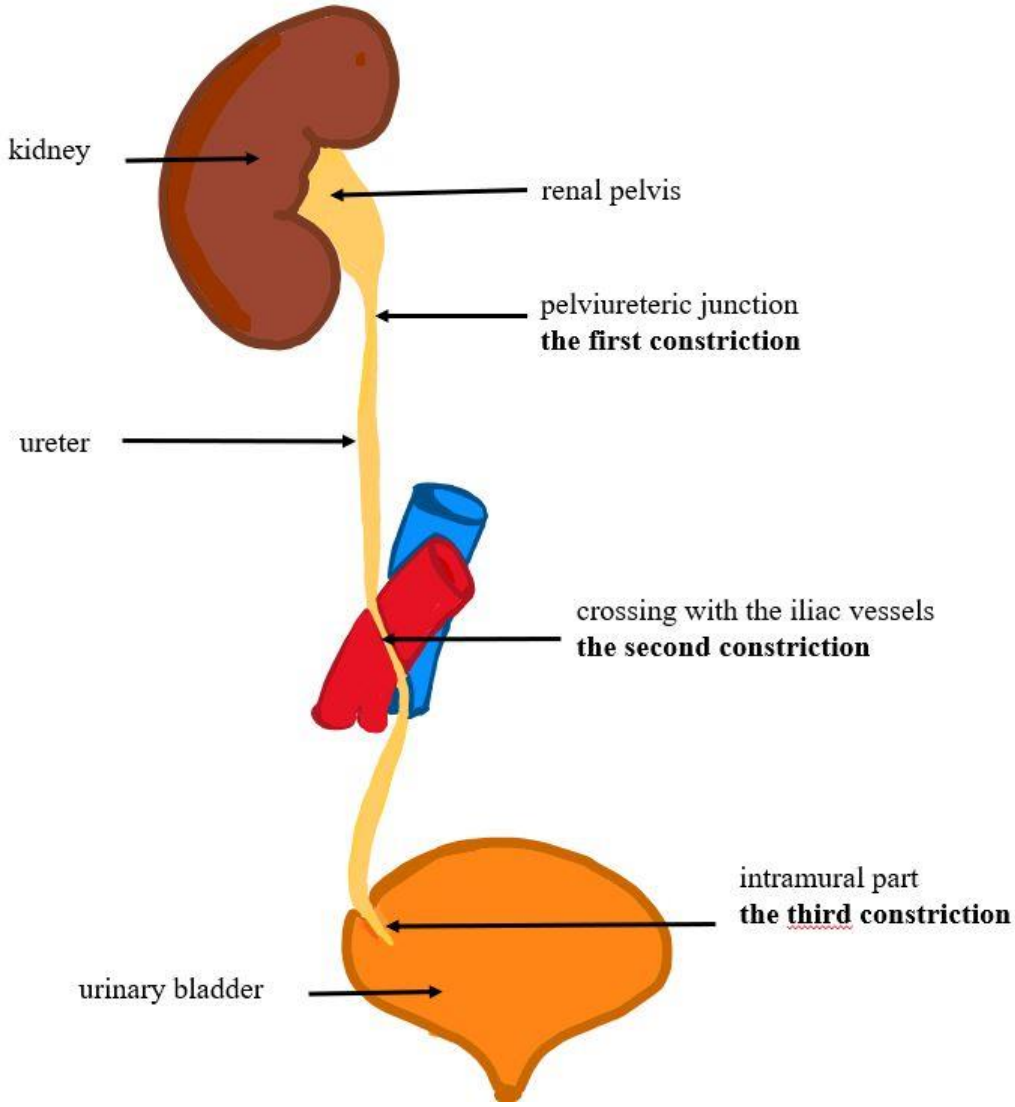

Fig. 14 Constrictions of the ureter.

Redrawn from Čihák, R. (2016). Anatomie 2. Třetí, upravené a doplněné vydání. Grada Publishing, a.s.

All these constrictions are common sites where the kidney stones may be lodged. Moreover, the knowledge of the constrictions is important for the instrumentations, e.g. ureteroscopy, placement or removal of a ureteric stent.

The first one is at the beginning of the ureter at the **pelviureteric junction**.

The second constriction is at the site where the ureter **enters the pelvis and crosses the iliac vessels** (see Fig. 16 and Fig. 17).

The third constriction occurs **at the entrance to the urinary bladder**, in its **intramural part**.

Inconstant constriction may be present in the area where the ureter is crossed by the gonadal (testicular or ovarian) vessels.

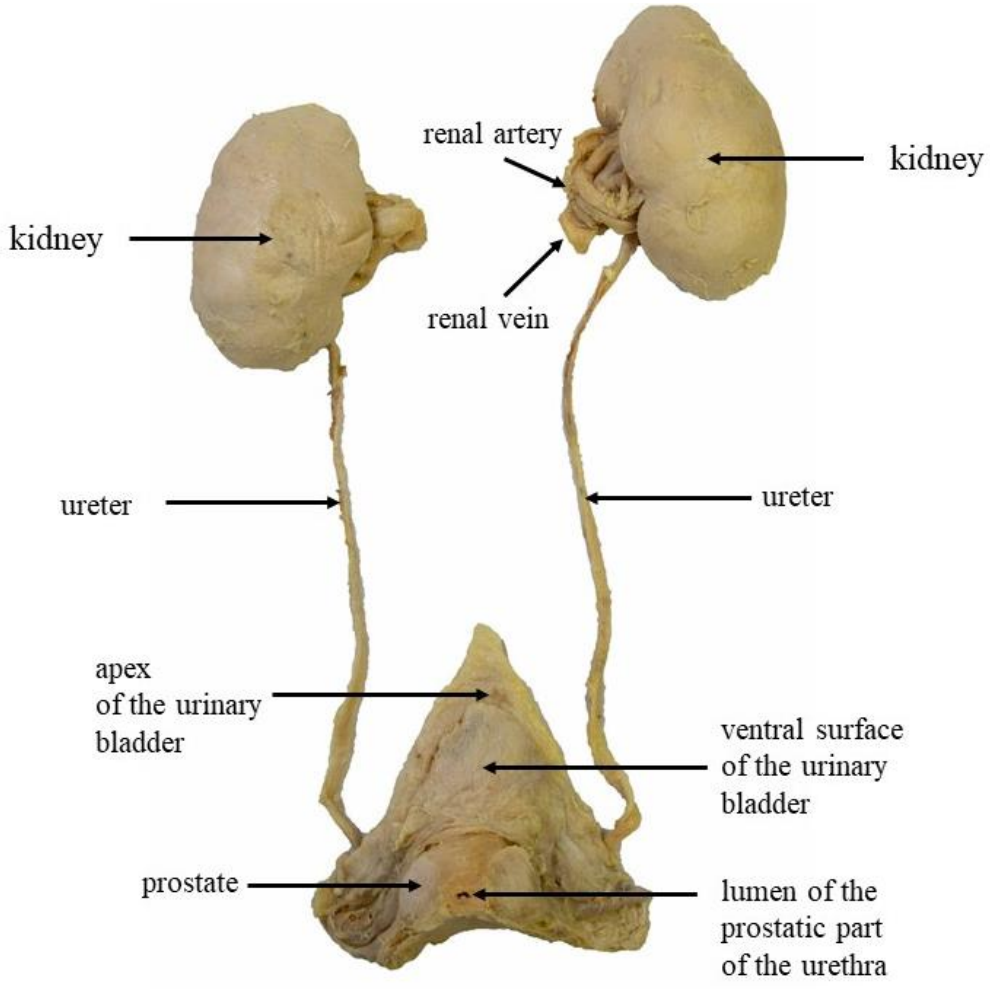

Fig. 15 Kidneys, ureters and the urinary bladder with the prostate.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

Relations of the ureter

The right ureter in the abdominal part is related to **the psoas major muscle**, **the descending part of the duodenum** and is **crossed by the attachment of the root of the mesentery.**

The left ureter is related to **the psoas major muscle, the coils of the jejunum and to the attachment of the root of the sigmoid mesocolon**.

Both ureters in their abdominal parts run over **the genitofemoral nerve** and more caudally they are crossed by **the gonadal (testicular or ovarian) vessels** (the ureter is behind the gonadal vessels). See Fig. 16.

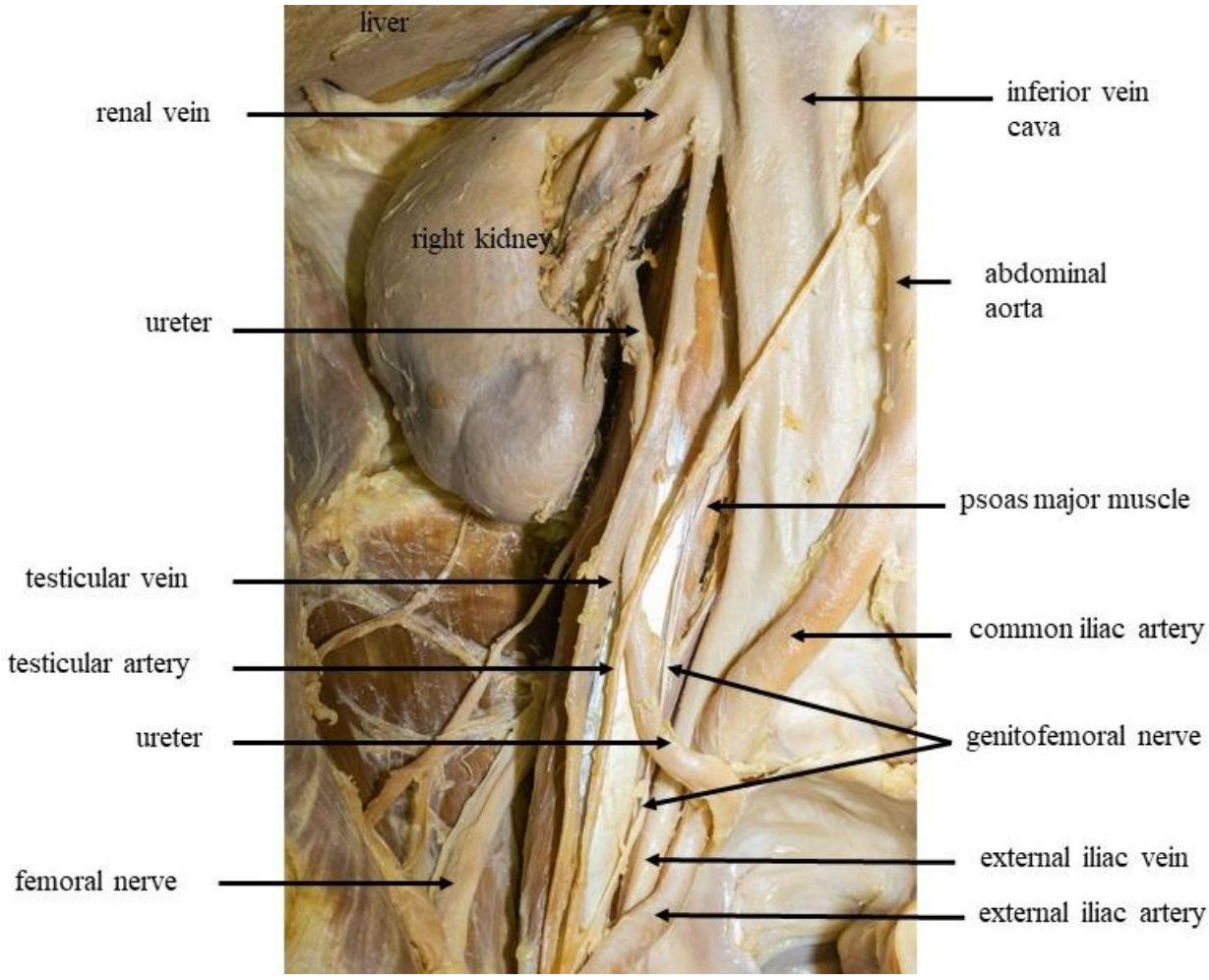

Fig. 16 Relations of the ureter in abdomen.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

When **the ureters run through the pelvic brim,** they cross (run over) **the iliac vessels**.

At the lateral pelvic wall, **the ureters are related to the obturator vessels and nerve and to the internal iliac vessels** (see Fig. 17).

In the male pelvis, the ureter is **crossed by the deferent duct** (the ureter is below the deferent duct) and when it enters the urinary bladder it is **above the seminal gland** (see Fig. 17).

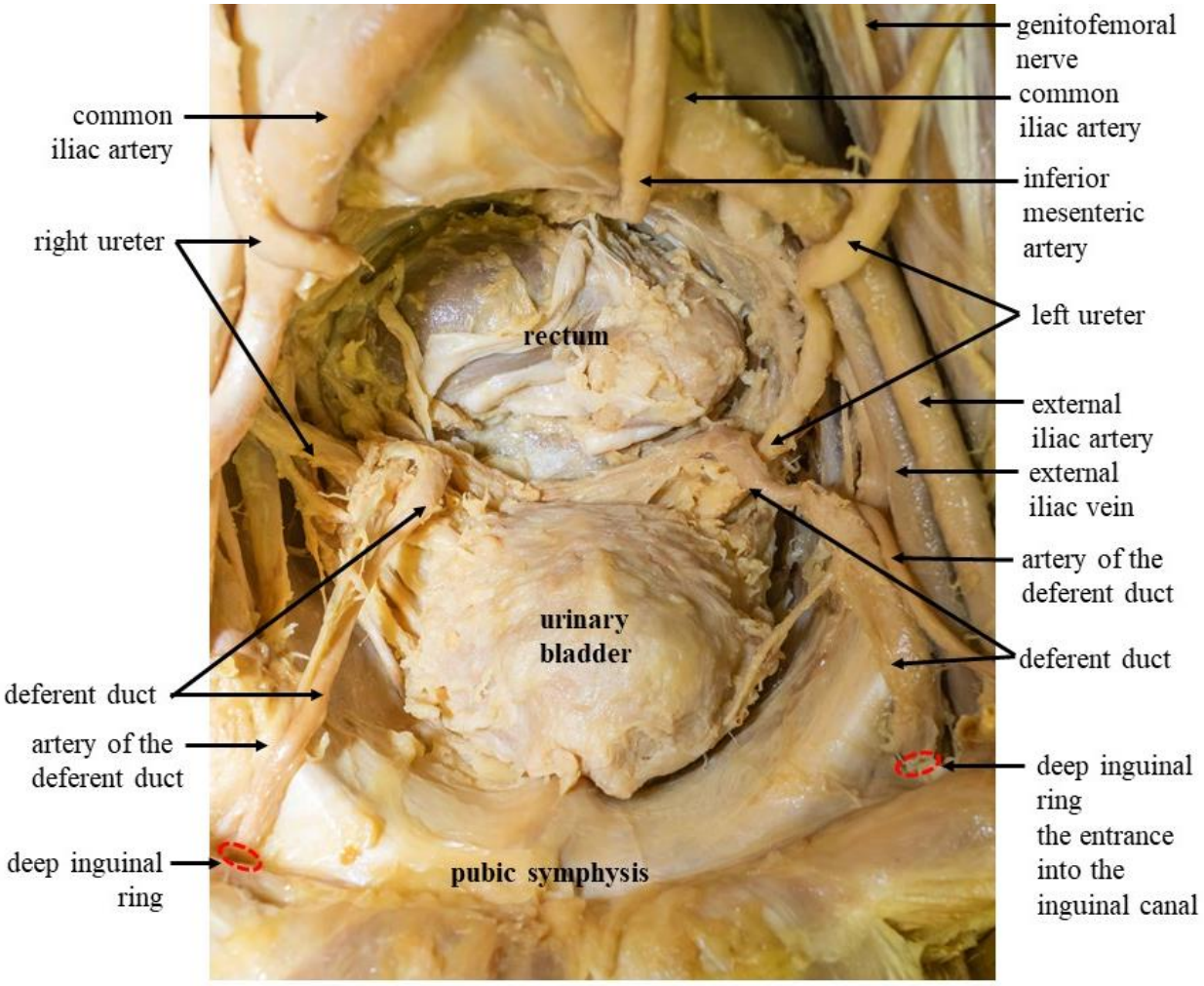

Fig. 17 Relations of the ureter in the male pelvis.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

In the female pelvis, the ureter is related to **the ovary**. In a nulliparous woman it is behind the ovary, however , in a parous woman, after the pregnancy and delivery) the ovary descends more dorsocaudally and the ureter is located in front of the ovary.

The ureter passes within the inferomedial part of **the broad ligament of the uterus** where it **crosses with the uterine artery** (next to the uterine cervix and the vaginal fornix).

Around 54% of iatrogenic injuries to the ureter are the result of gynecological surgery, mainly hysterectomy (surgical procedure to remove the uterus). The relation of the ureter to the uterine artery is a possible anatomy risk factor for the iatrogenic injury to the ureter because the ureter may be ligature-clipped and cut together with the uterine artery.*

Colorectal surgery is responsible for other 14 % of iatrogenic injuries to the ureter. Especially left ureter is cut during the sigmoid or rectosigmoid radical colectomy due to its relation to the root of the sigmoid mesocolon.

Iatrogenic ureteral injuries are considered a severe complication of abdominal and pelvic surgical procedures, occasionally associated with morbidity.

**iatrogenic injury is caused by physicians or health care clinicians associated with the medical treatment (e.g. during surgery or adverse effects of pharmacotherapy) and diagnostic or other invasive procedures .*

Ureteric wall

Ureteric wall consists of three layers.

The mucosal coat covers the internal surface (lumen).

The muscular coat is formed by the internal longitudinal and external circular layer of the smooth muscle cells. In the pelvic part there is another external longitudinal layer. As for the ureteric peristalsis, the waves are initiated in the atypical smooth muscle cells within the minor calices and they spread through the ureter downwards to the urinary bladder.

Adventitia is the external layer made up of collagenous connective tissue.

Blood supply, lymph drainage and nerve supply of the ureter

Due to the long course of the ureter, it has several sources of **arterial blood supply**. The arteries ascend and descend along the ureter and anastomose with each other.
The abdominal part of the ureter is supplied by the branches of **the renal artery, the gonadal (testicular or ovarian) artery and the common iliac artery**.
The pelvic part of the ureter takes the blood from the branches of the **internal iliac artery: artery of the deferent duct in male and the uterine artery in female, the superior and inferior vesical arteries in both male and female**.
The venous blood from the ureter is drained to the corresponding veins that accompany the above - mentioned arteries.

The lymph from the ureter is drained to the **lumbar lymph nodes, common iliac nodes and internal iliac nodes**.

The nerves of the ureter form the **ureteric plexus** around the ureter. **Sympathetic and parasympathetic** fibers for the ureters come from **the renal plexus, testicular or ovarian plexus, and deferential plexus. Sensory fibers** are carried through the lumbar splanchnic nerves to the spinal segments T11– L2.

The latest data support the theory that autonomic nerves do not play a key role in the initiation of the ureteric peristalsis, however, they have a more or less modulatory function. Atypical smooth muscle cells in the renal calices and pelvis are supposed to have the ability to contract spontaneously. There is strong evidence that ureteric peristalsis is initiated especially by the atypical smooth muscle cells within the minor calices. Under physiological conditions, ureteric peristalsis is 6 times per minute.

Ureteric pain (ureteric colic) is usually the result of the distention or spasm of the ureter that may be caused, e.g. by the kidney stone. It is a typical ***referred pain*** *when the pain appears in the skin areas nerve supplied by the spinal segments that innervate the ureter T11 – L2. Therefore, the typical symptom of ureteric colic is the pain in the lateral part of the abdominal wall, in the area above the iliac crest, pubic region and scrotum or labium majus. If the genitofemoral nerve is irritated, the pain may extend to the skin of the anterior femoral region above the saphenous hiatus (the area supplied by the femoral branch of the genitofemoral nerve), or the cremaster muscle may contract because it is supplied by the genital branch of the genitofemoral nerve.*

1.2.3 URINARY BLADDER

The urinary bladder is a hollow muscular organ that serves as a temporary reservoir of the urine. Its physiological capacity is around 300 – 400 ml, and exceptionally 500–750 ml.

The urge to urination occurs at a level around 350 ml of the urine inside the bladder. In maximal distension, it is still below the level of the umbilicus.

Position and relations of the urinary bladder

The position, size and shape of the urinary bladder depends on its content and the content of the rectum in male and uterus in female.

In adults, the empty urinary bladder is completely inside the **lesser pelvis, behind the pubic symphysis**. Its superior surface is covered by the parietal peritoneum lining the pelvis and therefore it is **subperitoneal in position** (see Fig.18).

When the urinary bladder is filled, it extends anterosuperiorly above the pubic symphysis and in front of the peritoneal cavity directly behind the anterior abdominal wall. So the **full urinary bladder is praeperitoneal in position** (see Fig. 19).

When the urinary bladder contains around 300 ml of urine, it extends 2-4 cm above the upper border of the pubic symphysis .

In certain circumstances (e.g., trauma, severe prostatic hypertrophy or cancer), the urethral catheterization is not possible and urinary retention must be relieved. In this case, suprapubic catheterization may be performed because the full bladder protrudes above the pubic symphysis. The needle pierces the anterior abdominal wall (approximately 2 cm above the upper margin of pubic symphysis) and then the wall of the urinary bladder without any contact with the peritoneal cavity .The urinary bladder in a newborn is entirely intra - abdominal in position with the internal urethral orifice at the level of the superior border of the pubic symphysis. It reaches the final adult position after puberty.

The urinary bladder in male is related to :

- **the retropubic space and pubic symphysis anteriorly**
- **the seminal vesicles, deferent ducts** (both situated in rectovesical septum) **and the rectum** (separated from the bladder by the rectovesical pouch) posteriorly
- **the prostate inferiorly**
- **the pelvic diaphragm** (levator ani muscle) **inferolaterally**
- **the sigmoid colon and the terminal coils of the ileum dorsocranially**

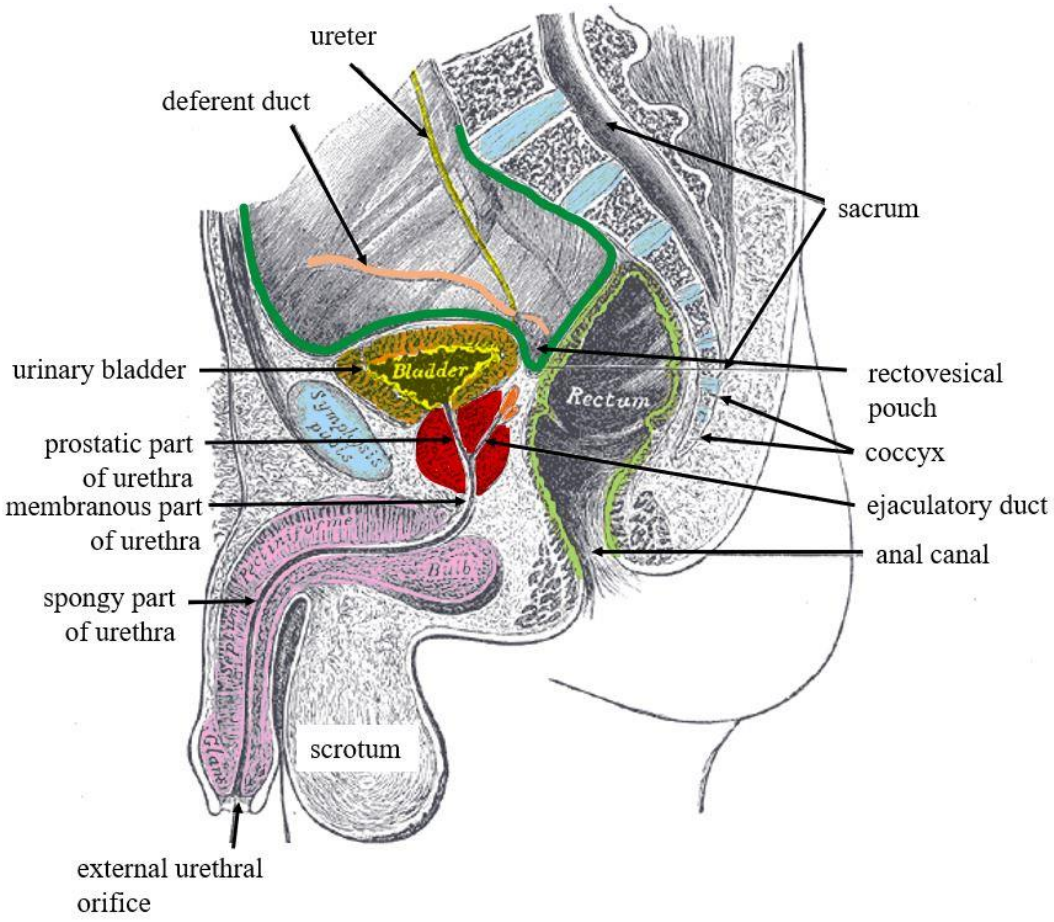

Fig. 18 Empty urinary bladder in the male pelvis. Sagittal section.

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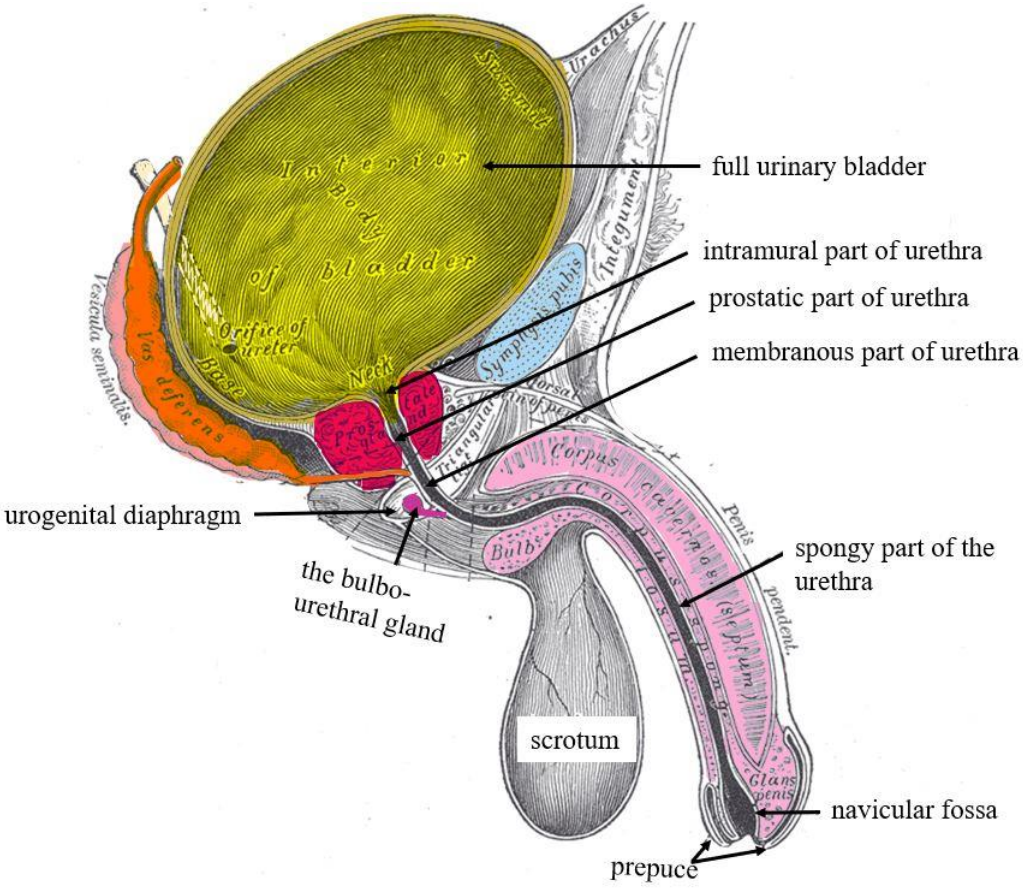

Fig. 19 Full urinary bladder in the male pelvis. Sagittal section.

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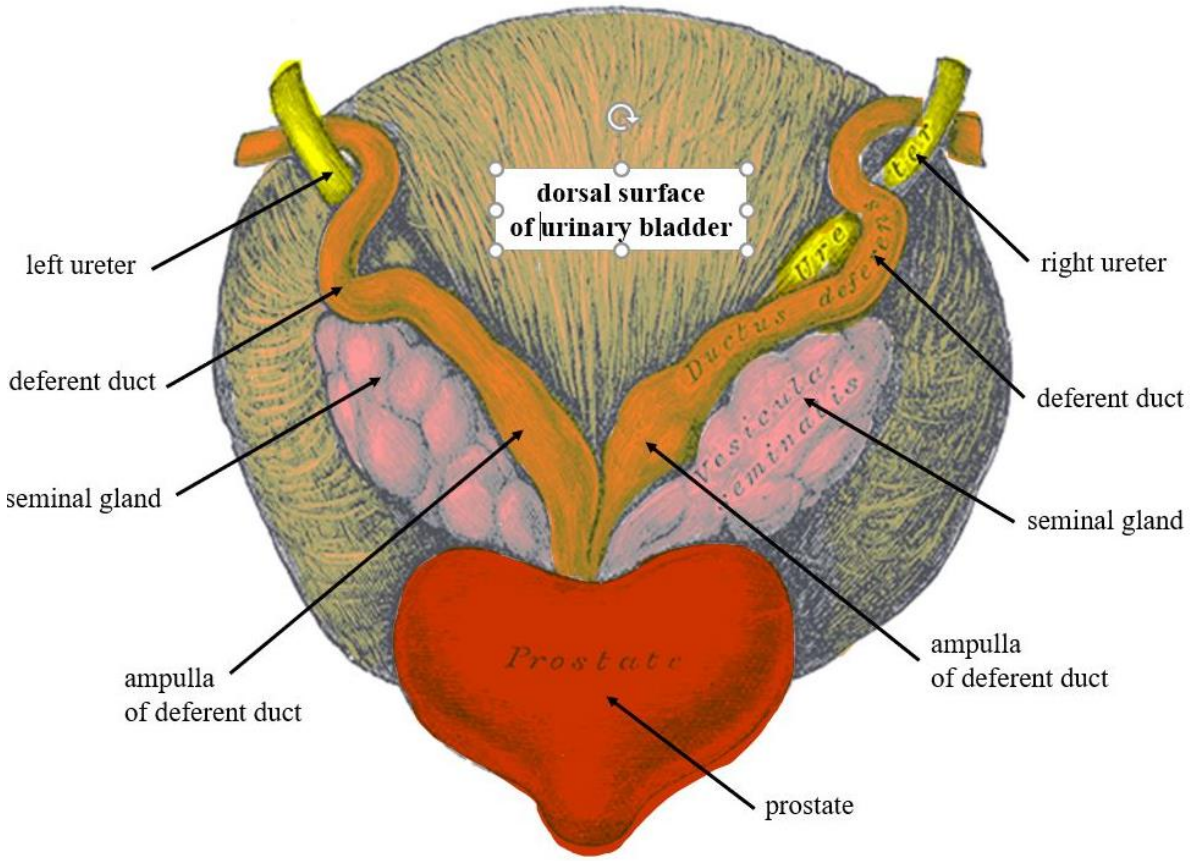

Fig. 20 The urinary bladder in male. Posterior view.

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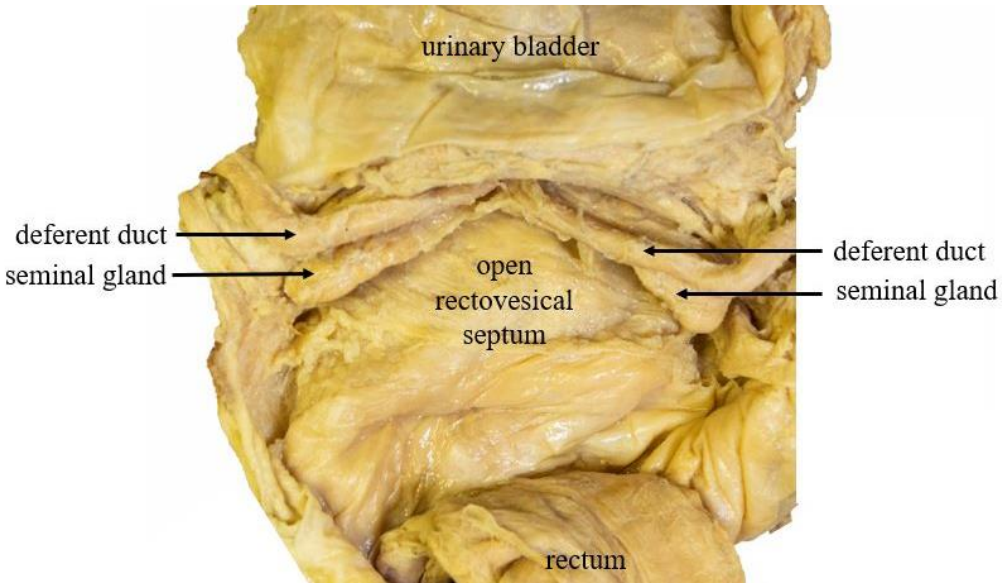

Fig. 21 The urinary bladder in the male. Superoposterior view.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

The urinary bladder in female is related to:

- **the retropubic space and pubic** symphysis anteriorly
- **the pelvic diaphragm (** levator ani muscle**) inferolaterally**
- **the uterus and vagina posteriorly,**

  the body of the uterus is separated from the bladder by the vesicouterine pouch,

  uterine cervix and vagina by the vesicovaginal septum (see Fig. 22)

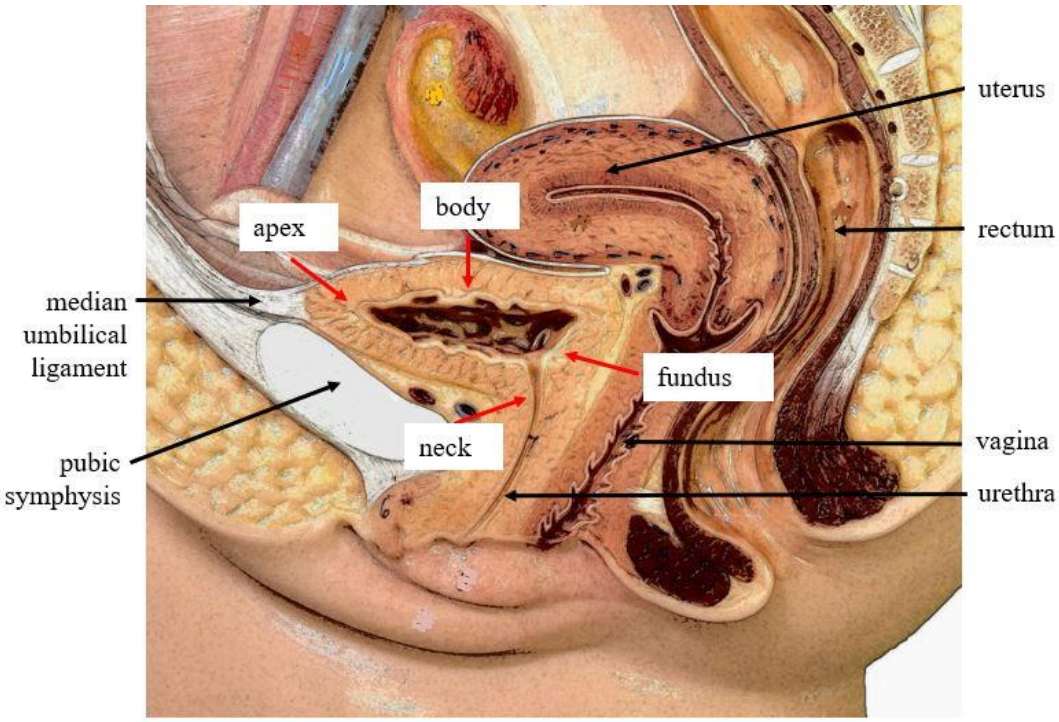

Fig. 22 The urinary bladder in the female pelvis. Sagittal section.

Phototography of SOMSO model, modified by additional drawing, labeling and colorization.

External description of the urinary bladder

The empty urinary bladder has a shape like a three-walled pyramid with the superior wall, two inferolateral walls and the base directed dorsocaudally and the apex projected ventrocranially.

The urinary bladderconsists of 4 parts: apex, body, fundus and the neck.

The apex of the urinary bladder leads forward and upward to the top of pubic symphysis. The **median umbilical ligament** extends from the apex to the umbilicus. The ligament is the remnant of the urachus.

The body is the uppermost widest part of the bladder and also the most expandable part of the urinary bladder.

The fundus (base) of the urinary bladder is directed downward and backward. On the internal surface of this part there is the **trigone of the bladder (trigonum vesicae)**. See Fig. 23 and Fig. 24. The ureters open into this part of the bladder, forming two posterolateral vertices of the vesical trigone. The anterior vertex of the trigone is formed by the internal urethral orifice. The trigone mucosa is always smooth because it is tightly connected to the muscular layer of the bladder wall.

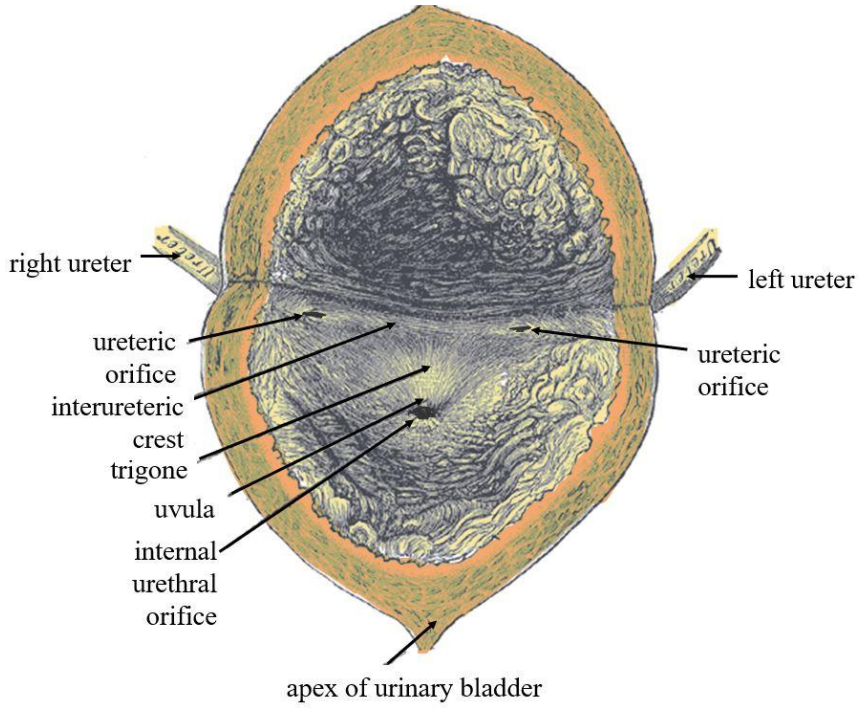

Fig. 23 Open urinary bladder. Transverse section.

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The neck (cervix) of the urinary bladder surrounds the intramural part of the urethra. It is the most caudal and the most fixed part of the bladder. In female, there is the **pubovesical ligament** that runs from the posterior surface of the pubis to the

neck. In male, there is the homologic **puboprostatic ligament** because the neck of the bladder is surrounded by the prostate and the ligament is attached to the prostatic capsule.

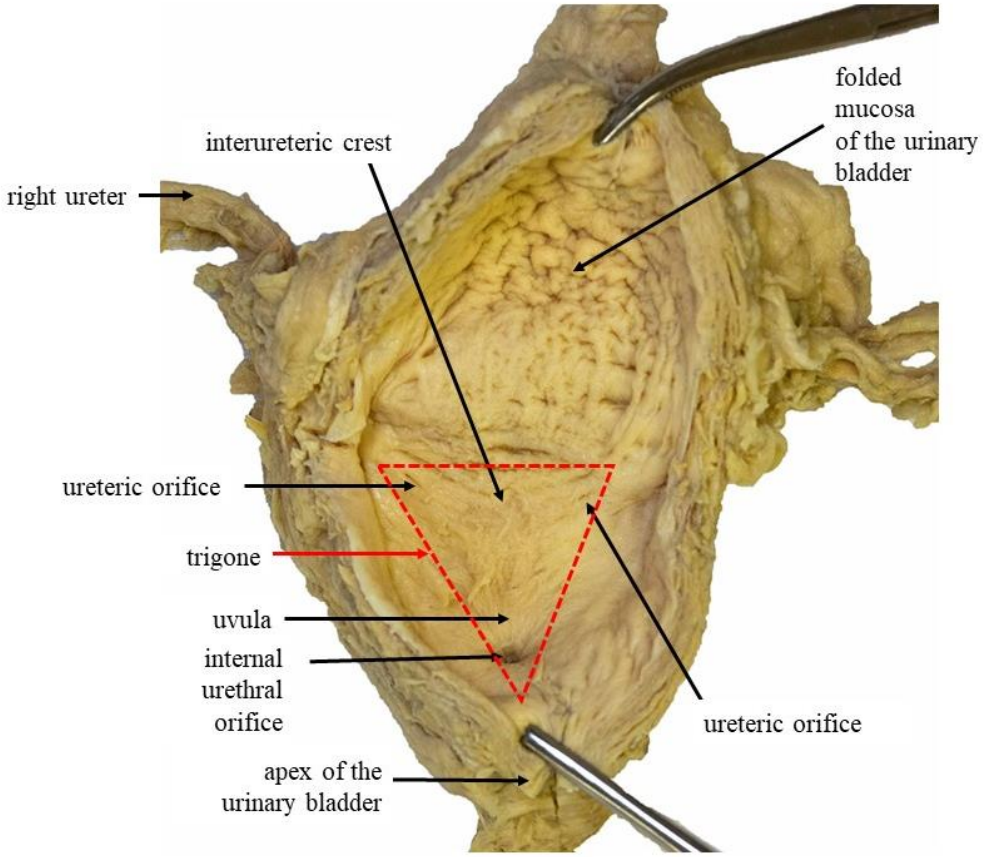

Fig. 24 Open urinary bladder - specimen. Transverse section.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

The wall of the urinary bladder

There are **three layers in the wall of the urinary bladder**: **the mucosa, the smooth muscle layer** and **the external layer** (serous coat or adventitia).

The urinary bladder mucosa is loosely attached to the muscular layer. When the bladder is empty, the mucosa forms numerous folds and how it fills, the folds flatten so much that they disappear.

However**, the mucosa at the vesical trigone** is always smooth because it is tightly attached to the muscular layer. The vertices of the trigone are formed by **the orifices of the ureters posterolaterally** and **the internal urethral orifice anteriorly** (see Fig. 23 and Fig. 24).

The ureteric orifices appear like **slits**. They are connected by an **interureteric crest** that is an important landmark or guide in cystoscopy to reveal the slit like ureteric openings. In an empty bladder, the distance between the ureteric orifices is around 2.5 cm, and the same distance is from the ureteric orifice to the urethral orifice. In adult male, immediately behind the internal urethral orifice, the uvula may be seen. It is the elevation above the middle lobe of the prostate.

The muscular coat of the urinary bladder is formed by three layers of the smooth muscle: internal plexiform, middle circular and external longitudinal layer. These three layers together form the **detrusor muscle.**

The stratification is clearly visible mainly in the neck of the bladder, however, the other parts may appear even unstratified, forming a meshwork of muscle fibres.

The smooth muscle bundles in the neck are morphologically, histochemically and functionally different from the detrusor muscle. These muscle budles form the internal urethral sphincter around the intramural part of the urethra. They also have different nerve supply, detrusor is nerve supplied by parasympathetic fibers, internal urethral sphincter by sympathetic fibers.
The latest studies revealed gender differences in the arrangement of the internal urethral sphincter.

In male, the internal urethral sphincter (or preprostatic sphincter) completely surrounds the urethra. It has its own sympathetic innervation and the smooth muscle cells are morphologically different from those in detrusor muscle. The function of this muscle is to close the internal urethral orifice in ejaculation and thus prevent the flow of the ejaculate into the bladder, or simply it prevents retrograde ejaculation.

In female, the smooth muscle cells of the neck or **the internal urethral sphincter** are also morfologically and histochemically different from the detrusor muscle.

However, unlike in male, the muscle fasciculi have an oblique or almost longitudinal course passing into the wall of urethra, no circular fasciculi as in male. It means that they do not have function in maintaining of continence in female.

At the trigone there is **the trigonal muscle**. It has 2 layers that are continuous from the internal and external longitudinal muscle bundles of the ureter. From the apex of the trigone it continues to the dorsal wall of the urethra. The trigonal muscle closes the ureteric orifices during the urination (micturition).

Urethral closure is supported by the pelvic floor, levator ani and pubovesical ligaments that hold the neck of the urinary bladder above the pelvic floor. In elderly and after the parturition, the position of the neck may be changed, it may fall down below the pelvic floor. It may result in incontinency due to the failure of the pelvic floor support function in the urethral closure in the neck of the urinary bladder.

Adventitia covers the inferolateral surfaces and the base of the urinary bladder. It is made from the collagenous bundles. Adventitia is continuous with the paravesical sparse tissue, **paracystium**.

Serous coat is the parietal peritoneum that covers the superior surface of the bladder body.

In male, the parietal peritoneum forms the rectovesical pouch between the urinary bladder and the rectum behind it.

In female, there is the vesicouterine pouch behind the urinary bladder and in front of the uterus.

The urinary bladder is fixed by the following ligaments to the following organs:

- ventrally in female by pubovesical ligaments and in male by puboprostatic ligaments to the pubis
- dorsally in female by vesicouterine ligament to the uterus and in male by rectovesical ligaments to the rectum

- caudally to the prostate in male and to the urethra in female; in both to the urogenital diaphragm.

Blood supply, lymph drainage and nerve supply of the urinary bladder

The upper part of the urinary bladder is supplied by t**he superior vesical artery** that comes from the umbilical artery.

The lower part takes the blood from **the inferior vesical artery** arising from the internal iliac artery.

The urinary bladder also takes the blood supply from the arteries that supply surrounding organs: **the inferior rectal artery, the uterine artery, the internal pudendal artery** and **the obturator artery.** Arteries supplying the urinary bladder have a wavy course because of the changing volume or size of the bladder.

Venous blood is drained into **the vesical venous plexus**, a venous network primarily around the fundus (base) of the bladder. **The vesical veins** take the blood from the plexus to the internal iliac veins. **The vesical venous plexus** has **numerous connections** (**anastomoses**) with the plexuses within the lesser pelvis - uterovaginal plexus in female, prostatic and rectal plexus in male.

Due to these **venous connections,** pathological processes (tumors, inflammation) spread easily from one pelvic organ to the other one.

The lymph from the anterior aspect of the bladder continues to the external lymph nodes. The posterior and inferolateral surfaces are drained to the internal iliac lymph nodes.

Around the fundus of the urinary bladder there is a **nervous vesical plexus**. This network receives autonomic and sensory fibers. **The sympathetic fibers come from the inferior hypogastric plexus** (from spinal segments L1 – L3). They are responsible for the contraction of the smooth internal urethral sphincter (sphincter urethrae internus). T**he parasympathetic fibers come from the inferior hypogastric plexus** (from spinal segments S2 – S4). They increase the muscle tonus of the detrusor muscle. **The afferent sensory fibers** take information such as pain

or tension of the bladder wall (spasmus or distention) through the spinal nerves L2 – S2.

1.2.3 MALE URETHRA

Male urethra is 18 – 22 cm long tube that drains urine from the urinary bladder out of the body. It begins as **the internal urethral orifice** within the fundus (base) of the urinary bladder and ends as **the external urethral orifice** at the top of glans of the penis.

Course and parts of the male urethra

Depending on its course, male urethra is subdivided to **four parts:**

intramural (preprostatic), prostatic, membranous and spongy (spongiose) part.

In the sagittal plane, the male urethra shows **two curvatures**. The first, **subpubic curvature** is situated at the interface between the mebranous and spongy part of the urethra. It is concave upward and fixed (permanent). The second curvature, **prepubic curvature** is located in the spongy part of the urethra below the pubic symphysis. The prepubic curvature is concave downward and it is not fixed. It disappears when the penis is in erection. During the uretheral catheterization or other instrumentation, e.g. cystoscopy, it may be straightened.

The intramural (preprostatic) part of the urethra passes through the wall of the urinary bladder. It is short (around 1 cm), with a narrow stellate lumen. This part is surrounded by the circular **internal urethral sphincter**, an involuntary smooth muscle. The function of this muscle is to close the internal urethral orifice in ejaculation and thus prevent the flow of the ejaculate into the bladder.

The prostatic part of the urethra traverses the prostate. It is the widest part of the male urethra. The lumen is C – shaped in the transverse section because of the midline elevation at the dorsal wall, **urethral crest** with the **seminal colliculus** at its midway point. The **ejaculatory ducts** open at the **seminal colliculus**. On both sides of the

urethral crest there are depressions, **prostatic sinuses,** where **the** p**rostatic ducts** like 15 – 25 openings empty.

Typical symptom of enlarged prostate is slow and weak urine flow and sometimes complete blockage of urine. Hyperplastic prostatic tissue reduces the lumen of the prostatic part of the urethra that can be partially or completely blocked and therefore the urine flow is reduced or stopped.

The membranous part is a narrow and short part (approximately 3 cm long) that runs through the urogenital diaphragm (transversus perinei profundus muscle). The lumen of this part has a stellate shape in the transverse section. Membranous urethra is surrounded by **the external urethral sphincter** (see Fig. 25), a voluntary striated muscle, derived from the fibers of the urogenital diaphragm.

The spongy (spongiose) part of the male urethra runs within **the bulb of penis and corpus spongiosum of the penis,** therefore, sometimes it is called the penile urethra. At the bulb of penis, the lumen is slightly dilated into **the ampulla** (bulbar part of the urethra). The ducts of **the bulbourethral glands open into the ampulla**.

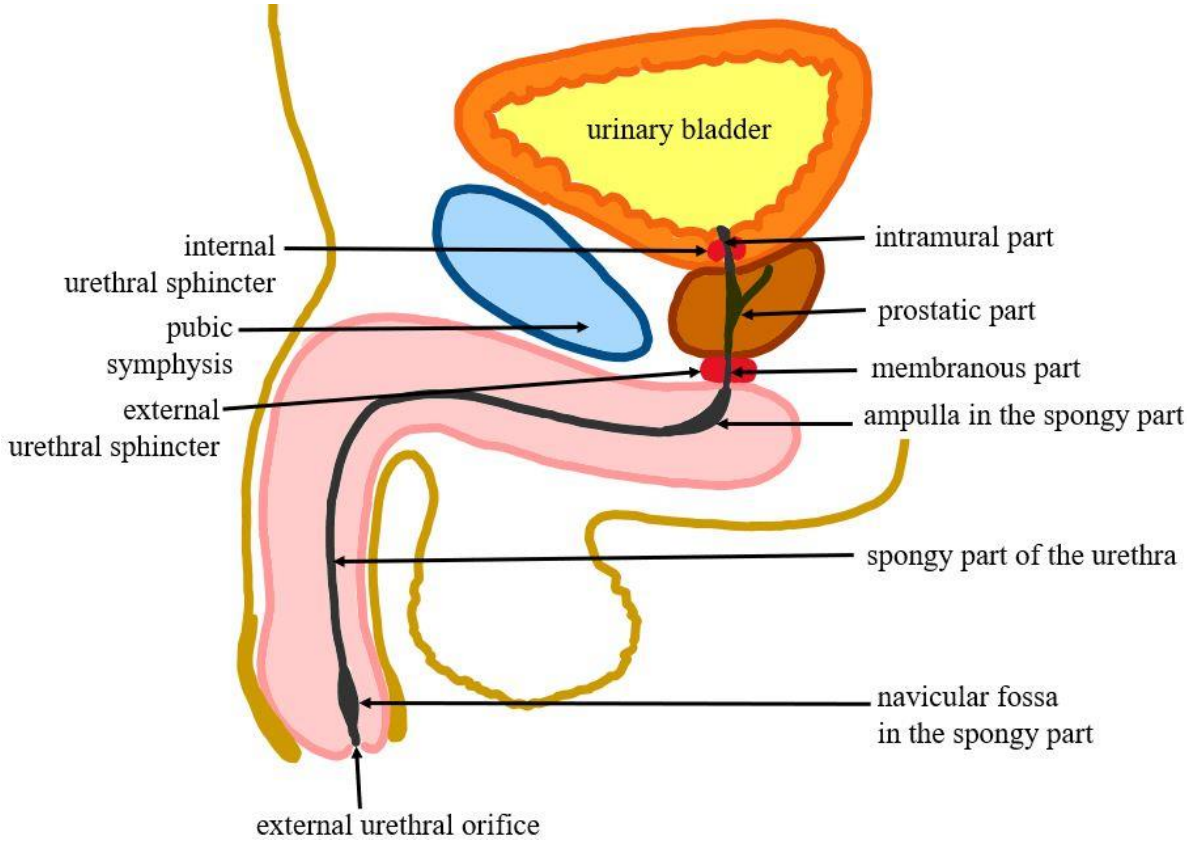

Fig. 25 Parts of the male urethra. Sagittal section.

Redrawn from Čihák, R. (2016). Anatomie 2. Třetí, upravené a doplněné vydání. Grada Publishing, a.s.

In corpus spongiosum, the urethra narrows, and at the end next to the external urethral orifice it widens again to form the **navicular fossa**.

The external urethral orifice is located at the top of the glans of penis. It is **the narrowest site of the male urethra.**

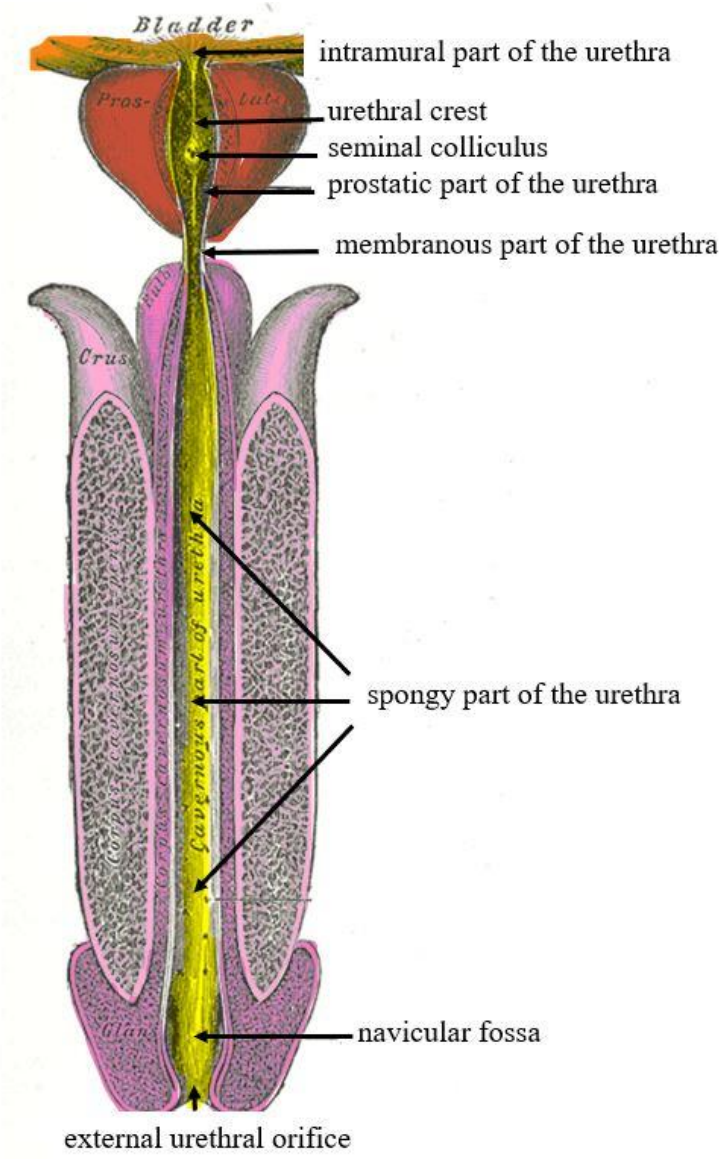

Fig. 26 The male urethra.

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Modified by additional colorization and labeling.

The constricted parts of the male urethra are: the intramural (preprostatic) part, the membranous part, the spongy part (except the navicular fossa and ampulla) and the external urethral orifice is the narrowest site (see Fig.25 and 26).

On the contrary, the **dilated portions** are the prostatic part, the ampulla and the navicular fossa (see Fig.25 and Fig. 26).

The wall of the male urethra is formed by the mucosa and smooth muscle layer.

Blood supply, lymph drainage and nerve supply of the male urethra

Upper parts of the male urethra are supplied by **the inferior vesical artery**, and occasionally by **the middle and inferior rectal arteries**. The spongy part is supplied by the **urethral artery** that comes from the internal pudendal artery.

Venous blood is drained through **the dorsal veins of penis** and **internal pudendal veins to the prostatic plexus**.

The lymph from the male urethra is predominantly drained into **the internal iliac lymph nodes,** in a lesser extent **to the external and superficial iliac lymph nodes**.

Autonomic nerve fibers mainly come from **the prostatic nervous plexus**. **Sympathetic fibers** are responsible for the contraction of **the internal urethral sphincter**. Pelvic splanchnic nerves contain parasympathetic fibres for the male urethra. Voluntary **external urethral sphincter** is nerve supplied by the branches of **the pudendal nerve**. **Sensory fibers from spongy part of urethra** are also contained in **the pudendal nerve**.

1.2.4 FEMALE URETHRA

The female urethra is much shorter than the male one, it has around 4 cm. It has a straight ventrocaudal direction in standing 'orthostatic' position, however, it is directed almost horizontally in lying position.

Course and parts of the female urethra

In front of the urethra there is the retropubic space with venous pudendal plexus and **more inferiorly the bulb of the vestibule** with its venous plexuses. **Behind female urethra there is the vagina.**

The internal urethral orifice is situated at the fundus of the urinary bladder.

The female urethra may be subdivided into 4 parts depending on its course: **intramural, pelvic, membranous, and perineal part** (see fig. 27).

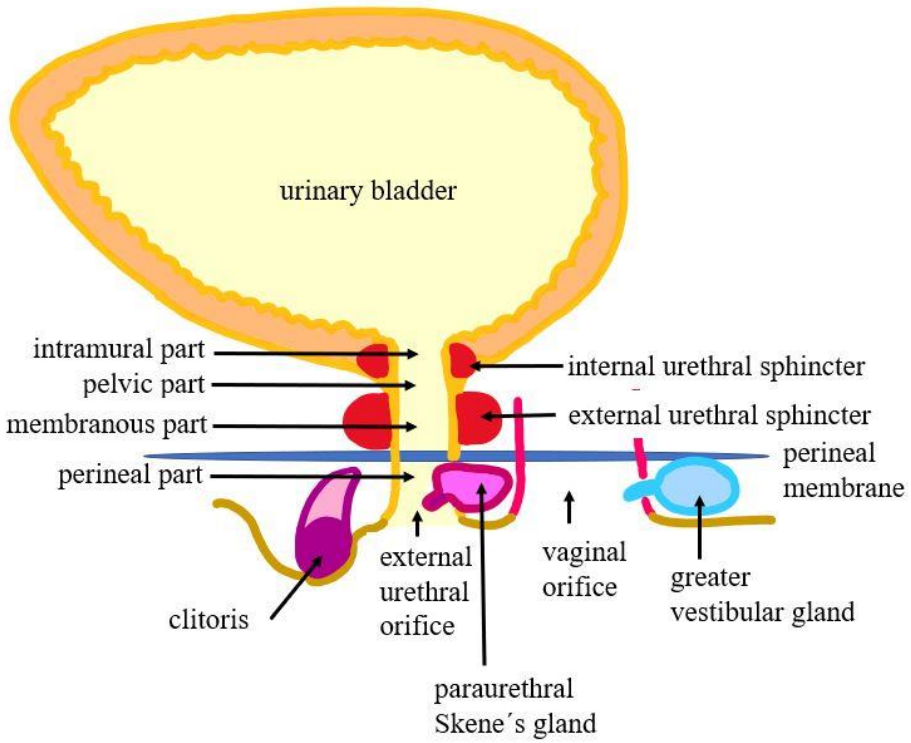

Fig. 27 Parts of the female urethra. Sagittal section.

Redrawn from Drake, R., Vogl, W., & Mitchell, A. (2010). Gray´s Anatomy for Students (2nd ed.). Churchill Livingstone.

The intramural part runs through the wall of the bladder. It is surrounded by spiral smooth muscle bundles of the internal urethral sphincter.

The pelvic part is immediately below the urinary bladder and is contiguous with the membranous part that traverses the urogenital diaphragm (transversus perinei profundus muscle).

Around **the membranous part**, **the external urethral sphincter**, voluntary striated muscle forms a collar.

Below the urogenital diaphragm to the external urethral orifice there is **the perineal part** of the female urethra.

The external urethral orifice opens into the vaginal vestibule at the **urethral papilla (papilla urethralis)** in front of the vaginal orifice and below the clitoris. The lumen of the female urethra in the transverse section is stellate. The wall is formed by the mucosa and the smooth muscle layer.

Blood supply, lymph drainage and nerve supply of the female urethra

Three arteries give branches for the blood supply of the urethra: **the inferior vesical artery, the vaginal artery and the artery of the bulb of vestibule**.

Vesical and uterovaginal venous plexus and pudendal veins receive the venous blood from urethra.

The lymph is drained into the **internal iliac and deep inguinal lymph nodes**.

Autonomic sympathetic and parasympathetic nerve fibers come from the **vesical plexus**. **The pudendal nerve** supplies the voluntary **external urethral sphincter** and provides sensory nerve supply to the external orifice.

Urethral catheterization is commonly used for therapeutic or diagnostic purposes (e.g. to relieve urinary retention, instill drugs or to measure the urine output).
Urethral catheterization or any instrumentation through the urethra is easier in female than in male because of the short and straight course of the female urethra. However, these anatomical conditions cause that the infections of the urinary tract are more often in female than in male.

2 MALE GENITAL SYSTEM

The male genital system consists of **the internal genital organs**:

- testes
- epididymes
- deferent ducts
- ejaculatory ducts
- accessory male genital glands: seminal glands, prostate and bulbourethral glands (see Fig. 28)

and **the external male genital organs:**

- penis
- scrotum (see Fig. 28).

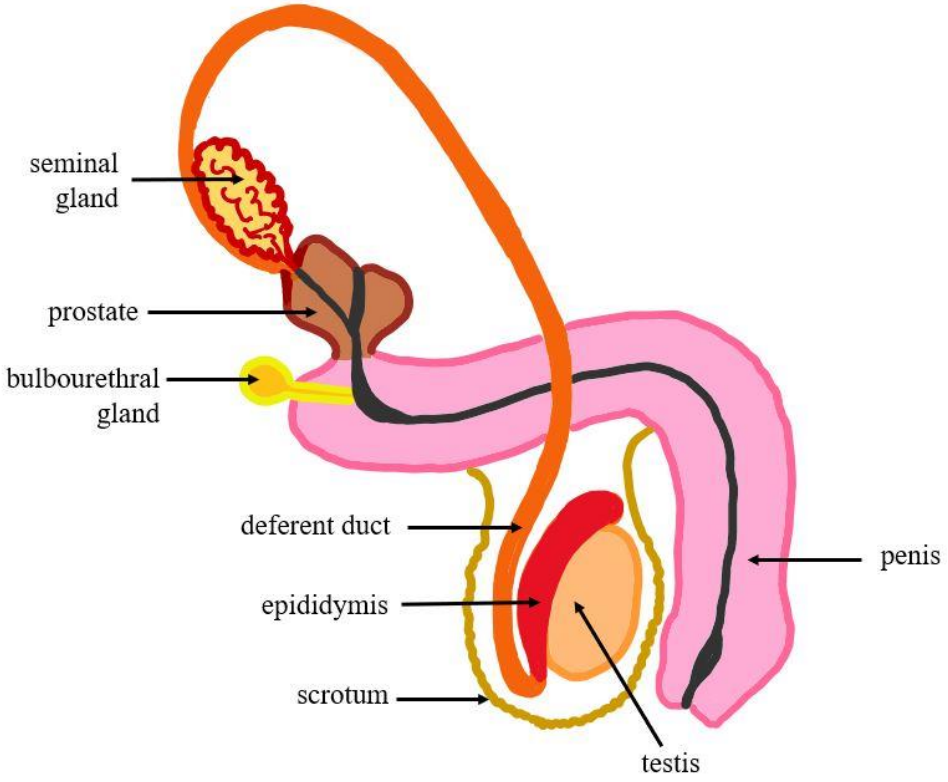

Fig. 28 The organs of the male genital system. Sagittal section.

Redrawn from Čihák, R. (2016). Anatomie 2. Třetí, upravené a doplněné vydání. Grada Publishing, a.s.

2.1 INTERNAL MALE GENITAL ORGANS

2.1.1 TESTIS (ORCHIS in Greek)

The testes are male **reproductive organs (male gonads)** that produce **the sperm cells.** Seminiferous tubules of the testis are the site of spermatogenesis.

Testes are also the **endocrine glands that produce the testosteron. Interstitial Leydig cells** synthetise the testosteron in response to the stimulation by the luteinizing hormon from adenohypophysis.

Position and relations of the testis

Testes are originally **developed inside the abdominal cavity**. During the intrauterine development, they **descend to the scrotum** (see chapter: Descent of the testes).

Postnatally (after the birth) in physiologic conditions, the **testes are situated in the scrotum**.

Each testis is situated in its own serous cavity of the scrotum. There are two serous cavities in the scrotum, one testis in one serous cavity.

The long axis of the testis passes obliquely, the upper pole of the testis directs ventrolaterally and the lower one dorsomedially.

The left testis is situated a little lower than the right one.

Each **testis** is **related to the epididymis and the spermatic cord**.

External description of the testis

Testis is ovoid in shape and compressed from side to side. The average weight of the testis is 10 – 15 g, it is around 4 – 5 cm in length, 3 cm in transverse and anteroposterior diameter.

It has **the superior and inferior extremities** (poles), **the medial and lateral surfaces** and rounded **anterior and posterior borders (margines)**. See Fig. 29 , Fig. 30 and Fig. 31.

The epididymis runs along the posterior border of testis. The anterior border is free. **The hilum** (hilus) **of the testis** is situated at the posterior border.

The inferior extremity is connected to scrotum by scrotal ligament (gubernaculum testis).

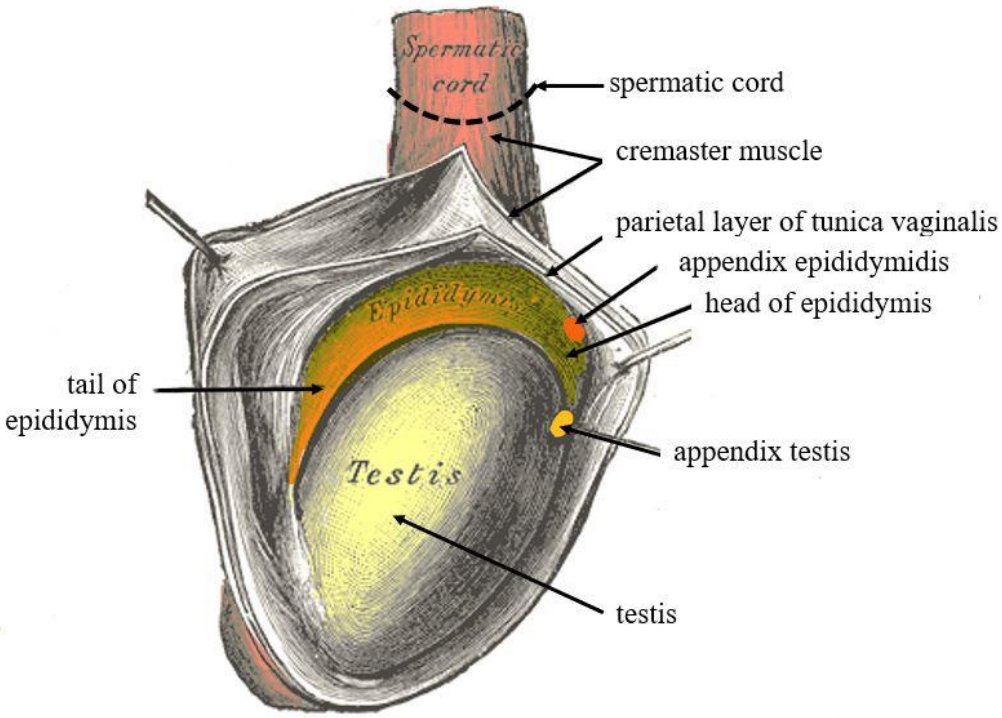

Fig. 29 Testis.

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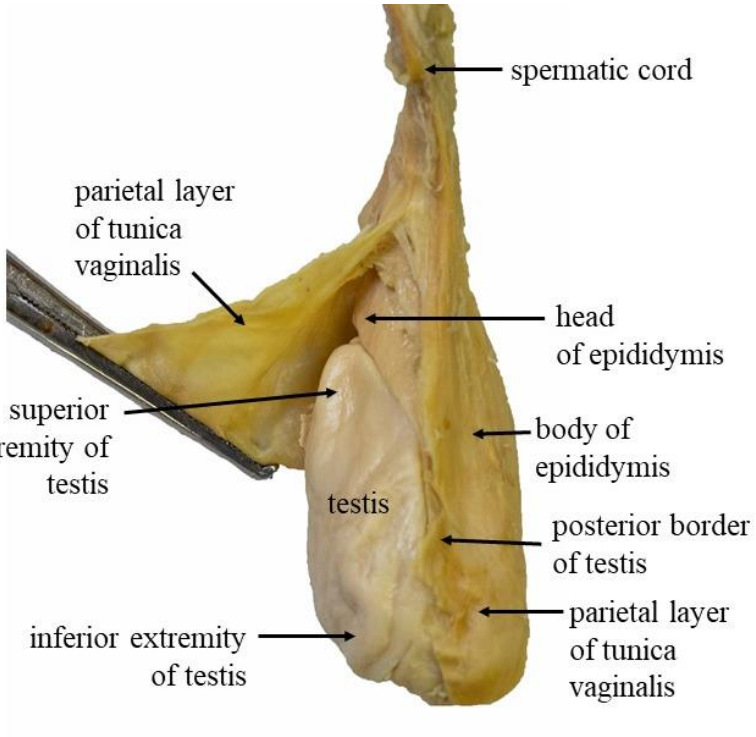

Fig. 30 Testis. Posterior view.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

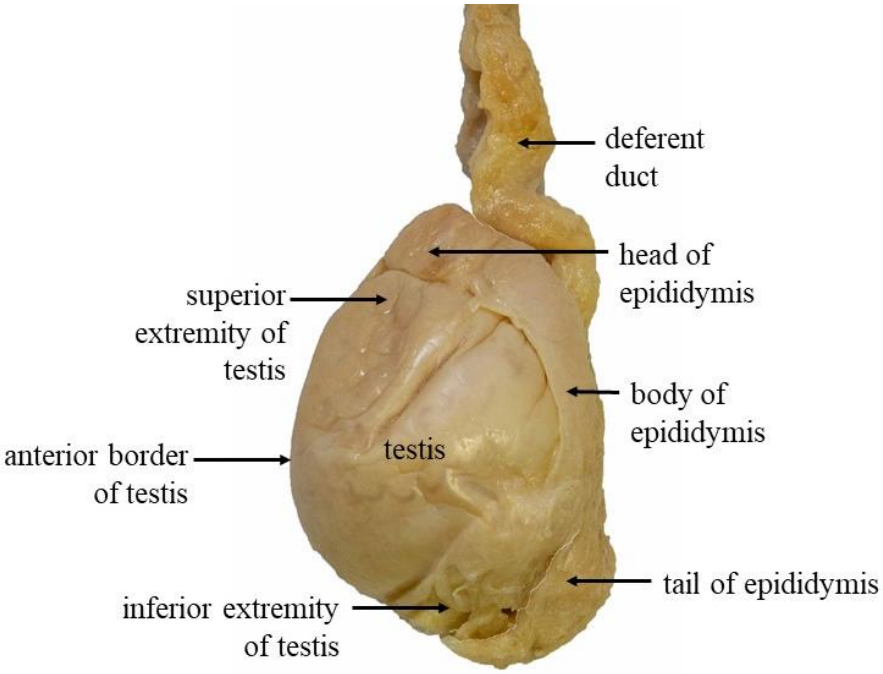

Fig. 31 Testis. Lateral view.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

Sometimes fixation of the testis may be inadequate and the testis is prone to the ***torsion of testis*** *(twisting of the spermatic cord). Testicular torsion may occur spontaneously or during exercise (physical activity). Torsion of the testis means the occlusion of the testicular vessels that results in edema and severe pain. The testis become ischemic and after 24 hours necrotic. Torsion of the testis requires the urgent surgery.*

Appendix testis *can be visible at the superior extremity of testis. It is the remnant of the Mullerian duct. Its torsion may produce the symptoms like the testicular torsion.*

Internal structure of the testis

The surface of the testis is covered by a serous membrane, **the visceral layer of tunica vaginalis testis (epiorchium)**. Tunica vaginalis testis is a remnant of peritoneum formed from the processus vaginalis (see chapter Descent of the testes). It is absent along the posterior border because here it covers or overlaps the epididymis.

Immediately below the visceral layer of tunica vaginalis testis, there is the dense collagenous membrane, **tunica albuginea**. It gives off **septula testis** that subdivide the testis into the **lobules of the testis (lobuli testis)**. See Fig. 32.

Tunica vasculosa (erythroidea) is a vascular plexus lining the internal surface of tunica albuginea and septula testis.

There are 250 – 300 lobules in each testis. The **lobule of the testis** is conical in shape. The base of the lobule directs to the external surface of testis and the apex projects dorsally to the mediastinum testis.

The lobules of the testis contain the **seminiferous tubules.** They are usually 80 cm long with a miniature lumen (only 0.2 mm in diameter). In the testis, there are around 500 seminiferous tubules.

The **seminiferous tubules are the site of spermatogenesis**.

Spermatogenesis *is a process of the divisions and transformations of the spermatogenic cells to mature spermatozoa. Within the epithelium of the seminiferous tubules, there are basally located*

spermatogonia and above them (adluminally) the primary spermatocytes, secondary spermatocytes, spermatids and the mature spermatozoa. Differentiating cells have specific metabolic needs that are provided by sustentacular (supportive) Sertoli cells situated within the seminiferous epithelium as well. The process of spermatogenesis from spermatogonia to mature spermatozoon takes 64 days.

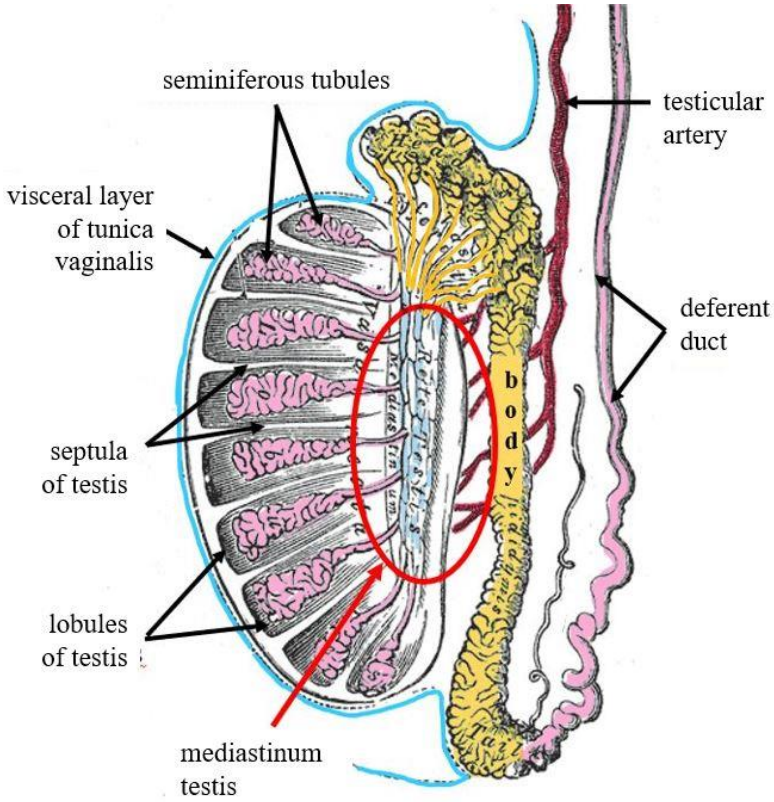

Fig. 32 Testis. Sagittal section.

Original diagram from Gray's anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the Human Body. Philadelphia: Lea & Febiger, 1918. Available online: at Bartleby.com, 2000. www.bartleby.com.Modified by additional colorization and labeling.

The main part of the seminiferous tubule, **the convoluted seminiferous tubule**, is highly curled. The short terminal part, **the straight seminiferous tubule**, is continuous with the collecting net, **the rete testis**.

The interstitium between the seminiferous tubules contains loose connective tissue with clusters of the **Leydig cells** that synthetise the **testosteron**.

The fetal Leydig cells, that produce the testosteron during the intrauterine development, are responsible for the differentiation of the male genitalia. They degenerate after the birth. During the puberty, the adult Leydig cells appear. They originate from undifferentiated stem cells. The androgens, synthetized by the adult Leydig cells ,are necessary for the initiation and maintaining of spermatogenesis and they are also responsible for the development of the secondary sexual characteristics.

Along the posterior border of testis, there is the **mediastinum testis** or **testicular hilum** (hilus). This area contains connective tissue of tunica albuginea, rete testis and the vessels. At the superior part of the mediastinum testis 12 – 20 efferent ductules arise from rete testis and enter the head of the epididymis.

The spermatozoa are differentiated within the seminiferous tubules and **then transported through the rete testis and efferent ductules to the head of epididymis.**

Blood supply, lymph drainage, and nerve supply of the testis

The testis is **blood supplied** by **the testicular artery** arising from the **abdominal aorta.** The testis develops intraabdominally and therefore it carries the vessels, lymphatics and the nerves from the abdomen. The testicular artery runs retroperitoneally in the abdominal cavity, passes through the inguinal canal, the spermatic cord to the hilum of testis. The course of the testicular artery shows the pathway of he tdescent of the testis.

Venous blood from the testis is drained to **the pampiniform plexus**. This plexus is formed by several veins that surround the testicular artery. The pampiniform plexus originates from mediastinum testis, continues through spermatic cord and inguinal canal. This plexus acts as **'a heat exchanger'** because it contains blood from the testes and epididymis that is colder than blood from the testicular artery that comes from the abdominal cavity. This way it helps to regulate the temperature in the testis. The optimal temperature for spermatogenesis is around 35 degrees Celsius. In abdomen, the veins of the pampiniform plexus unite and create two testicular veins

by the sides of the testicular artery. In the terminal portion, these two veins join to form one testicular vein.

The **right testicular vein opens into the inferior vena cava,**

the left testicular vein to the left renal vein.

The orthogonal junction between the left testicular vein and the left renal vein may affect the venous return. Therefore the dilation of the veins of the pampiniform plexus, varicocele, is much more often on the left side. The presence of varicocele can increase the temperature in the testis and thus negatively affects the spermiogenesis, or it may result in testicular pain.

The lymph of the testis is drained to the **lumbar lymph nodes** due to the intraabdominal development.

The nervous testicular plexus accompanies the vessels**.** It contains **sympathetic fibers** coming from the coeliac plexus through ganglion spermaticum (lying next to the origin of the testicular arteries of the abdominal aorta) and then continuing along the vessels to the testis. **Parasympathetic fibers** are from the **vagus nerve**. The presence of the vagus nerve explains the nausea and vomitus that accompany the testicular pain. Sensory fiberss ascend to the spinal segment T10.

Descent of the testes

During **the early phase of the intrauterine development** the testis is situated at the posterior abdominal wall at the level of the first or second **lumbar vertebra** (LI – LII). It is covered by the visceral peritoneum and attached to the dorsal wall by the peritoneal duplication, **mesorchium**. The mesenchymal condensation, **gubernaculum testis**, fixes the inferior extremity of the testis to torus genitalis.

The course of the testicular artery shows the course of the course of the descent of the testis because the blood vessels, lymphatics and nerves are carried by the descending testis.

Descent of the testis may be subdivided into two parts: **transabdominal** and **gubernacular.**

The transabdominal part of the descent begins in **the third month of intrauterine development** when the **testis descends** through the retroperitoneal space **to the iliac fossa**.

From **the fourth to the seventh month** the testis lies **next to the deep inguinal ring**.

The transabdominal part of the descent is 'relative' caused by the growing abdomen, while the testis is fixed by the gubernaculum.

Since the seventh month of intrauterine development the gubernacular part of the descent begins, gubernaculum testis shortens.

During **the 27th – 28th week of the intrauterine development,** the testis descends through **the inguinal canal** and around **the 33rd week it reaches the scrotum**.

The descent through the inguinal canal and scrotum, the gubernacular part of the descent, is the „real“ descent.

Descent of the testis from the abdomen, through the inguinal canal to scrotum is regulated by the gonadotropins and androgens.

The peritoneum of the abdominal cavity (on both sides of the median plane) forms extensions, **vaginal processes** (in Latin **processus vaginales**).

The **formation of vaginal process precedes the descent of the testis**.

Each **vaginal process** follows the gubernaculum testis, during the descent it pushes the layers of the anterior abdominal wall forming the walls of the inguinal canal, and finally it enters the scrotum.

The **testis descends along the posterior aspect of the vaginal process**. When the testis reaches the scrotum, it squeezes into the **vaginal process** that **becomes tunica vaginalis testis**. One layer covers the surface of the testis like the **visceral layer of tunica vaginalis**. The other layer forms the **parietal layer of tunica vaginalis testis** and lines the cavity of scrotum.

After the birth by 1.5 year of age, the connection between the peritoneal cavity and vaginal process obliterates.

*Healthy full – term newborns have the testes well descended in scrotum. The absence of testis in scrotum is defined as **cryptorchidism**. The incidence of cryptorchidism in full - term male newborns is 1-6 %, in pre - term newborns up to 30 %. The majority of undescended testes complete the descent to scrotum during the first three month after the birth. The unilaterally undescended testis is more often than bilateral absence of the testes in scrotum. The gubernacular part of the descent is much more error – prone than the transabdominal. Incomplete descent along the normal pathway is **'arrested testis'**. The testis is usually arrested in inguinal canal. If the testis leaves the normal pathway of descent, it becomes „**ectopic testis**" (e.g. in the superficial inguinal pouch). Undescended testes are associated with higher risk of seminoma and infertility.*

2.1.2 EPIDIDYMIS

The epididymis is usually defined as **a reservoir of sperm cells**. During the transit through the epididymis, the sperm cells (spermatozoa) acquire fertilization capability and develop motility potential. These changes are especially biochemical and functional, and therefore, they are not demonstrated morphologically.

Position and relations of the epididymis

The **epididymis** lies **along the posterior border of the testis** (see Fig. 33).

It is **covered by the visceral layer of tunica vaginalis testis.** Between the testis and epididymis tunica vaginalis forms a fold, sinus epididymidis.

The epididymis is attached to the testis by the **superior and inferior ligament of the epididymis**. The tail of the epididymis is connected to the floor of scrotum by the **scrotal ligament (gubernaculum testis)**.

The epididymis is related to testis and deferent duct.

External and internal description of the epididymis

The average length of the epididymis is 4 – 5 cm. It consists of t**he head, body and tail** (see Fig. 33).

The upper part, **the head of the epididymis**, receives 12 – 20 efferent ductules. Within the head, they enlarge and form coiled lobular ducts that open to the single **duct of the epididymis** running within the **body and tail of the epididymis**. The duct of epididymis is highly convoluted with the total lenght of more than 6 m. It **continues as the deferent duct (vas deferens)**.

The duct of epididymis is lined by the pseudo - stratified columnar epithelium surrounded by the smooth muscle fibres. Fibrous bands keep the convolutions of the duct together. Peristalsis drives sperm cells to the tail of the epididymis.

*The **appendix of the epididymis** is a vesicular remnant at the head of epididymis. Its torsion can imitate the torsion of testis.*

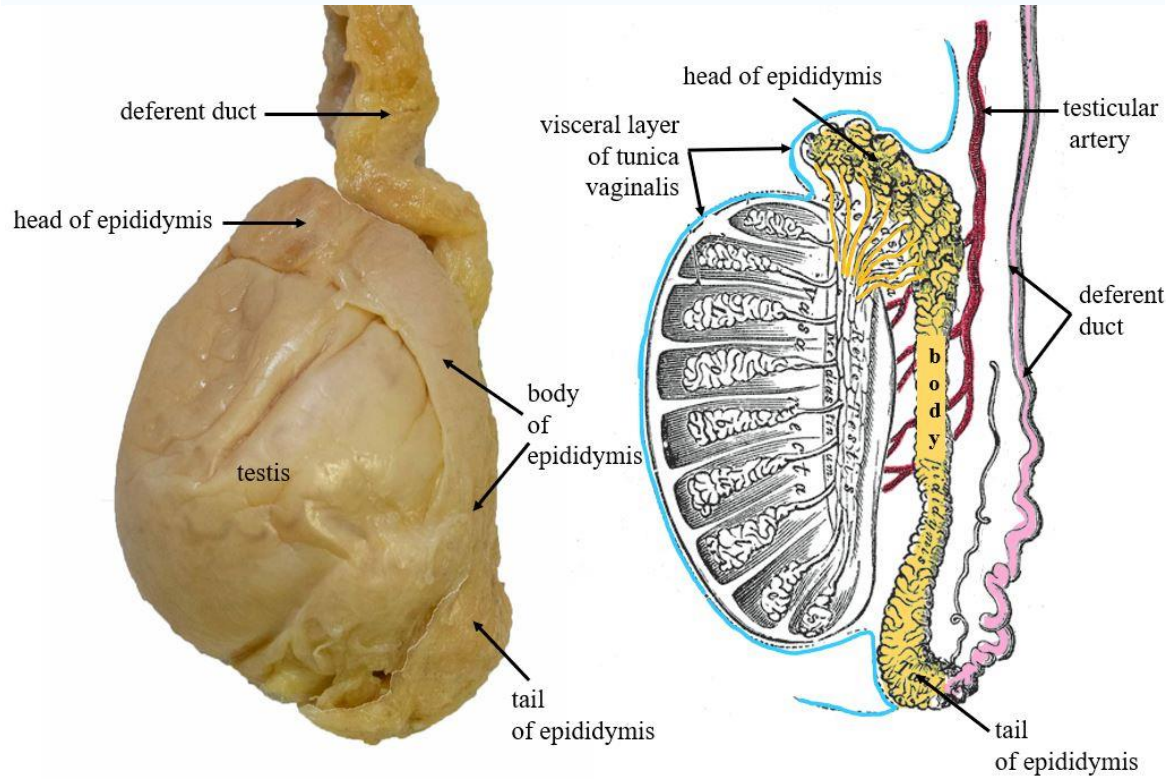

Fig. 33 Epididymis.

A Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University. B Original diagram from Gray's anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the Human Body. Philadelphia: Lea & Febiger, 1918. Available online: at Bartleby.com, 2000. www.bartleby.com. Modified by additional colorization and labeling.

Blood supply, lymph drainage and nerve supply of the epididymis

The epididymis is blood supplied by **the branch of the testicular artery.**

Venous blood from the epididymis is drained to **the pampiniform plexus**.

The lymph from **the head and body of the epididymis** is drained to the **lumbar lymph nodes, from cauda** along the artery of the deferent duct to the **pelvic lymph nodes** and partially to the **superficial inguinal lymph nodes** through the lymphatics of the scrotum.

The nerve supply for the epididymis comes from **the testicular plexus.** Sensory fibers ascend to the spinal segment T11 – T12.

2.1.3 DEFERENT DUCT (VAS DEFERENS)

The **deferent duct (vas deferens)** transports the spermatozoa from the epididymis (the duct of epididymis) to the ejaculatory duct. It is 45 – 50 cm long tube with an external diameter 3 – 4 mm and a lumen diameter around 0.5 mm.

Position and relations of the deferent duct

On the basis on its course the deferent duct is subdivided into following parts:

scrotal, funicular, inguinal, abdominal and pelvic part (see Fig. 34)**.**

The initial **scrotal part of the deferent duct,** immediately as it continues from the duct of epididymis, has a highly convoluted course. However, as it extends upward **behind the testis** and **medially to the epididymis,** it straightens.

At the level of the superior extremity (pole) of the testis it enters **the spermatic cord** (funiculus spermaticus) and continues as **the funicular part of the deferent duct**. Within the spermatic cord it is related to the **testicular artery, the venous pampiniform plexus and the nervous testicular plexus**.

Together with these vessels and nerves, it continues through the superficial inguinal ring to **the inguinal canal (the inguinal part of the deferent duct)**. The deferent

duct enters the abdominal cavity through the deep inguinal ring (the abdominal opening of the inguinal canal).

As it enters **the abdominal cavity**, it is related to **the inferior epigastric vessels** which ascend around the deep inguinal ring medially to the deferent duct. Then the deferent duct crosses **the external iliac vessels** and descends into the pelvis.

In its **pelvic part,** it runs below the peritoneum and extends to the posterior wall of the urinary bladder. During this course, it is related to the obliterated umbilical artery, obturator vessels and nerve. Next to the bladder and above the upper part of the seminal gland the deferent duct **crosses the ureter** (see Fig. 34).

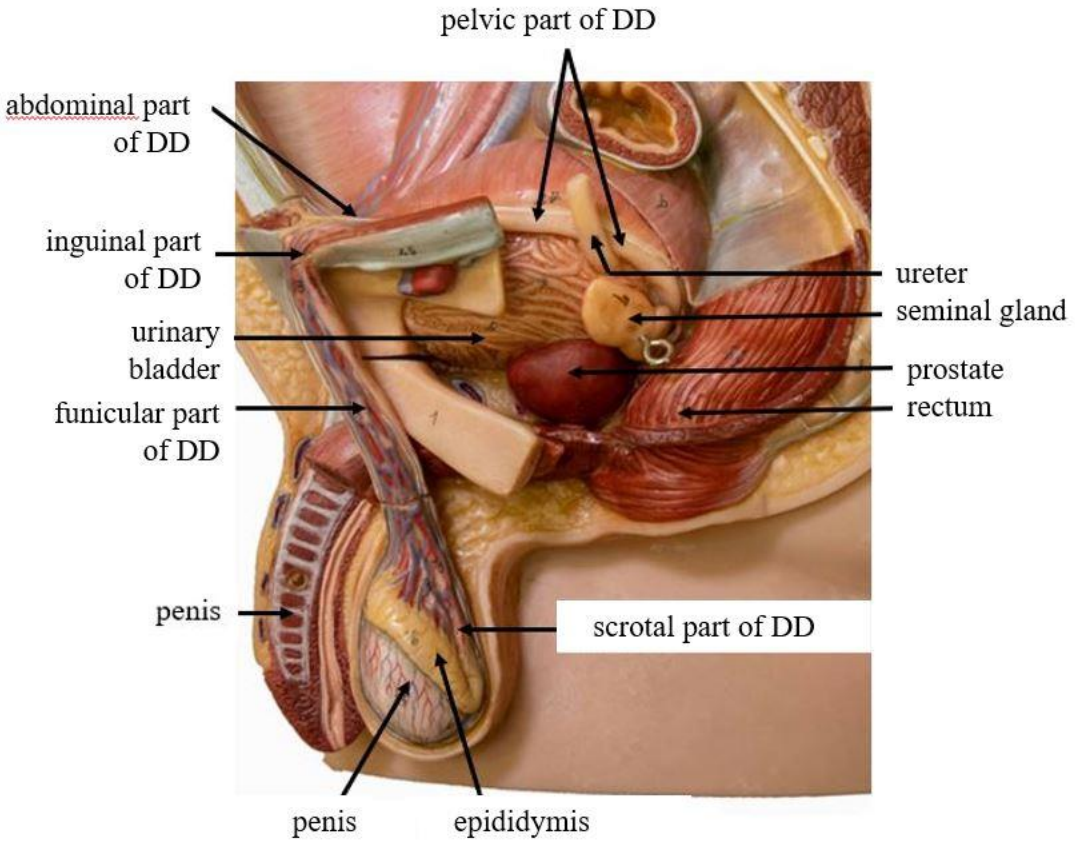

Fig. 34 Deferent duct (DD). Course and parts. Sagittal section of the male pelvis.

Phototography of SOMSO model, modified by additional drawing, labeling and colorization. Modified by additional colorization and labeling.

As the deferent duct continues behind the urinary bladder, it descends along the medial side of the **seminal gland** (seminal vesicle, vesiculous gland) and in front of

the rectum (see Fig. 34 and Fig. 35). The **terminal part** of the deferent duct is dilated forming **the ampulla of the deferent duct**.

Directly above the prostate, the deferent duct unites with the duct of **the seminal gland** (seminal vesicle, vesiculous gland) creating **the ejaculatory duct**.

The ejaculatory duct traverses the prostate and opens into **the prostatic part of the urethra at the seminal colliculus**.

The deferent duct is related to:

- **the testis and epididymis in scrotum**
- **the testicular artery, venous pampiniform plexus, nervous testicular plexus in the spermatic cord (funiculus spermaticus) and inguinal canal**
- **the inferior epigastric vessels and external iliac vessels in abdominal cavity**
- **the obliterated part of umbilical artery, obturator vessels and nerve, ureter and seminal glands** (seminal vesicles, vesiculous glands) and **rectum in pelvis**.

Vasectomy (a method of male sterilization) is a minor surgical procedure when the deferent ducts are cut or blocked in the funicular part. This way the transport of the sperm cells is stopped. The course of the deferent duct within the spermatic cord is easily accessible through the skin and superficial fascia. It may be palpated within the spermatic cord and differentiated from the testicular vessels according to its thick and solid wall.

According to the American Urological Association (2012), vasectomy should be performed with local anaesthesia. The small incisions on the both sides of the scrotum allow the urologist to isolate and cut the deferent ducts. The ends of the deferent ducts should be occluded, e.g. by mucosal cautery with or without a fascial interposition, by ligatures or clips. Although vasectomy is considered to be a permanent form of birth control, it does not provide immediate sterility. The male or female partner should still use another form of contraception for 8-16 weeks until the occlusion of the deferent duct is confirmed by the postvasectomy semen analysis.

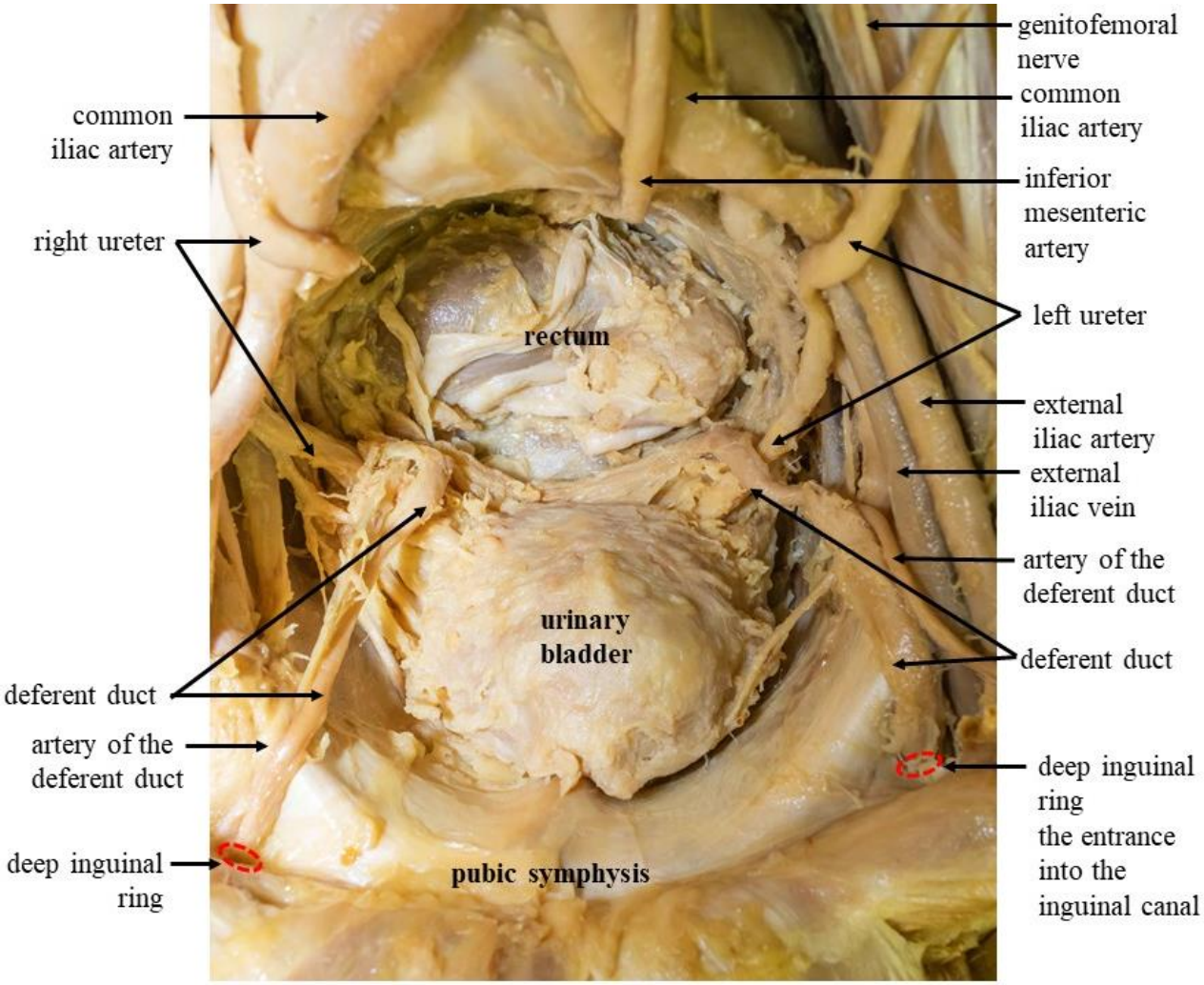

Fig. 35 Course of the deferent duct in the pelvis.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

Wall of the deferent duct

The deferent duct has **thick wall** with 4 mm in outside diameter and only a minute lumen (0.5 mm in diameter).

The external layer is formed by loose connective tissue, **adventitia**.

The middle and the thickest is **the muscular layer** composed of the smooth muscle fibres. In the cross-section there are visible 3 layers: internal longitudinal, circular and external longitudinal layer. In the spatial arrangement the muscle fibres form the spirals. Contraction of the muscle layers (peristalsis) allows the emission of the sperm

cells from the epididymis through the ejaculatory duct to the prostatic part of the urethra.

The internal lumen of the deferent duct is lined by **mucosa** that forms longitudinal folds.

The wall of the ejaculatory duct is much thinner.

Blood supply, lymph drainage and nerve supply of the deferent duct

The **deferent duct** takes blood supply from the **internal iliac artery**. The **artery of the deferent duct** can arise directly from the internal iliac artery or from the **superior vesical artery or umbilical artery**.

Venous blood from the scrotal, funicular and inguinal part of the deferent duct is drained to the **pampiniform plexus** and from the pelvic part to the **vesical plexus**.

Lymphatic vessels transport the lymph to the **internal and external iliac lymph nodes**.

The deferential nervous plexus receives the fibers from the **inferior hypogastric plexus**, **sympathetic fibres** from segments L1-L3 through lumbar splanchnic nerves and **parasympathetic fibers** from segments S2-S4 through pelvic splanchnic nerves. Especially **sympathetic fibers are responsible for the emission of the sperm cells**.

SPERMATIC CORD

The spermatic cord is a bundle consisting of **the deferent duct** and surrounding neurovascular structures: **the testicular artery, artery of the deferent duct, venous pampiniform plexus, nervous testicular plexus, nervous deferential plexus and lymphatics** (see Fig. 36 and Fig. 37).

The **testicular artery** is located ventrally and it is surrounded by the veins that form the **pampiniform plexus** and by the nerves forming the **testicular plexus**. **The**

deferent duct is situated posteriorly. **The artery of the deferent duct** and **nervous deferential plexus** lies immediately around the deferent duct

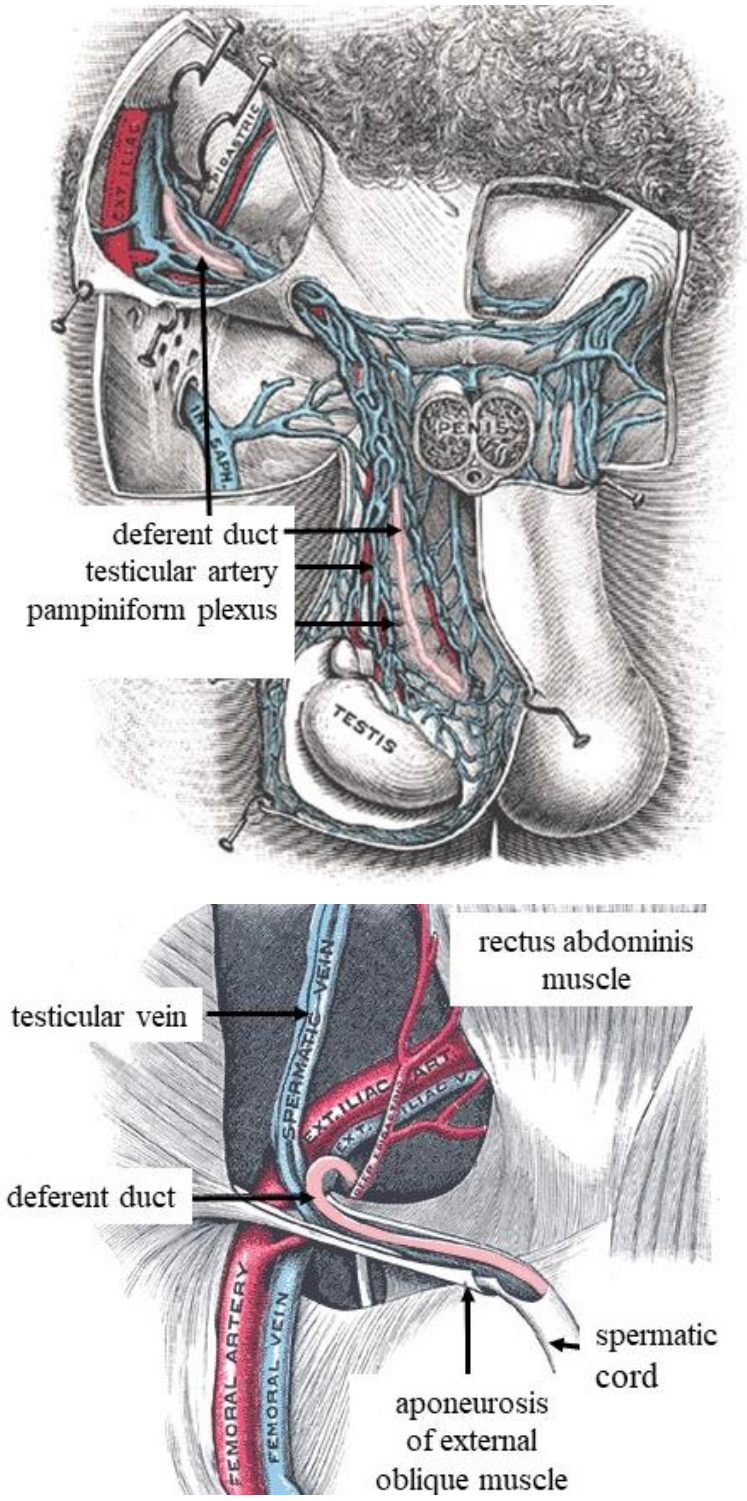

Fig. 36 Spermatic cord.

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All these structures are **ensheated by the layers derived from the layers of scrotum**: internally **the internal spermatic fascia**, in the middle **cremaster muscle and cremasteric fascia** and outside **the external spermatic fascia**.

The peritoneal vaginal process is obliterated within the spermatic cord and only the remnant may be seen, vestige of vaginal process.

The genital branch of the genitofemoral nerve enters and supplies the cremaster muscle. The ilioinguinal nerve is externally attached to the spermatic cord.

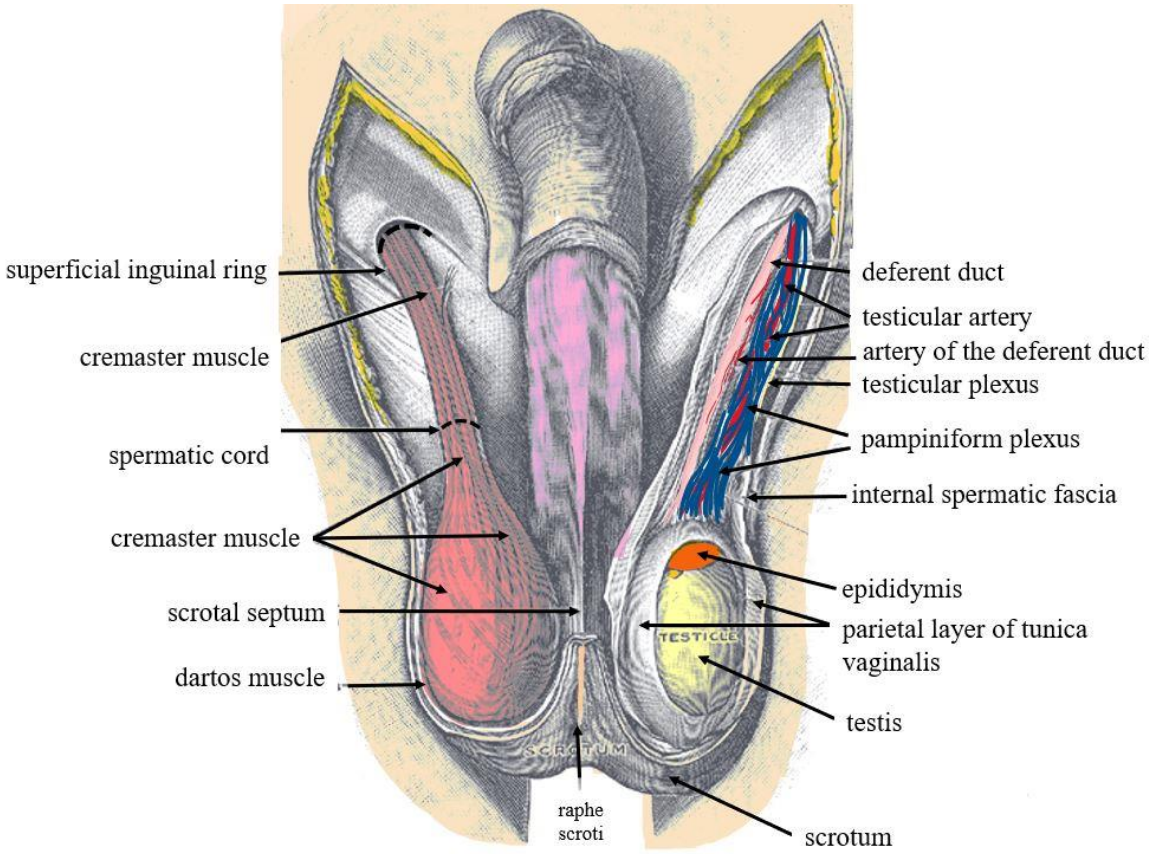

Fig. 37 Spermatic cord.

Content of the scrotum (anterior wall removed, penis reflected upward).

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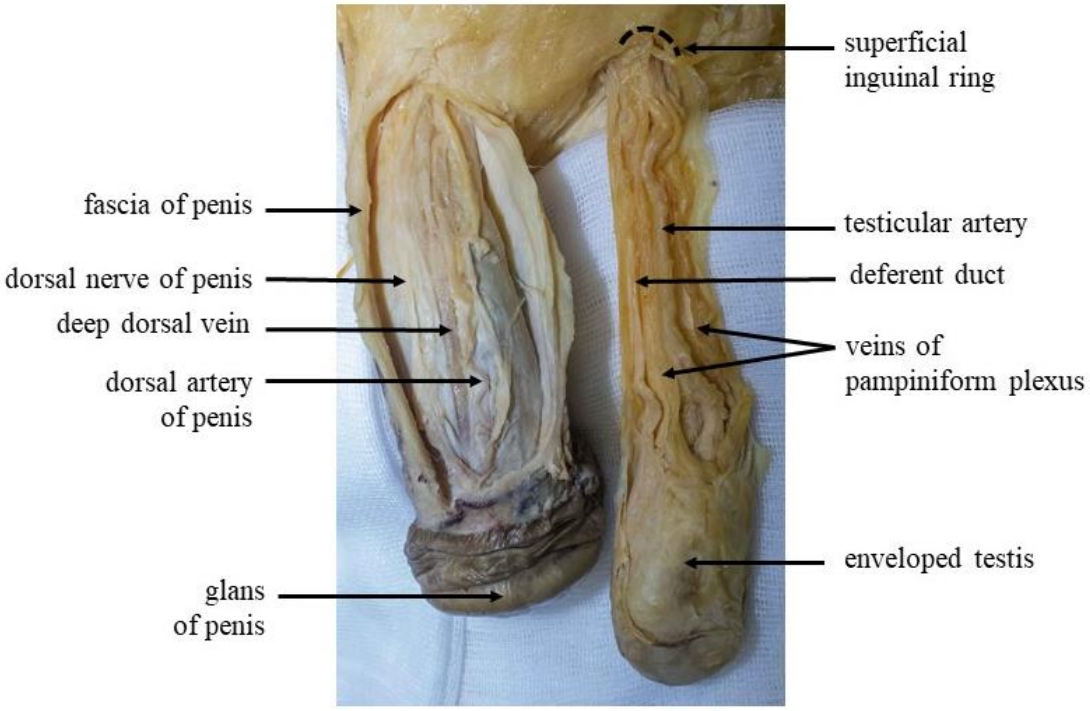

Fig. 38 Spermatic cord.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

2.1.4 SEMINAL GLAND (SEMINAL VESICLE, VESICULOUS GLAND)

The seminal gland (**seminal vesicle, vesiculous gland**) is a paired **accessory gland** of the male reproductive system (see Fig.39).

The gland is not a reservoir of the spermatozoa (it is the epididymis), however, **its secret forms the majority (60-80%) of the ejaculate** (semen).

The fluid produced by the seminal glands plays a key role in the semen coagulation, sperm cell mobility and sperm chromatin stability. It is also responsible for the suppression of the immune response in the female genital organs. This alkaline fluid contains the specific proteins, citric acid, high concentration of the fructose (an energy source for the sperm cells), prostaglandins (important for the mobility and viability of the sperm cells), potassium and phosphorus.

Position and relations of the seminal gland (seminal vesicle, vesiculous gland)

The seminal glands are situated **behind the urinary bladder** and **in front of the rectum** in **rectovesical septum** (see Fig. 39 and Fig. 40).

The uppermost parts of the glands are covered by the parietal peritoneum that forms the rectovesical pouch.

Along the medial side of the seminal vesicle, **the deferent duct** descends.

Above the seminal gland, there is **the ureter**.

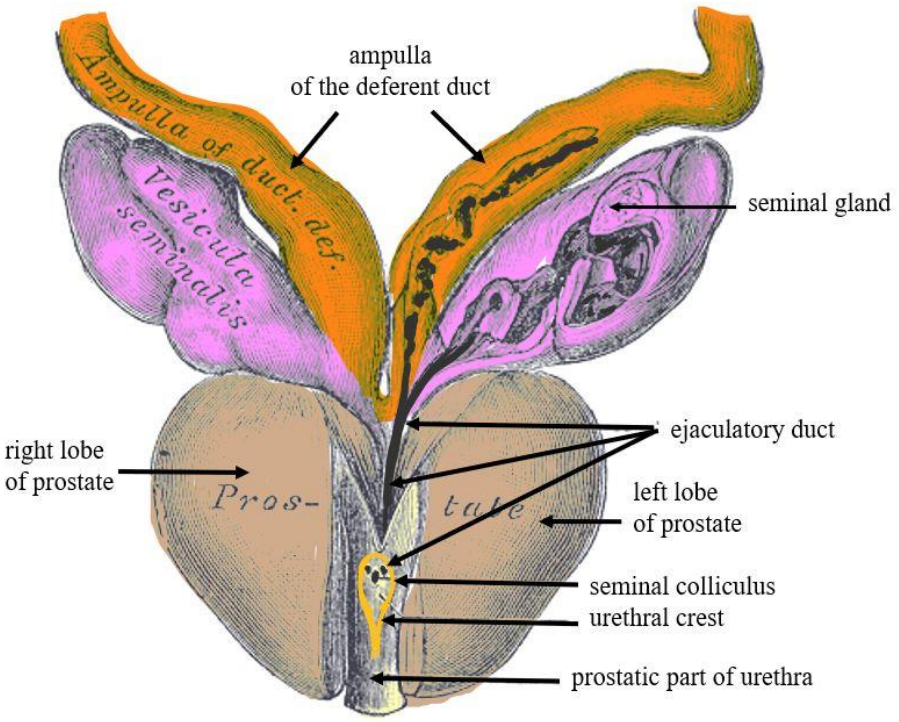

Fig. 39 Prostae, seminal vesicles and the deferent ducts.

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Modified by additional colorization and labeling.

External description of the seminal gland (seminal vesicle, vesiculous gland)

The seminal gland is around 5 cm long **sacculated organ**.

The gland is formed by a coiled tube with the uncoiled lenght around 13 cm and the lumen near 3 mm.

The duct of the seminal gland joins with the deferent duct to form the ejaculatory duct that opens into the prostatic part of the urethra.

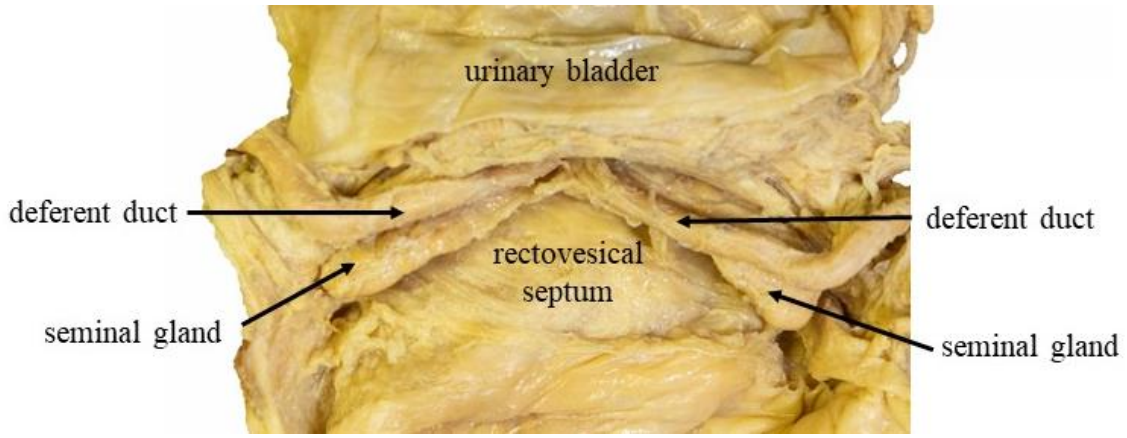

Fig. 41 Seminal glands within the rectovesical septum.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

Internal structure of the seminal gland (seminal vesicle, vesiculous gland)

The convolutions of the seminal gland are externally enclosed by the connective tissue, **adventitia**. It contains mainly collagenous and elastic fibres. Adventitia fixes the gland to the fundus (base) of the urinary bladder. Posteriorly, behind the gland, there is the rectovesical septum (Denonvilliers' fascia).

The muscular coat contains 3 layers of the smooth muscle cells (similarly as in the deferent duct).

The internal surface is lined by pseudostratified columnar epithelium with goblet cells. **Mucosa** is highly folded when the gland is empty and may be distended when the fluid is stored until its emission during ejaculation. The fluid secreted by the seminal glands play a key role in the facilitation of the sperm survival and transport through the male and female genitalia.

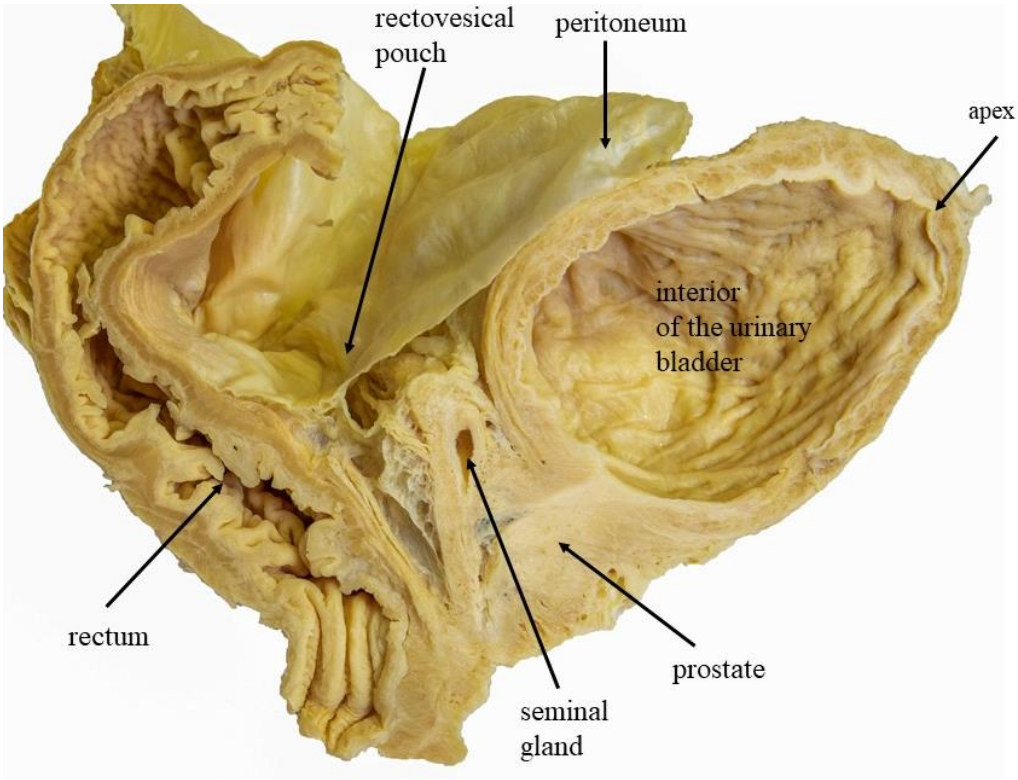

Fig. 41 Seminal glands in rectovesical septum.

Sagittal section of the male pelvis.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

Blood supply, lymph drainage and nerve supply of the seminal gland

The seminal glands are blood supplied by **the inferior vesical artery**, **the artery of the deferent duct** and **the middle rectal artery**.

Venous blood is drained to **the prostatic and vesical venous plexus**.

Lymphatic vessels of the seminal vesicles deliver the lymph to the **internal and external iliac lymph nodes**.

The nerves come from **the inferior hypogastric plexus.** Sympathetic fibers from segments L1 – L3, parasympathetic fibers from segments S2 – S4.

2.1.5 PROSTATE

The prostate is an **unpaired accessory gland** of the male reproductive system. Prostatic secretions form up to 1/6 of the ejaculate (semen). The prostate surrounds the male urethra.

The prostatic fluid contains citric acid, phosphatase, amylase, fibrinolysin, prostatic specific antigen (PSA) and a high concentration of zinc. An important component of the prostatic fluid are the prostasomes, vesicles produced by the epithelial cells within the secretory acini, which are capable of fusing with a sperm. They increase the motility of the sperm cells and help to protect the sperm cells against the immune response in the female genital organs. The antioxidant and antibacterial properties are also discussed.

External description of the prostate

The prostate has a shape and size similar to **a chestnut**. The average weight is around 20 g, the transverse diameter 4 cm, ventrodorsal 2 cm, and craniocaudal 3 cm.

Its wider upper portion, **the base**, is closely related to the urinary bladder.

The apex of the prostate directs ventrocaudally to the urogenital diaphragm (transversus perinei profundus).

The anterior surface is slightly convex, related to the retropubic space and connected to the pubic bones by puboprostatic ligaments . (see Fig. 34).

The posterior surface of the prostate is flat and may be palpable per rectum. The rectovesical septum (Denonvillier' fascia) is situated between the prostate and rectum.

The inferolateral surfaces are related to the pelvic diaphragm (levator ani muscle).

The urethra passes between the anterior and middle third of the prostate.

The ejaculatory ducts pierce the dorsocranial part of the prostate, pass ventrocaudally and open into the prostatic part of the urethra.

The prostate is subdivided into **the right, left and middle lobes** and **the isthmus** (commisure of the prostate). See Fig. 42.

The middle lobe is embedded between the ejaculatory ducts and behind the urethra. **The right and left lobes** are situated on the sides.

The isthmus is the anterior part of the prostate, located between the right and left lobes in front of the urethra. It contains mainly fibromuscular stroma and almost no prostatic glands.

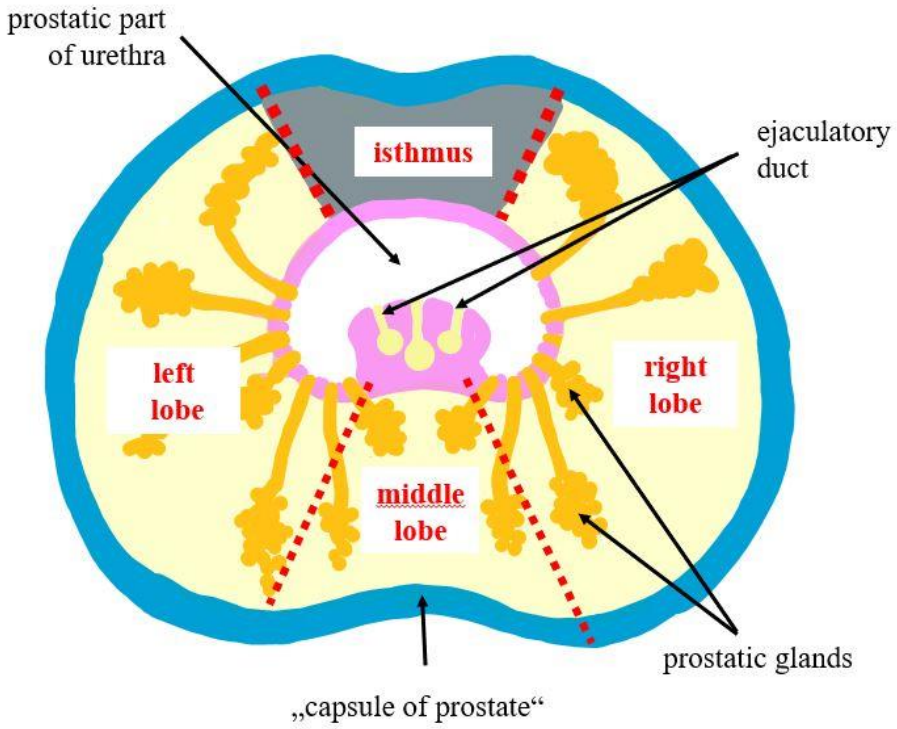

Fig. 42 Lobes of the prostate. Transverse section of the prostate.

Redrawn from Čihák, R. (2016). Anatomie 2. Třetí, upravené a doplněné vydání. Grada Publishing, a.s.

Position and relations of the prostate

The prostate is situated **below the urinary bladder**, **in front of the rectum** and **behind the pubic symphysis** (retropubic space).

The inferolateral surfaces of the prostate are **related to the pelvic diaphragm** (levator ani muscle).

The apex of the prostate touches the **urogenital diaphragm** (transversus perinei profundus muscle).

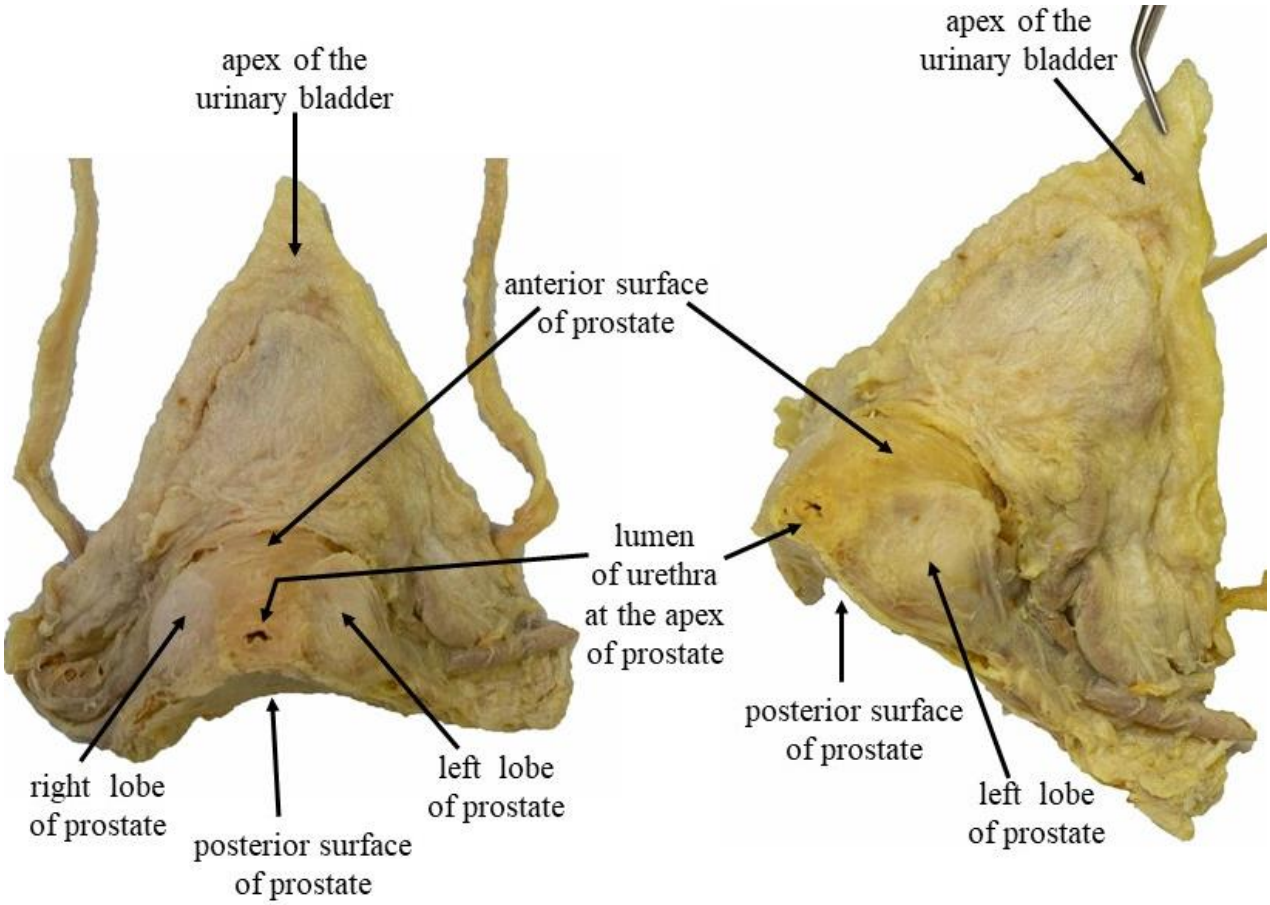

Fig. 43 Prostate and urinary bladder.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

Internal structure of the prostate

The terminology that determines the coverings of the prostate is not completely unified (different names in different references).

The older textbooks describe the prostatic capsule consisting of two layers, proper and periprostatic capsule. However, the latest studies have revealed a different layout.

Most authors have agreed that **there is no true 'prostatic capsule'.**

Actually, there is **a visceral prostatic fascia** formed by the external fibromuscular layer of the prostate and neurovascular tissue and the **lateral prostatic fascia** (**periprostatic fascia, prostatic fascia**).

The lateral prostatic fascia (**periprostatic fascia, prostatic fascia**) is situated between the external fibromuscular layer of the prostate called the " capsule" and the levator ani fascia. Morphological studies confirmed that lateral prostatic fascia is a multilayered connective tissue containing the collagen fibres, adipose tissue and blood vessels. This fascia extends from the endopelvic fascia and covers the anterior and lateral surfaces of the prostate. Dorsally there is a Denonvilliers' fascia (rectovesical septum). Extension of the longitudinal muscle fibers of the detrussor vesicae, **detrussor apron**, covers the anterior surface of the prostate.

Prostatic glandular tissue is made up of follicles. They open into the channels that join to form around **15 – 20 prostatic ducts** opened into the **prostatic sinuses** within **the prostatic part of the urethra.** Prostatic sinuses are depressions in the floor of the urethra around the seminal colliculus.

Originally, the prostate was subdivided into five lobes, however, they can be recognized only to the 20th week of intrauterine development.

In anatomy the **subdivision** into **the right, left, middle lobes and isthmus** is commonly used.

From the point of **view of the pathology**, the prostatic glandular tissue is arranged in three **zones**: **peripheral, central and transitional** (see Fig. 44).

Nonglandular tissue (isthmus) is located in front of the urethra between the peripheral zones. The central zone is behind the urethra and surrounds the ejaculatory ducts. The transitional zone is immediately around the urethra anterior to the central zone. The peripheral zone forms the largest volume of prostatic glandular tissue, approximately 70 %. It encloses the central zone.

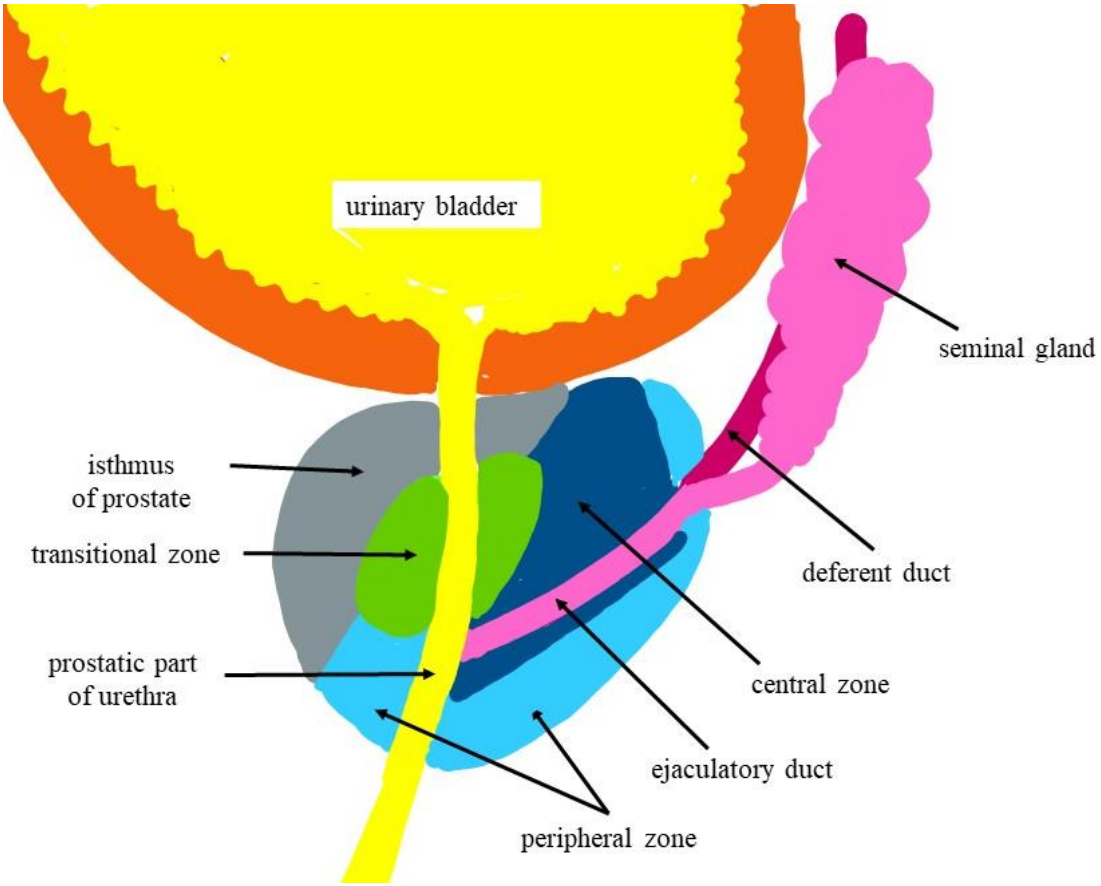

Fig. 44 Zonal anatomy of the prostate.

Redrawn from Franz, M. C., Anderle, P., Bürzle, M., Suzuki, Y., Freeman, M. R., Hediger, M. A., & Kovacs, G. (2013). Zinc transporters in prostate cancer. Molecular aspects of medicine, 34(2-3), 735–741.

The ***zonal anatomy changes with increasing age****.*

Central zones become atrophic, while the transitional zones enlarge.

Benign prostatic hyperplasia *begins around 50 years of age as small nodules within the* ***transitional zone****. Growing nodules may compress the urethra and reduce its lumen, which results in restriction or blockage of the urine passage. Sometimes when the obstruction is severe, the transurethral or suprapubic catheterization is needed.*

Prostatic carcinoma *usually occurs* ***in the peripheral zones****. Digital examination per rectum usually reveals a hard, rock-like tumour. The blood test may show elevated levels of prostatic specific antigen (PSA). Biopsy under ultrasound control is always necessary to confirm the diagnosis.*

The ***central zone is rarely affected by pathological processes****. It probably results from the histomorphological characteristics dependent on the development. The central zone originates from the Wolffian duct; however, the rest of the prostate originates from the urogenital sinus.*

Blood supply, lymph drainage and nerve supply of the prostate

The prostate is blood supplied by the branches from **the inferior vesical artery**, **the middle rectal artery** and **the internal pudendal artery**.

Prostatic venous plexus takes the venous blood to **the internal iliac vein**.

The lymph is mainly drained into the **internal and external iliac lymph nodes** and **sacral lymph nodes**.

The nerves come from the **inferior hypogastric plexus**. **Sympathetic fibers** from the segments L1 – L3, **parasympathetic** from S2 – S4. The autonomic nerves of the prostate run around the prostatic fascia to form the periprostatic nervous plexus posterolaterally behind the prostate.

The autonomic nerves for the seminal vesicles, urethra, bulbourethral glands and penis are closely related to the prostate and can be injured during radical prostatectomy.

2.1.6 BULBOURETHRAL GLAND (COWPER'S GLAND)

The bulbourethral gland is a **paired exocrine accessory gland** of the male reproductive system. It is homologic to the greater vestibular gland in female (Bartholin's glands).

Before ejaculation, the bulbourethral glands produce the mucinous fluid that contributes to the lubrication of the urethra for the emission of semen. It also neutralizes acidic urine residue in the spongy urethra.

Position, relations and external description of the bulbourethral gland

The pea-shaped **bulbourethral glands** are embedded **in the inferior surface of the urogenital diaphragm**.

The **bulbourethral glands** are located laterally to the **membranous part of the urethra**, superolaterally to the **bulb of the penis**, **above the perineal membrane**.

These glands are small , around 1 cm in diameter, yellowish consisting of lobules enclosed by the fibrous capsule and muscle fibers of the external urethral sphincter. **The excretory duct of the bulbourethral gland** descends mediocaudally and pierces the perineal membrane and **opens into the spongy part of the urethra within the bulb of the penis** (see Fig. 46)**.**

Blood supply, lymph drainage and nerve supply of the bulbourethral gland

The glands are supplied by branches of **the artery of the bulb of penis** and **penile artery coming from the perineal artery**.

Venous blood is taken by the accompanying veins to the **internal pudendal vein**.

The lymph is drained into the **internal and external iliac lymph nodes**.

The autonomic nerve fibers come from the **inferior hypogastric plexus**.

Adenocarcinomas of the bulbourethral glands can release high levels of the prostatic specific antigen (PSA) and therefore can be confused with prostatic cancer.

Stasis of the secretion may cause the formation of stones. The infection process in the urethra may also spread to the bulbourethral glands. The acute inflammation of the bulbourethral glands (Cowperitis) can result in faintness, fever and perineal pain, sometimes painful defecation, and urinary retention. Chronic inflammation of the bulbourethral glands is usually associated with congenital defects, e.g. syringocele.

2.2 EXTERNAL MALE GENITAL ORGANS

2.2.1 PENIS

The penis is a male copulatory organ that consists of **the root** and **the body** (see Fig. 47 and 48).

External and internal description of the penis

The root of the penis (radix penis) is located in the urogenital triangle of the perineum, within the superficial perineal pouch (between the perineal membrane and the superficial fascia).

The root is a fixed part of the penis formed by **the bulb of the penis** and two **crura of the penis.**

The bulb of the penis is a rounded mass of erectile tissue situated between the crura and attached to the perineal membrane. **Urethra enters into the bulb** through its superior surface. Distally **it is continuous with corpus spongiosum** in the body of penis. The inferolateral surface of the bulb of the penis is covered by the **bulbospongiosus muscle.**

Contraction of the bulbospongiosus muscle helps to empty the spongy part of the urethra during both ejaculation and urination. The bulbospongiosus muscle is attached to the fascia of the penis and its contraction results in compression of the deep dorsal vein of the penis, thus making a contribution to the erection of the penis.

Crura of penis (singular crus of penis) are paired rounded and elongated masses attached to the phallic crest at the inferior pubic rami. **Crura of penis** distally **continue as corpora cavernosa** in the body of penis. The **ischiocavernosus muscle** covers the surface of the crus of the penis.

Contraction of the ischiocavernosus muscle results in compression of the crura of the penis and decelerates the return of venous blood from the body of the penis. This way it helps to maintain the erection of the penis.

The body of the penis is a pendulous part covered by the skin.

It consists of **three erectile masses: corpus spongiosum and two corpora cavernosa**.

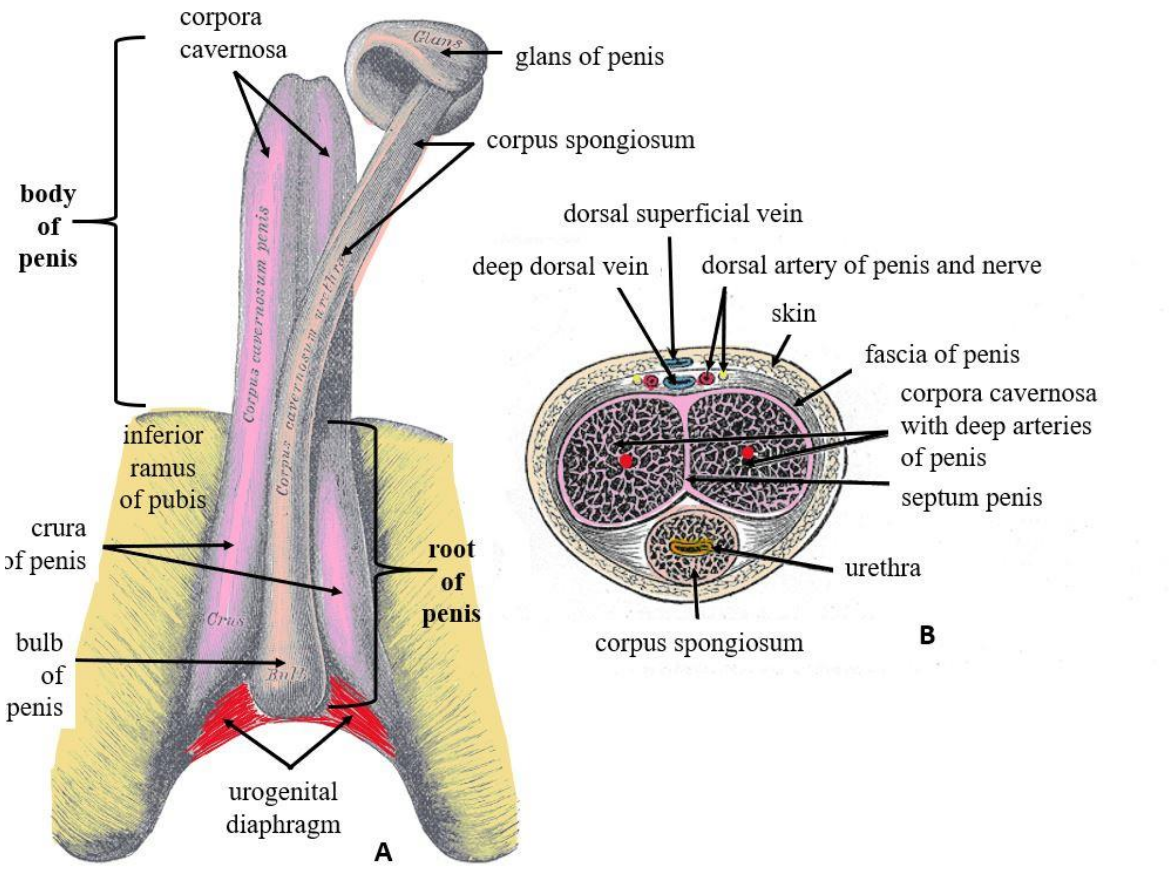

Fig. 45 Penis. A – inferior view. B section through the body of the penis.

Original diagram from Gray's anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the Human Body. Philadelphia: Lea & Febiger, 1918. Available online: at Bartleby.com, 2000. www.bartleby.com.
Modified by additional colorization and labeling.

The anatomical position of the penis is when it is in erection, therefore corpora cavernosa are described as dorsal bodies and corpus spongiosum as ventral one (see Fig. 45).

There are **two surfaces of the penis: the dorsum of the penis** (in flaccid penis it directs ventrally) and the **urethral surface** (in flaccid penis it directs dorsally).

The dorsum of the penis is formed by the corpora cavernosa, and the urethral surface by the corpus spongiosum that is traversed by the urethra. The neurovascular bundle runs along the dorsal surface of the penis.

The proximal part of **the body of penis is fixed by two ligaments: fundiform and suspensory (triangular) ligament**. he fundiform ligament is more superficial

and continues from the fascia of the penis to the lower part of the linea alba. The suspensory ligament (triangular) is deeper one, attached to the pubic symphysis.

Corpora cavernosa (cavernous bodies) are two erectile bodies separated by the septum of the penis and enveloped by a common **tunica albuginea**. Tunica albuginea is composed of two layers. The superficial layer is formed by the longitudinal fibres enclosing both cavernous bodies. The deep layer consists of circular fibres that envelope each body separately and fuse in the middle as a septum of the penis. Distally the septum is not complete and allows the blood circulation between both cavernous bodies.

Corpus spongiosum (spongy body) is the continuation of the bulb of the penis. Its terminal part is enlarged to form **the glans of the penis**.

The urethra passes through the corpus spongiosum and **opens at the top of the glans of the penis** as **the external urethral orifice**.

The glans of the penis is conical in shape, overlapping the terminal parts of the corpora cavernosa. Its base (proximal part) forms **corona of the glans**. Above corona of the glans there is the neck of the penis.

The skin covering the body of the penis is **loosely attached to the tunica albuginea**.

Above the corona glandis, the **skin** forms a fold, **prepuce (foreskin**). The inner layer of the prepuce continues from the neck of the penis onto the glans.

At the glans of the penis, the skin is firmly attached. At the urethral surface in the midline of the glans, there is **frenulum of the prepuce** connecting the prepuce to the glans.

The preputial sac is a narrow space between the inner layer of the prepuce and the glans of the penis. The skin at the neck of the penis and corona of the glands contains the **preputial glands** (sebaceous glands) that produce **the smegma**.

The superficial fascia of the penis is formed by loose connective tissue. It is devoid of fatty tissue. **The deep fascia of the penis** separates the superficial dorsal vein from the deep dorsal vein of the penis.

Blood supply, lymph drainage and nerve supply of the penis

The penis is supplied by **the branches of the internal pudendal artery**.

The bulb of the penis and the corpus spongiosum are supplied by the **artery of the bulb of the penis**. This artery also supplies the urethra and bulbourethral glands.

The corpora cavernosa takes the blood from the **deep arteries of the penis** (**cavernosal arteries**). One artery runs within each crus and continues in corpus cavernosum. The branches of the deep artery of the penis supply erectile tissue and are responsible for the filling of the cavernous spaces (helicine arteries).

The dorsal arteries of penis run below the superficial fascia on both sides of the **deep dorsal vein** in the dorsum of the penis. **The dorsal nerve of the penis** runs laterally from the artery on each side. It supplies the skin of the penis, tunica albuginea, and the glans of the penis (see Fig. 46).

Venous blood from the penis is drained into three veins:

- **dorsal superficial vein/veins of penis** - runs above the superficial fascia; it takes the blood from the skin of penis to the external pudendal veins
- **deep vein of the penis** – passes below the superficial fascia and drains blood from the cavernous bodies to the venous prostatic plexus
- **vein of the bulb of penis** – takes the vebous blood from the bulb into the prostatic venosus plexus.

The lymph from the skin and fasciae of the penis is drained into the **superficial inguinal lymph nodes**. **External iliac lymph nodes** receive the lymph from the erectile bodies.

The sensory nerves of the penis are mainly carried by the **pudendal nerve**. The sensory fibers of the root of the penis may run in the **ilioinguinal nerve**.

Sympathetic nerve fibers come from the inferior hypogastric plexus. They have a vasoconstriction effect. **Parasympathetic fibers,** cavernous nerves, have a vasodilation effect.

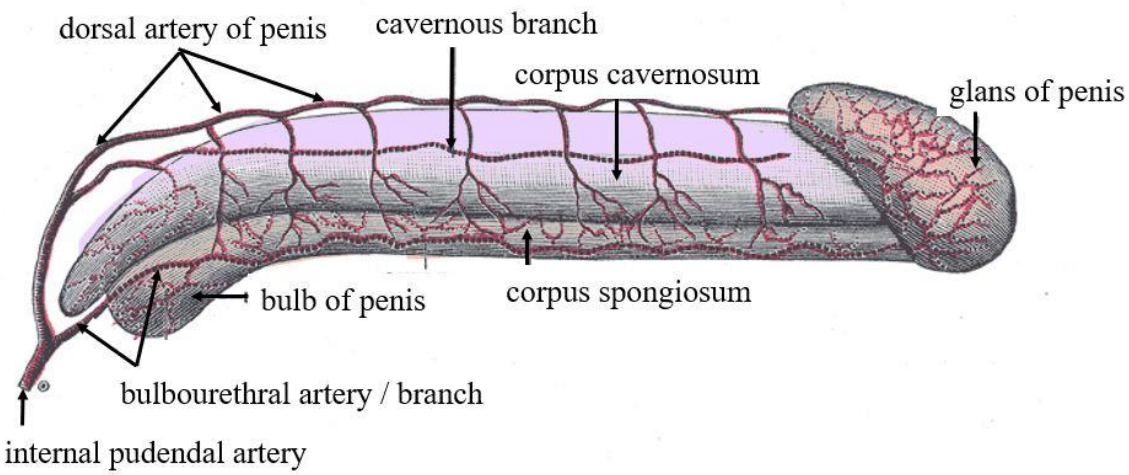

Fig. 46 Blood supply of the penis.

Original diagram from Gray's anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the Human Body. Philadelphia: Lea & Febiger, 1918. Available online: at Bartleby.com, 2000. www.bartleby.com.
Modified by additional colorization and labeling.

Erection of the penis is the result of dilatation (relaxation) of the deep arteries of the penis (cavernous arteries) as a response to parasympathetic stimulation through the cavernous nerves. The dilatation of these arteries results in the filling of the cavernous spaces. The contraction of the ischiocavernosus and bulbospongiosus muscles compreses the crura of the penis and the deep dorsal vein. It restricts the return of venous blood from the body of the penis, and therefore, helps to maintain the erection of the penis.

2.2.2 SCROTUM

The scrotum is a **sac containing testes, epididymes** and structures of the **spermatic cord**. There are two serous cavities in the scrotum separated by the septum of the scrotum. The septum is formed by the same layers as the scrotum except for the skin. The subdivision may be seen on the skin of the scrotum as a raphe of the scrotum.

The cavities of the scrotum are lined by **parietal layer of tunica vaginalis - periorchium** (remains of peritoneum).

The wall of the scrotum is formed by the following layers derived from the layers of the abdominal wall (see Fig. 47):

- **Skin** is thin and pigmented, containing hair and sebaceous glands. There is **no subcutaneous fatty tissue below the skin of the scrotum.**
- **The dartos muscle (tunica dartos)** is a thin layer of smooth muscle fibres. It contributes to thermoregulation in the testes. Contraction of the dartos muscle results in the formation of folds (wrinkles) which diminishes the surface for heat loss. Relaxation of the muscle enlarges the surface (because the folds dissapear) and increase the heat loss. When the temperature in the testes is lower than optimal, the dartos muscle contracts, and when it is higher, the muscle relaxes.
- **The external spermatic fascia** is derived from the fascia of the external oblique abdominal muscle.
- **Cremaster muscle** (striated muscle) and **cremaster fascia** are derived from the internal oblique abdominal muscle and transverse abdominal muscles and their fasciae. When the temperature is lower it contracts and the scrotum with the testes retracts upwards closer to the body.

  However, it may contract during sexual arousal or stress (fight or flight responce) to get the testes closer to the body to more protected position.
- **The internal spermatic fascia is** derived from the transversalis fascia.
- **The parietal layer of the tunica vaginalis (periorchium)** lines the serous cavity of the scrotum.

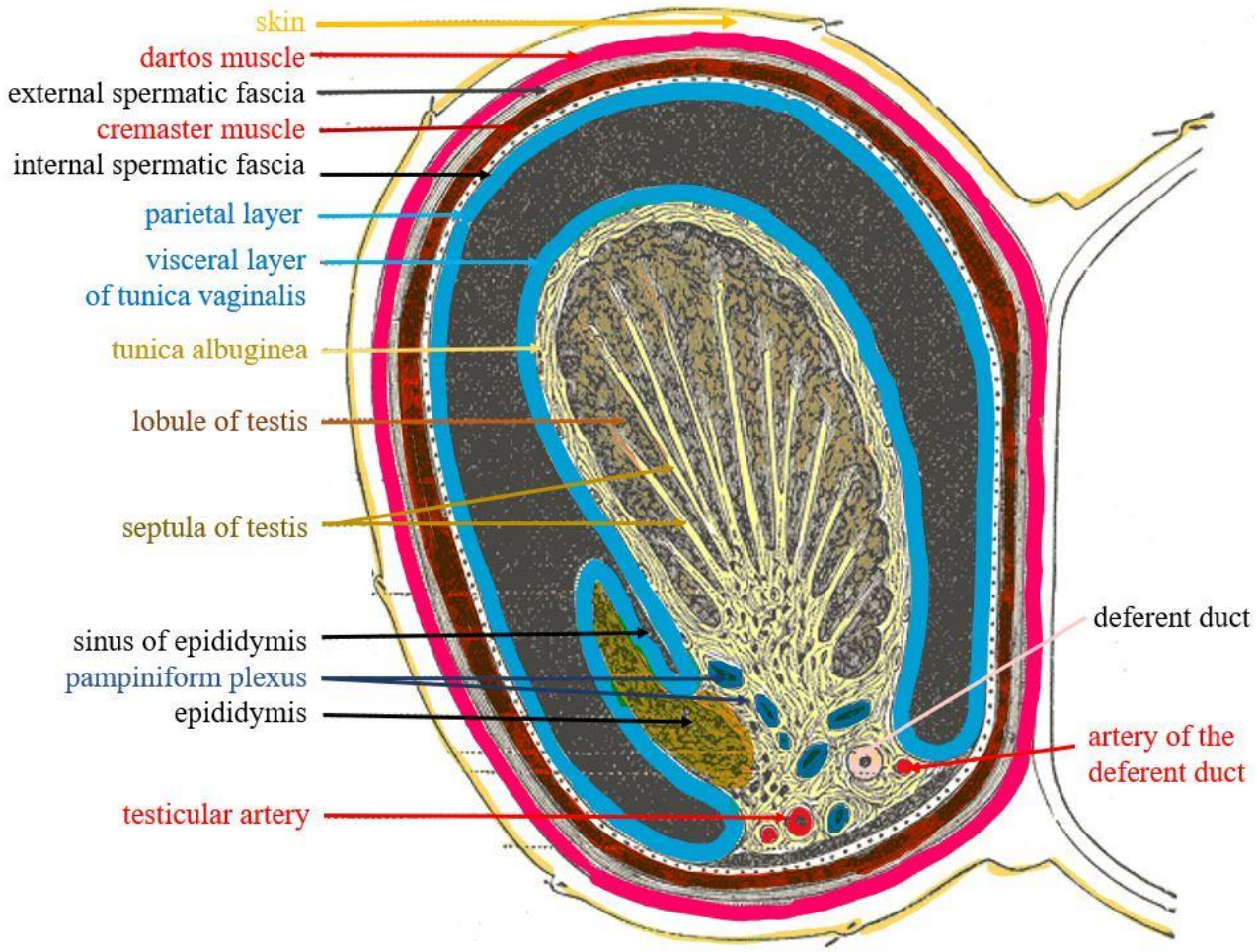

Fig. 47 Transverse section of the left side of the scrotum.

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Modified by additional colorization and labeling.

Blood supply, lymph drainage and nerve supply of the scrotum

The scrotum is supplied by the branches of **the internal and external pudendal arteries.** The posterior surface of the scrotum is supplied by **the posterior scrotal arteries of the internal pudendal artery**. **The anterior scrotal arteries** for the anterior surface of the scrotum come **from external pudendal arteries**. Cremasteric artery for the cremaster muscle is a branch of **the inferior epigastric artery**.

The venous blood of the scrotum is taken by the tributaries to **the internal and external pudendal veins**. The veins accompany the arteries.

The lymph from the scrotum drains into **the external iliac lymph nodes** and **the superficial inguinal lymph nodes**.

Sensory nerves from the scrotum are taken by **the pudendal nerve** (posterior aspect of the scrotum), **the ilioinguinal nerve** (anterior aspect of the scrotum) and **the genital branch of the genitofemoral nerve** (anterolateral surface of the scrotum).

Cremaster muscle is nerve supplied by **the genital branch of the genitofemoral nerve**.

Tunica dartos is nerve supplied by the sympathetic fibers.

3 FEMALE GENITAL SYSTEM

The female genital system consists of the internal female genital organs:

- ovaries
- uterine tubes
- uterus
- vagina

and **external female genital organs:**

- mons pubis
- labia majora
- labia minora
- vestibule of vagina
- clitoris
- bulbus vestibuli
- greater vestibular glands .

3.1 INTERNAL FEMALE GENITAL ORGANS

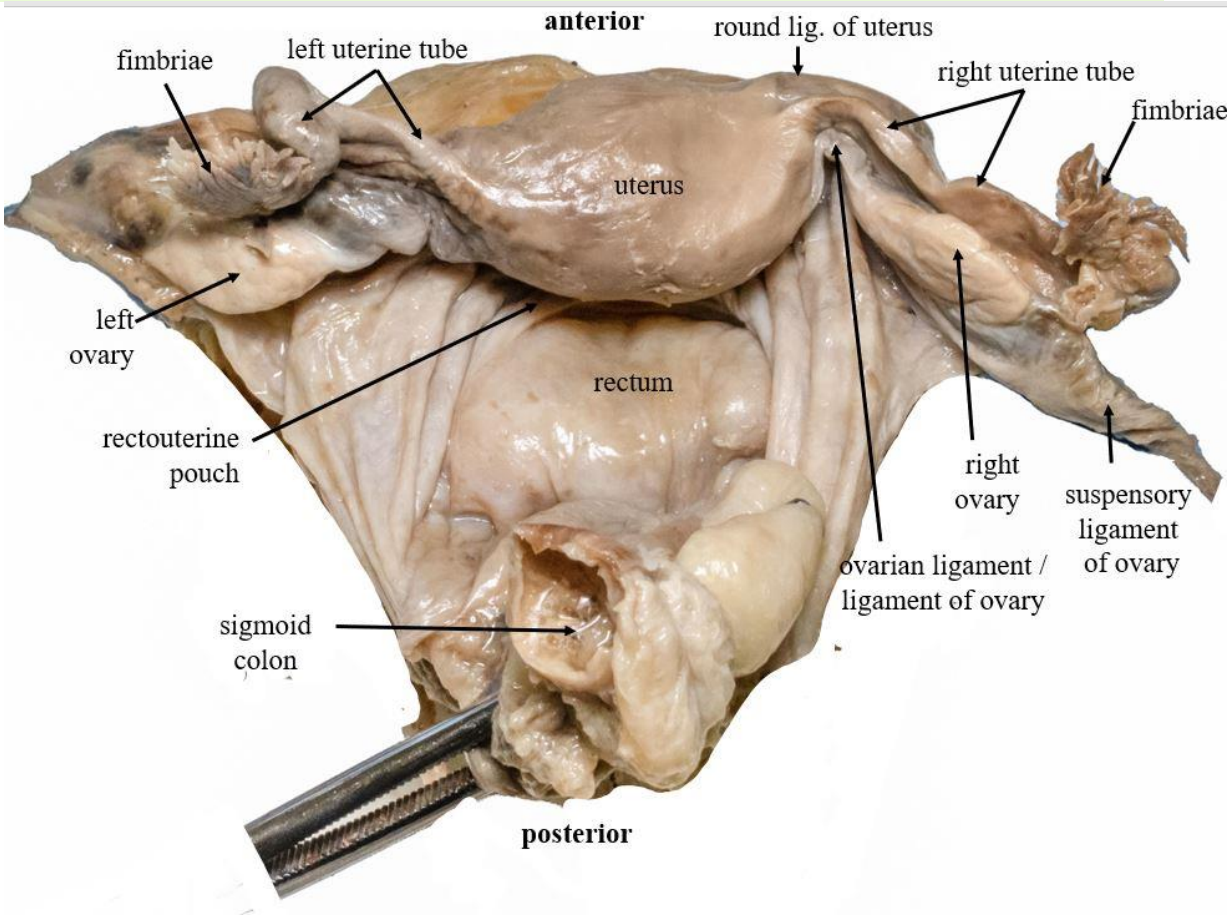

Fig. 48 Internal female genital organs.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

3.1.1 OVARY

The ovary is a **paired reproductive organ**, **the site of oogenesis**, and **the endocrine gland** that produces **the estrogen and progesterone**.

The ovaries and the uterine tubes are commonly called "**adnexa**".

Position and relations of the ovary

Ovaries, similarly like testes, **develop intraabdominally** in the posterior abdominal wall at the level of LI – LIII. As the abdomen or trunk of the fetus grows, the ovaries **descend into the pelvis before the birth**.

The ovary is located **in the lesser pelvis adjacent to the lateral pelvis** wall just below the pelvic inlet (brim).
It is **intraperitoneal in position**, having a peritoneal attachment, **mesovary (mesovarium**). The mesovary connects the ovary to the posterior surface of the broad ligament of the uterus. It contains the blood vessels and the nerves that enter the **ovarian hilum**.

In a nulliparous woman (a woman who has never given birth to a child) it lies in the **ovarian fossa**, **in front of the ureter and internal iliac vessels** (see Fig. 49). During pregnancy, when the uterus with a fetus grows upward into the abdomen, the ovaries are also lifted into the abdomen because they are attached to the uterine horn by the proper ligament of the ovary. Before the third trimester, the ovaries become intraabdominal organs. During the first month after pregnancy, the uterus contracts and returns to the pelvis together with the ovaries. After pregnancy and delivery (parturition), the position of the ovaries changes. In **multiparous women**, **the ovaries** are located **behind the ureter and internal iliac vessels, at Claudius fossa**.

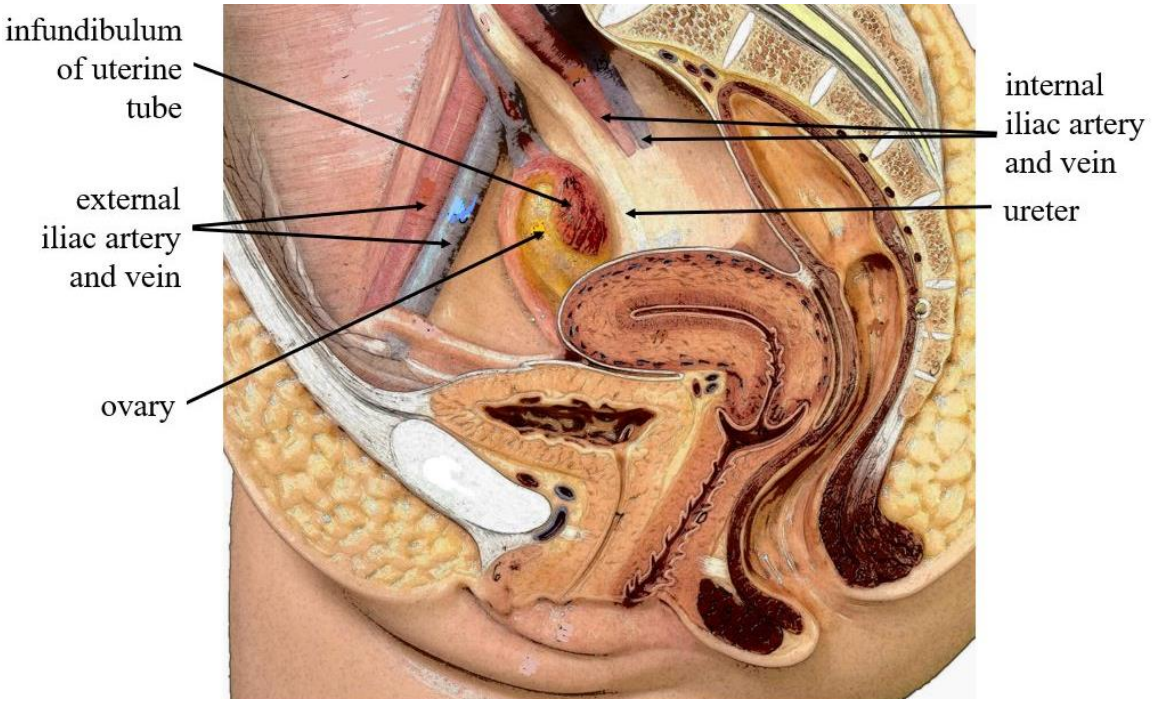

Fig. 49 Position of the ovary. Sagittal section of the female pelvis.

Phototography of SOMSO model, modified by additional drawing, labeling and colorization.

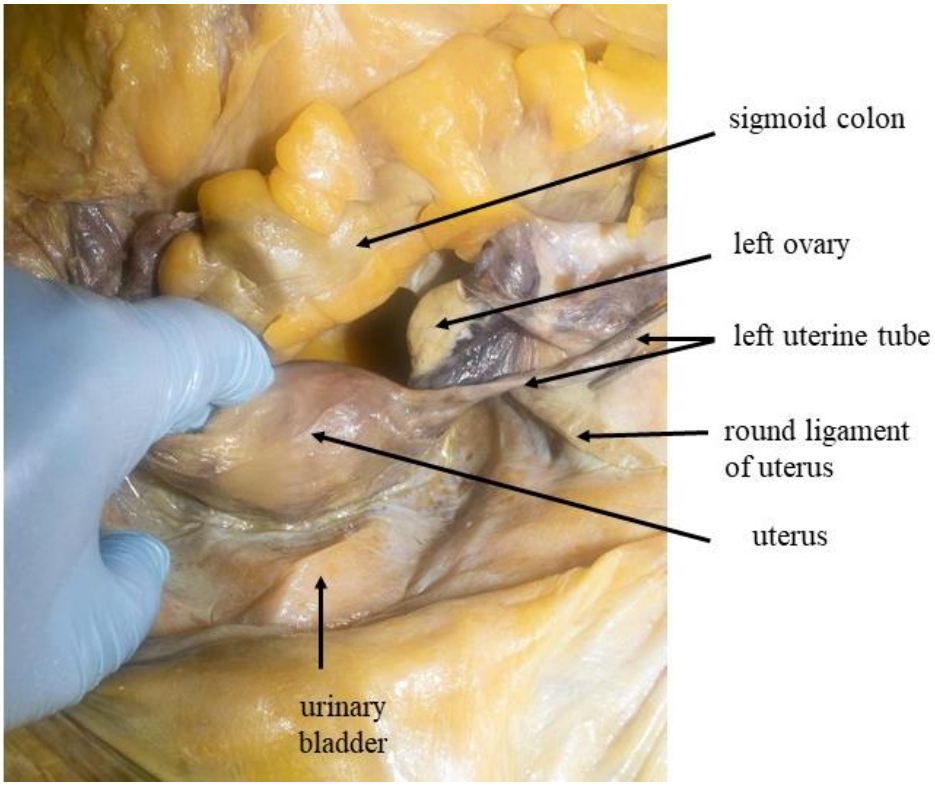

Fig. 50 Left ovary.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

Both ovaries are **related to the lateral pelvic wall**, **the ureter**, **the obturator nerve**, and **the uterine tube**. Fimbriae of the uterine tube are closely related especially to the superior (tubal) extremity of the ovary.
Furthermore, **the right ovary is related to the ileum and appendix coils and the left ovary to the sigmoid colon** (see Fig. 50).

External description of the ovary

In adult fertile woman, **the ovary** is an **almond-shaped organ** with an average size of 4 x 3 x 2 cm and an average weight of 7 – 14 g. The size of the ovary before the puberty is only one third of the size in adult fertile woman. During pregnancy, it may be twice as large. After the menopause, the size of the ovary is reduced to a half or less than is the size of the ovary in adult fertile woman.

The surface of the ovary is **smooth before the puberty**, however, **uneven in adult woman in child – bearing age**, due to the growing follicles within the ovarian cortex. **The postmenopausal ovary is involuted and shrunken**, with grooves and slits on the surface (therefore called **ovarium gyratum**).
The superior pole of the ovary is related to the uterine tube, therefore it is called **the tubal (superior) extremity** (see Fig. 52). The inferior pole directs to the uterus like **the uterine extremity**.

The ovary is flattened from side to side, showing **the lateral surface** related to the pelvic wall and **the medial surface** related to the coils of the intestines.

The surfaces meet on **the mesovarian and free border (margin)**.

The mesovary is attached to the anteriorly directed **mesovarian border**. **The hilum of the ovary** is located on **the mesovarian border**. **The free border** faces posteriorly.

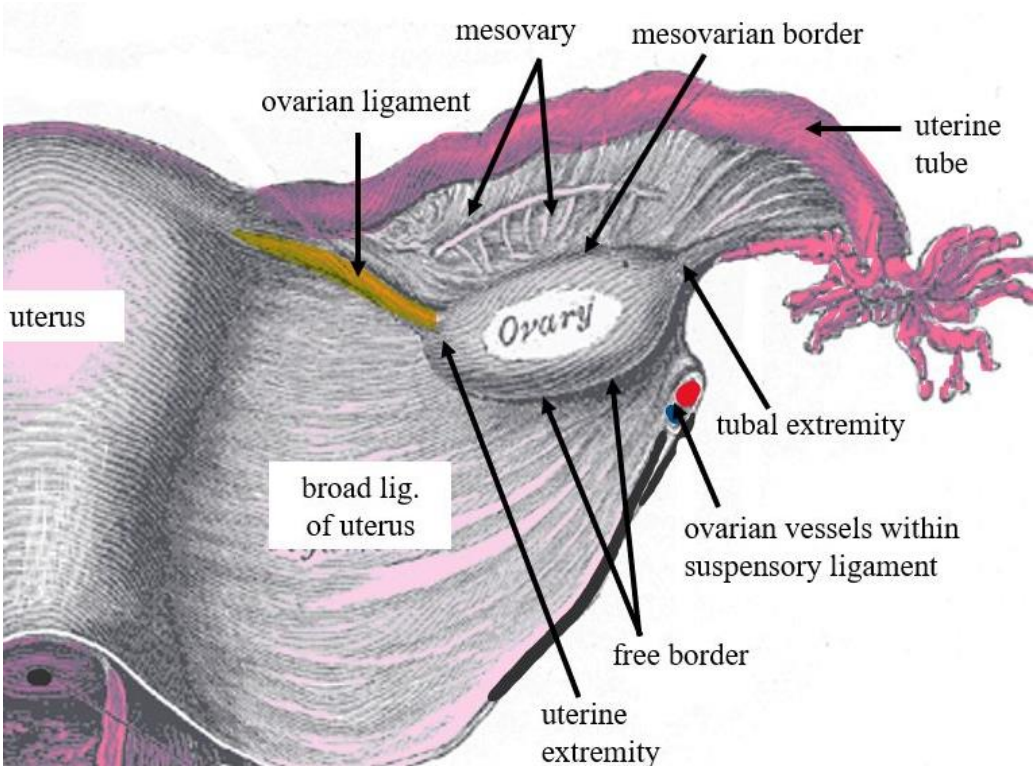

Fig. 51 Ovary and uterus.

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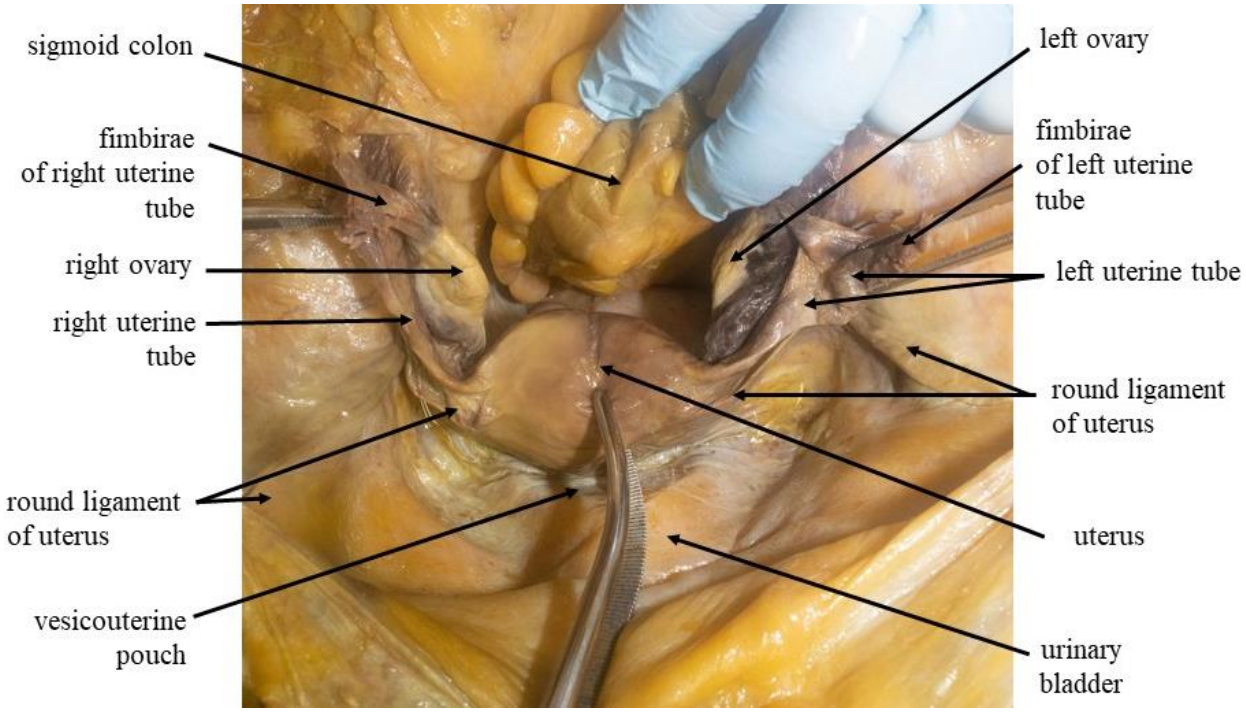

Fig. 52 Ovary. Internal female genital organs.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

The ovary is fixed in its position by the mesovary, the suspensory ligament and the ligament of the ovary (proper ligament of the ovary).

The mesovary is a peritoneal duplication that attaches the ovary to the posterior aspect of the broad ligament.

The suspensory ligament (infundibulopelvic ligament) is a peritoneal fold above the ovarian vessels and nerves attached to the superior part of the ovary. This ligament is formed from the embryonal superior gonadal ligament.

The ovarian ligament (ligament of the ovary) runs inferomedially from the uterine extremity of the ovary to the uterine horn. It is a remnant of the gubernaculum (see Fig. 53).

Internal structure of the ovary

The ovary is covered by the cuboidal epithelium commonly called **the ovarian surface epithelium** (see Fig. 53). The term germinal epithelium was also used to name this layer. However, this epithelium is not a source of germ cells, but is the coelomic epithelium (modified mesothelium).

Most ovarian tumors originate in the surface epithelium.

The **transition between the surface epithelium and the peritoneum** is marked by a macroscopically visible white line, the Farre – Waldeyer line.

The epithelium of the ovarian surface is matt – whitish, the mesovary peritoneum appears smooth shiny - pink.

The term „germinal epithelium" has been considered to be a misnomer, because it does not give a rise to new germ cells. However, in 2004 researchers from the University of Tenessee demonstrated that the mesenchymal cells of tunica albuginea may differentiate into the surface epithelium and/or to the primitive granulosa and germ cells.

Immediately **below the surface epithelium,** there is a firm collagenous membrane, **tunica albuginea.**

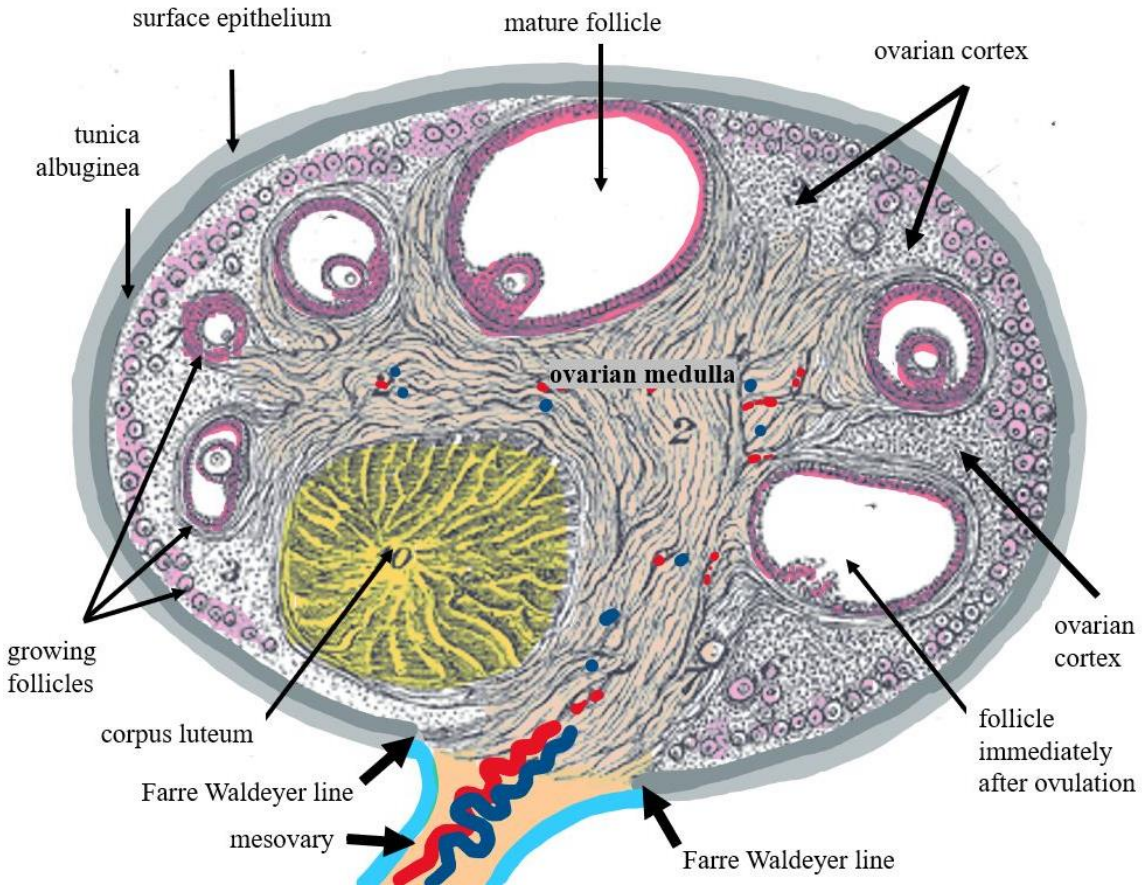

Fig. 53 Internal structure of the ovary. Section of the ovary.

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The ovarian cortex is **the site of oogenesis**. The cortex contains the ovarian follicles at various stages of development, corpora lutea and corpora albicantia (see Fig. 53).

The inner core of the ovary is formed by **the medulla** that contains the loose connective tissue stroma, with veins, spiral arteries and nerves (see Fig. 53).

Oogenesis is the process of differentiation of the ovum. It begins during intrauterine development when oogonia are developed from primordial germ cells. The oogonia in the fetal ovary divide to increase the number by the sixth month of intrauterine development.

At birth, the ovarian cortex contains around 1 000 000 primordial follicles containing the primary oocyte surrounded by a single layer of flat follicular cells. The diploid primary oocytes are arrested in the prophase of the meiosis since before birth and remain at this stage until puberty. After puberty, meiosis continues.

During each menstrual cycle, around 15-20 oocytes are recruited and differentiated into secondary oocytes. However, only one secondary oocyte is ovulated in the most dominant follicle. It is arrested in the metaphase of the meiosis.

The second meiotic division continues when the sperm enters the ova.

The germ cells are developed within the follicles that undergo their own maturation process. ***Folliculogenesis*** *corresponds to oogenesis. Both processes, oogenesisand folliculogenesis, are performed under hormonal control.*

Primary oocytes develop within the primordial, primary and secondary follicles. Secondary oocytes differentiate within the tertiary follicles and Graafian follicles (mature pre-ovulating follicle).

During the maturation of the follicles, the endocrine cells of theca interna become round and produce androstenedione from which the granulosa cells synthesize estrogens.

During one menstrual cycle, several primary follicles may develop to the secondary follicles; however, only one tertiary follicle develops, the rest turns to the atretic.

The rupture of the Graafian follicle and the release of the ova is called ***ovulation****.*

After ovulation, the remnant of the follicle becomes ***the corpus luteum****. If the ooocyte is not fertilized,* ***the corpus luteum menstruationis*** *serves for 14 days and produces progesterone, estradio, and chorionic gonadotrophin. After degeneration, usually in 2 months, the corpus luteum* ***becomes corpus albicans****. If fertilization occurred, the* ***corpus luteum graviditatis*** *is developed. It grows and also produces progesterone, estrogen and relaxin. It serves until the fourth month of pregnancy.*

Blood supply, lymph drainage and nerve supply of the ovary

The ovaries are blood supplied by the **ovarian arteries** that arise **from the abdominal aorta immediately below the renal arteries.** Ovaries are developed intraabdominally and therefore each ovary carries the vessels, lymphatics and nerves from the abdomen.

The **ovarian artery** crosses the genitofemoral nerve, the ureter and iliac vessels. It runs within the suspensory ligament.

The **uterine artery** (branch of the internal iliac artery) also **gives off the ovarian branch** that anastomoses with the ovarian artery.

Venous blood from the ovaries is drained into the plexus within the mesovary and then to the **ovarian veins**.
The right ovarian vein opens into the inferior vena cava,
the left ovarian vein into the left renal vein.

The lymph of the ovaries is drained into the **lumbar lymph nodes due to intra-abdominal development.**

The nervous ovarian plexus accompanies the vessels. It contains **sympathetic fibers** of the spinal segment T10 and T11 and **parasympathetic fibers** of the **vagus nerve**. Sensory fibers ascend to spinal segments L1 – L3.

3.1.2 UTERINE TUBE (FALLOPIAN TUBE; SALPINX in Greek)

The uterine tubes connect the ovary with the uterus. The tubal transport of the oocyte usually takes 3 – 4 days.

Due to the hormonal regulation, the cells within the tubal mucosa become more ciliated and smooth muscle fibres more active.

Transport is mainly the result of tubal peristalsis due to contractions of the smooth muscle fibres in the wall of the uterine tube.

The passage through the ampulla is slow and it may last more than 70 hours. It passes around 8 hours through the isthmus and the uterine part.

Position and relations of the uterine tube

The uterine tube is located **in the upper border of the broad ligament**, attached to it by peritoneal duplication, **mesosalpinx.** It is **intraperitoneal in position**.

The left uterine tube is related to the **sigmoid colon**, **the right uterine tube** to **the ileum and appendix** (if it is in pelvic position).

External description of the uterine tube

The **uterine tube (salpinx**) is around 13 cm long tube with **abdominal and uterine openings.**

It consists of 4 parts: **infundibulum, ampulla, isthmus and uterine part** (see Fig. 54).

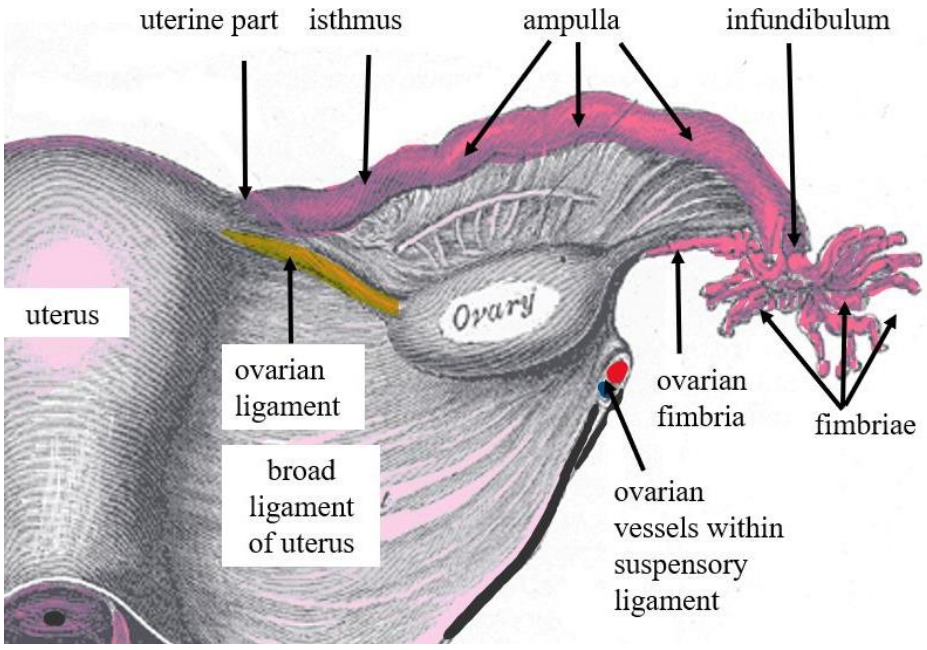

Fig. 54 Parts of the uterine tube.

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Modified by additional colorization and labeling.

The infundibulum is a funnel-shaped expansion of the abdominal end of the uterine tube. The infundibulum opens into the abdominal - peritoneal cavity. Its border is rimmed by numerous projections looking like narrow fingers, **fimbriae**. The longest one, **the ovarian fimbria**, is firmly attached to the tubal extremity of the ovary.

The ampulla is a tortuose, thin-walled, dilated part of the uterine tube with a length of around 5 cm and a lumen diameter of 1 cm. It is the most common fertilization site.

The ampulla is laterally continuous with **the isthmus**. It is narrower and shorter than the ampulla, the lumen is around 3 mm in diameter and the length is 3 cm.

The uterine part is the most medial part that passes through the wall of the uterus. It is the shortest and the narrowest part of the uterine tube. The lumen in this part is only 0.5 mm thin.

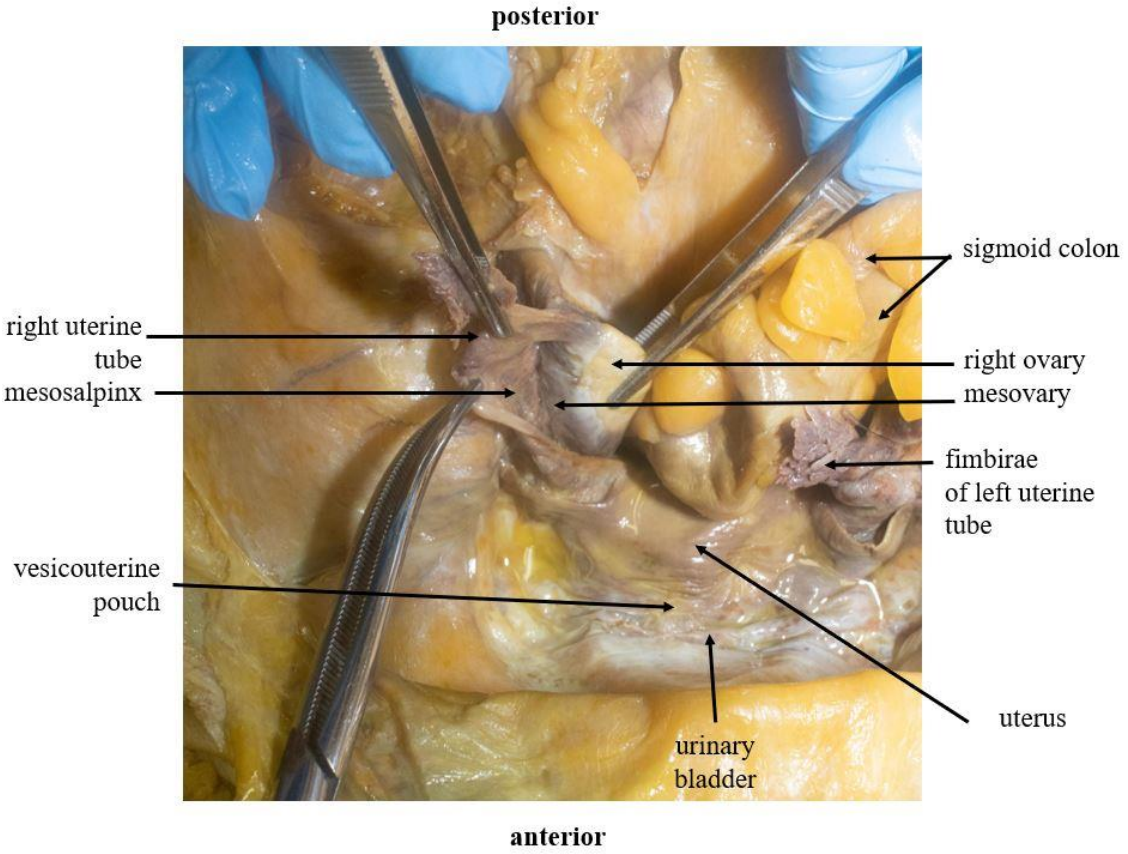

Fig. 55 Mesosalpinx, mesovary.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

Internal structure of the uterine tube

The wall the uterine tube is formed by **the mucous coat, muscular coat and serous coat**.

The mucous coat (mucosa) of the uterine tube forms numerous longitudinal folds. The singlelayered columnar epithelium contains mainly ciliated and secretory cells. Secretory cells are active especially during ovulation to provide nutrients to oocytes and sperm cells.

The muscular coat consists of the circular or spiral layer of the smooth muscle cells internally and the longitudinal layer externally. The peristalsis of the uterine tube drives the gamets and fertilized ova.

The external surface of the uterine tube is covered by the **peritoneum** which forms **the serous coat**.

Blood supply, lymph drainage and nerve supply of the uterine tube

The uterine tube is **blood supplied** by **the tubal branches of the ovarian artery** (lateral 1/3) and **the uterine artery** (medial 2/3).

Venous blood is drained into **the ovarian veins** from the lateral parts of the uterine tube and into **the uterine plexus** from the medial parts.

Lymphatic drainage is to the **paraaortic and internal iliac lymph nodes**.

Autonomic nerves reach the uterine tubes around the vessels and come from the **ovarian and uterovaginal autonomic plexus**.

The mucosa within the uterus after the ovulation is high and well prepared for the nidation of the fertilized ova.

In certain circumstances, the fertilized ova does not nidate within the uterus. It can implant into the mucosa of the uterine tube or due to the opening of the uterine tube to the peritoneum when the fertilized ova is dropped out of the uterine tube. Such ectopic pregnancy (extrauterine pregnancy) can lead to severe hemorrhagia, due to vessel erosion or rupture of the uterine tube or peritoneum. Early ectopic pregnancy without hemorrhagia is usually treated with methotrexate, which stops the

growth. In most cases, ectopic pregnancy requires surgical intervention (removing the growing fertilized ova) because it may cause life-threatening hemorrhagia.

Tubal ligation is a very effective method for birth control or female sterilization. The uterine tubes are blocked by using a clip or coagulation, or they are tied, cut or banded. Sometimes, the whole tubes may be removed by salpingectomy.

Inflammation of the uterine tube (salpingitis) is usually caused by ascending bacterial infection and may lead to female infertility due to blockage of the tube, e.g. when the walls of the tube stick together.

4.1.3 UTERUS (METRA or HYSTERA in Greek)

The uterus is the **muscular pear-shaped organ** with **a cavity inside** that serves as the site for the implantation of the fertilized ova, development of the embryo and fetus.

Position and relations of the uterus

The uterus is located in the **lesser pelvis behind the urinary bladder and in front of the rectum**.

It is **intraperitoneal in position**. The peritoneum covering the uterus is anteriorly continuous with the **vesicouterine pouch** and posteriorly with **the rectouterine pouch** (see Fig. 56).

The folds of the peritoneum that cover the anterior (vesical) and posterior (intestinal) surface fuse at the margins of the uterus, forming the **broad ligament of the uterus**. This **peritoneal duplication attaches the uterus to the lateral pelvic walls**.

The position of the the uterus changes slightly depending on the content or volume of the urinary bladder and rectum. In physiological conditions, the non-pregnant uterus does not extend above the level of pubic symphysis.

Uterus is related to the urinary bladder, sigmoid colon, ileum and rectum (see Fig 56 and Fig. 57).

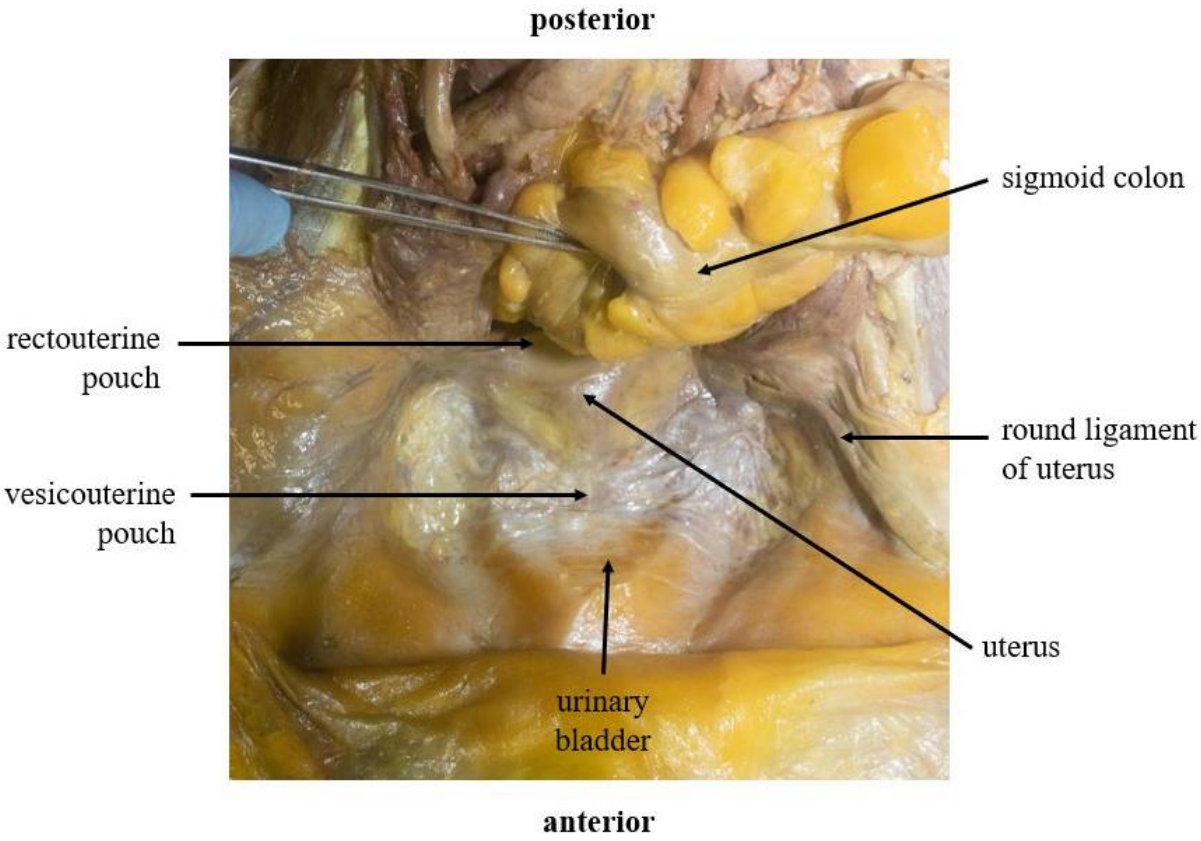

Fig. 56 Uterus. Rectouterine and vesicouterine pouch.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

External description of the uterus

In a nulliparous woman in child – bearing age, the uterus is 9 cm long, 4 cm wide and 3 cm thick. The average weight is 50 g.

The size of the uterus varies slightly during the menstrual cycle. During pregnacy, it grows up to 1 kg in the third trimester. In a postmenopausal women, the uterus becomes smaller.

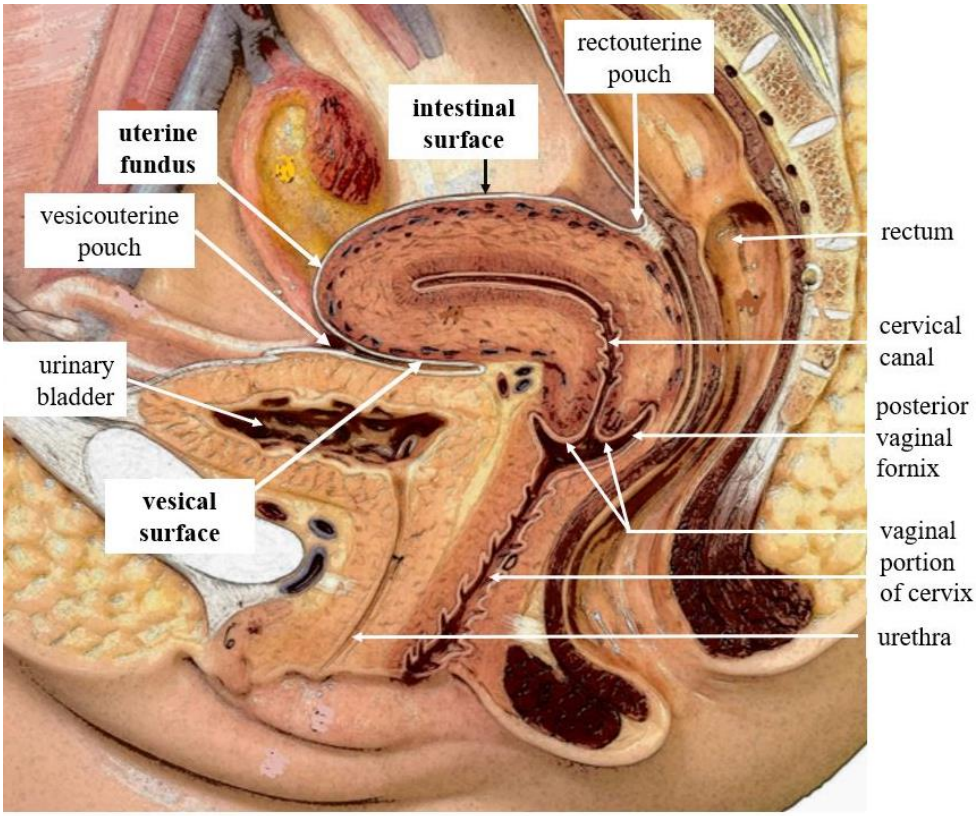

Fig. 57 Uterus. Sagittal section of the female pelvis.

Phototography of SOMSO model, modified by additional drawing, labeling and colorization.

The uterus is pear-shaped and **anteroposteriorly flat**.

It is subdivided into **three parts: the body, isthmus and cervix** (see Fig. 58).

The body of the uterus is wider superiorly and it narrows inferiorly. It shows **two surfaces: vesical and intestinal**. Anteriorly directed **vesical surface** is separated from the urinary bladder by **the vesicouterine pouch**. Its posteriorly directed **intestinal surface** is related to **the sigmoid colon and ileum** and separated from **the rectum by the rectouterine pouch**.

The surfaces meet in margins (right and left). **The broad ligament of uterus** connects the margins to the lateral pelvic walls.

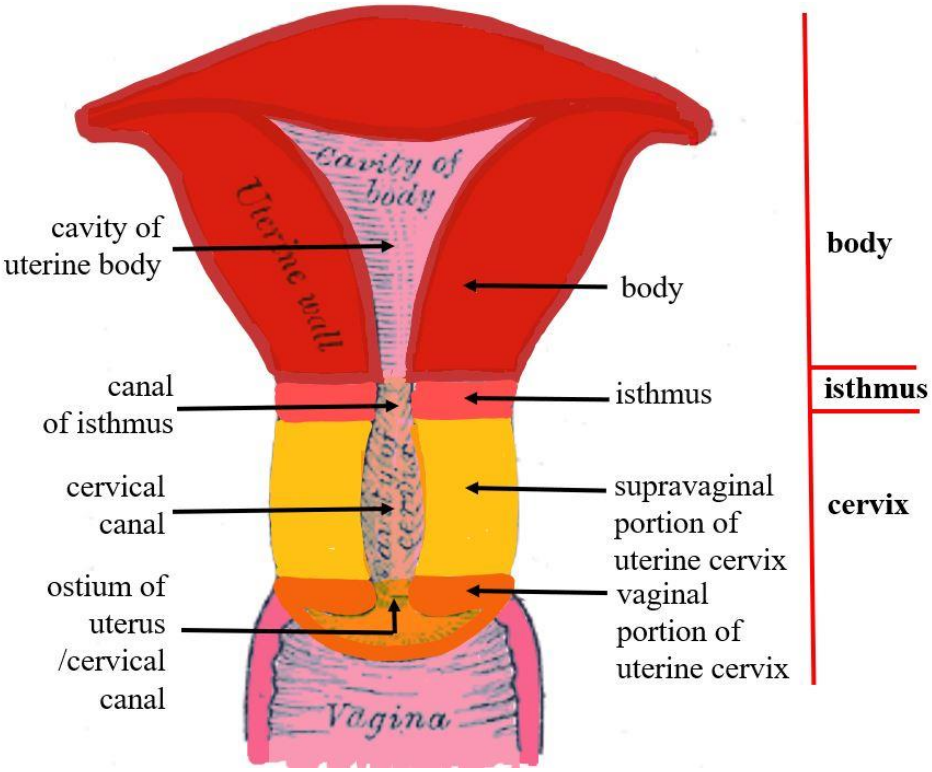

Fig. 58 Uterus - parts.

Original diagram from Gray's anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the Human Body. Philadelphia: Lea & Febiger, 1918. Available online: at Bartleby.com, 2000. www.bartleby.com.
Modified by additional colorization and labeling.

The uterine horns are the portions where the uterine tubes enter the uterus. Immediately **below the horns, two ligaments are attached: the round ligament of the uterus anteriorly and the ligament of the ovary posteriorly** (see Fig. 59 and Fig. 60). **The round ligament of the uterus** runs from the uterine horn, through the inguinal canal, to the labium majus. **The ovarian ligament** (proper ligament of the ovary) passes from the uterine horn to the uterine extremity of the ovary.

The uppermost convexity above the level of the uterine horns is **the uterine fundus**.

The uterine fundus may be palpable *per anterior abdominal wall during gynaecological examination.*

In a non-pregnant physiologic uterus, the uterine fundus reaches the level of pubic symphysis. During pregnancy, the uterus grows and around the 20th week of pregnancy the uterine fundus is at the level of umbilicus. During the 36th week, the uterine fundus extends to the xiphoid process.

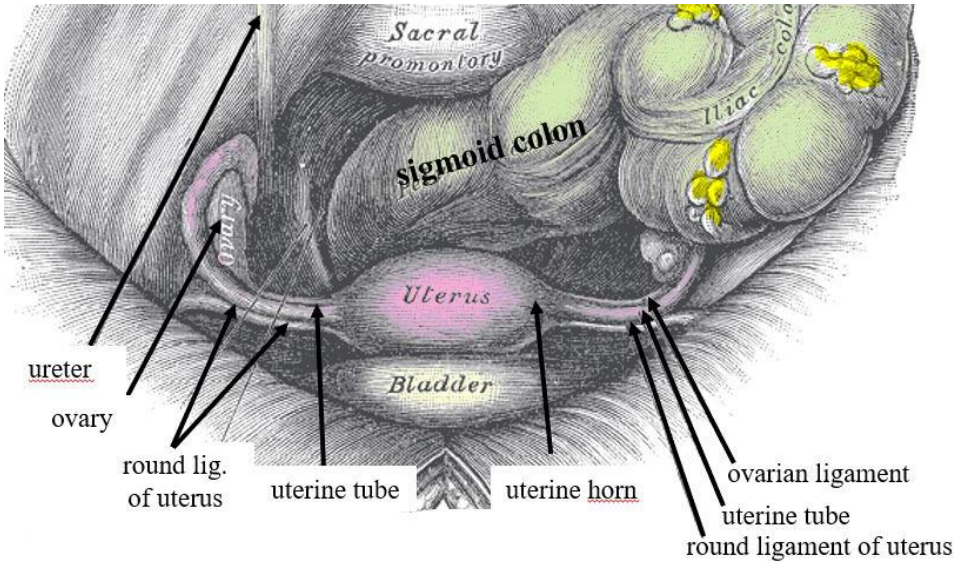

Fig. 59 Uterus in the pelvis.

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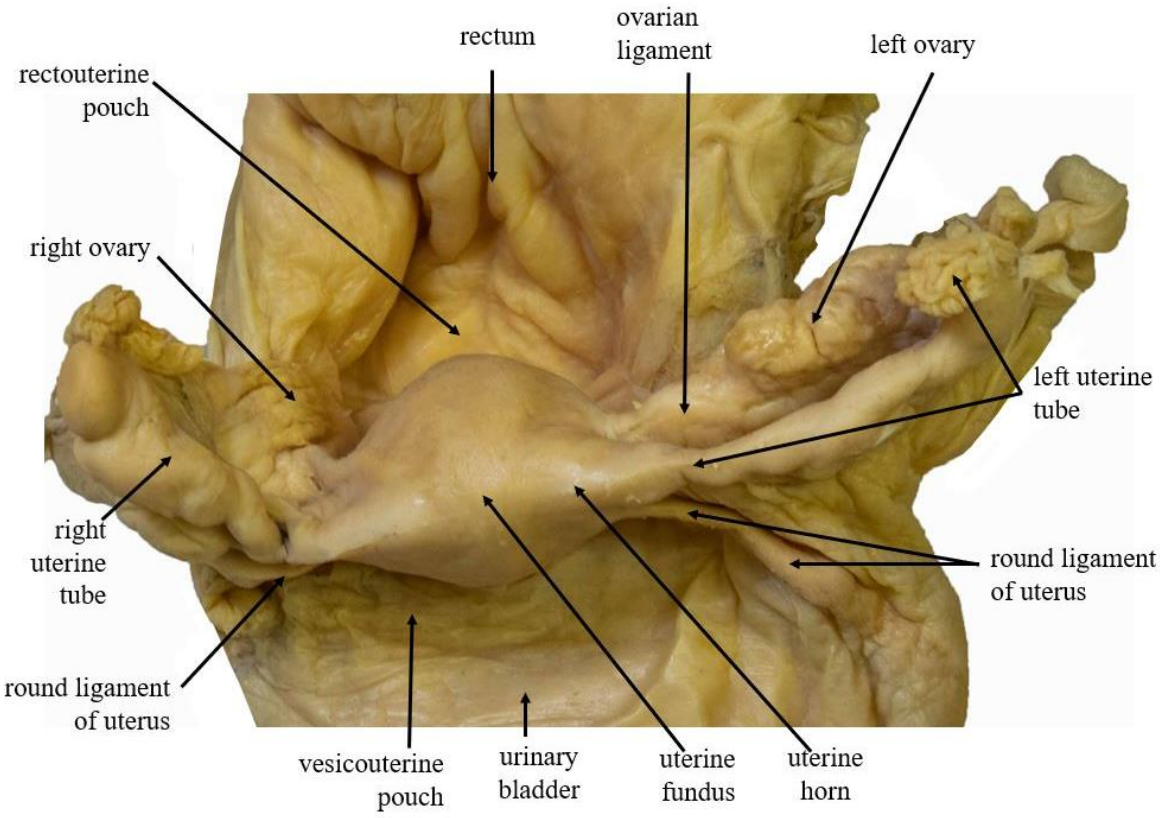

Fig. 60 Uterus and the structures attached to the uterine horn.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

The cavity inside the uterine body is triangular in the anterior view and flat anteroposteriorly.

The isthmus is a short part **between the uterine body and the cervix**. It is a narrow part of the uterus only 1 cm long. The canal of the isthmus is continuous with the canal of the cervix. In a nulliparous woman it is a narrow canal similarly like a cervical canal. In a parous woman, the isthmus canal is dilated during pregnancy and becomes part of the cavity within the uterine body, the so-called 'lower uterine segment'.

The uterine cervix is **the lowermost part of the uterus**.

The cervical canal is fusiform in shape and the inner surface of its mucosa forms palmate folds.

Attachment of the vagina to the cervix subdivides it into the supravaginal portion and the vaginal portion (see Fig. 58) . **The supravaginal portion** of the uterine cervix is a part above the vaginal attachment. **The vaginal portion** of the uterine cervix projects into the vagina and is surrounded by a circular space, **the vaginal fornix**. In the center of the vaginal portion, there is **the ostium of the uterus** (ostium of the cervical canal, external os).

The ostium of the uterus is circular in a nulliparous woman. In a **parous woman**, during the delivery (parturition) it largely dilates and after the delivery (parturition) it **becomes a transverse slit** (see Fig. 61).

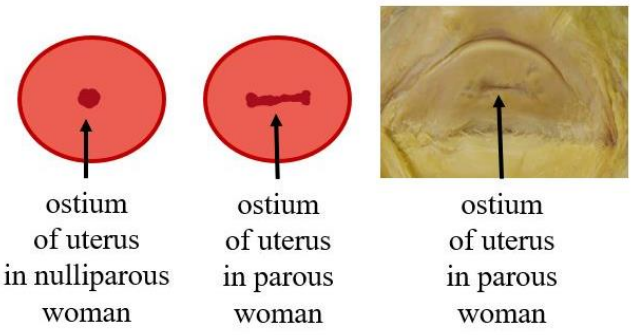

Fig. 61 Vaginal portion of the cervix with ostium of the uterus in schema and cadaveric specimen.

Cadaveric specimen, Department of Anatomy, Jessenius Faculty of Medicine, Comenius University.

The supravaginal portion of the uterine cervix is surrounded by **parametrium**.

The parametrium is made up of **parametral ligaments** that are formed by subserous tissue within the broad ligament of the uterus.

Parametral ligaments:

- **Transverse ligaments** (ligamenta cardinalia uteri in plural, ligamentum cardinale uteri in singular) connect the uterine cervix to the lateral pelvic walls.
- **Rectouterine and sacrouterine ligaments** connect the cervix to the rectum and sacrum, respectively.
- **Vesicouterine ligaments** run from the uterine cervix to the urinary bladder and continue as pubovesical ligaments to the posterior side of the pubis.

Due to these parametral ligaments, the **uterine cervix is the most fixed part of the uterus and the least moveable part of the uterus**.

The **position of the uterus** is supported by the **pelvic diaphragm** (levator ani muscle) and the **urogenital diaphragm** (transversus perinei profundus muscle), and by the **broad ligament of the uterus** and **parametral ligaments** (round ligament of the uterus, transverse ligament of the uterus, rectouterine ligaments, sacrouterine ligaments, vesicouterine and pubovesical ligaments).

The uterus is in physiological position when it is in **anteflexion and anteversion**.

The uterine cervix is anteverted to the vagina.

The uterine body is anteflexed to the uterine cervix (see Fig. 62).

The anteflexion and anteversion of the uterus represent the most protective position that prevents the uterus from the extrusion to the vagina when the intraabdominal pressure increases (e.g. coughing or sneezing).

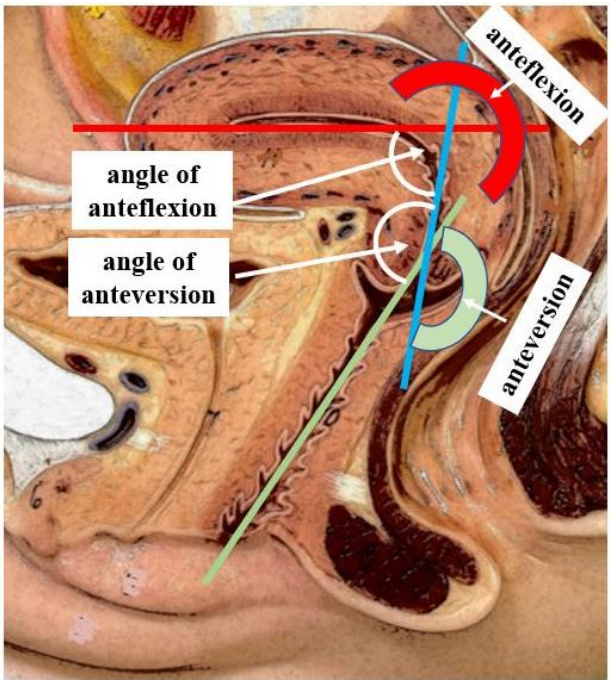

Fig. 62 Anteversion and anteflexion of uterus.

Phototography of SOMSO model, modified by additional drawing, labeling and colorization.

The wall of the uterus

The uterine wall is formed by three layers: mucous coat (endometrium), muscular coat (myometrium) and serous coat (perimetrium).

The endometrium is made up of the endometrial stroma and a singlelayered columnar epithelium. It is formed by the basal layer (close to the myometrium) and located below the functional layer. After puberty, the functional layer of the endometrium undergoes regular changes during the menstrual cycle.

*During the **proliferative phase, the** endometrial glands and stroma proliferate, the thickness of the endometrium increases. This phase is under estrogen control.*

***After ovulation,** the increase in the level of progesterone initiates the **secretory phase**. This phase takes 14 days constantly.*

If the ova is not fertilized and implanted, the endometrium enters the menstrual phase when the endometrium is shedding. If the ova is fertilized, the endometrium grows up to 12 mm and secretory changes continue. The postmenopausal endometrium is very thin and atrophic.

The myometrium is the thickest layer composed of the **smooth muscle fibres, stroma and vessels**.

Myometrial contractions during pregnancy dilate the cervix, deliver the fetus and expel the placenta.The contractions of the myometrium can be observed in nonpregnant myometrium as the so-called 'endometrial waves'. However, the contractility of myometrium in nonpregnant uterus is different from those in pregnant uterus.

Myomas (fibroids) are benign tumors of the smooth muscle cells of the myometrium. They are common especially in women older than 50 years with an incidence of around 70 %. Ethiology is not fully understood, although hormonal influence and genetic predisposition have been identified.

The **perimetrium or serous coat** is formed by **the peritoneum.**

The mucosa of the cervical canal is clinically called the **endocervix**. It contains a columnar (glandular) and stromal epithelium that is not shed. The endocervical glands produce fairly thick alkaline mucus, except the days around ovulation, when it becomes less viscous to allow the passage of sperm cells.

The surface of the vaginal portion of the cervix is called 'ectocervix or exocervix', it is covered by stratified squamous epithelium without keratinizing.

After puberty and during the first pregnancy, the columnar glandular epithelium from the cervical canal is everted to the ectocervix forming cervical erosion, 'ectropion'. This area undergoes squamous metaplasia that forms the physiological or normal transformation zone.

However, the transformation zone may become abnormal or atypical. This area is prone to neoplastic changes due to hormonal influence or papillomavirus infection.

Preventative examination of the uterine cervix - inspection and smear cervical tests are effective in cervical cancer screening. During the cervical smear test, epithelial cells are gently collected from the vaginal portion of the cervix by a spatula and examined under the microscope. These tests allow us to reveal the atypical cells, precancerous or cancerous changes, inflammation and infection.

Blood supply, lymph drainage, and nerve supply of the uterus

The uterine artery arises from the anterior branch of the internal iliac artery. It runs within the broad ligament of the uterus, where it is **crossed by the ureter**. It reaches the uterus at the level of the uterine cervix and then it ascends along the uterine margin. It has a **highly wavy course** to prepare for growth during pregnancy (see Fig. 63).

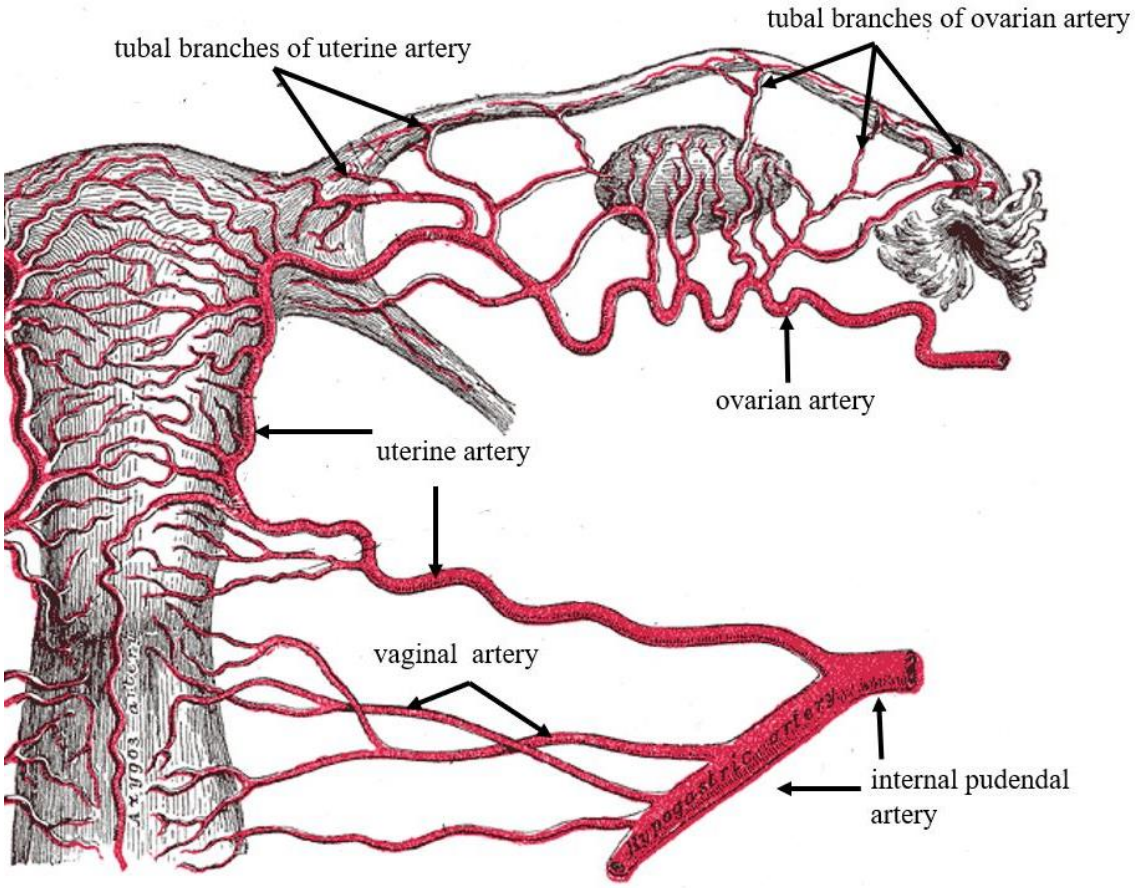

Fig. 63 Blood supply of the internal female genital organs.

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The uterine venous plexus surrounds the uterus and takes the venous blood from the uterus to the uterine veins. **Uterine veins** open into **the internal iliac vein**.

The lymph from the uterus is drained into the **internal and external iliac** and **obturator lymph nodes**. Along the round ligament of the uterus, the lymph continues to the **superficial inguinal lymph nodes**.

The uterovaginal nervous plexus contains the **sympathetic nerve fibers** of the spinal segments T10 – L2 and the **parasympathetic fibers** of the spinal segments S2 – S4, coming from the inferior hypogastric plexus. Sympathetic nerve fibers are responsible for the contraction of the myometrium and vasoconstriction, and parasympathetic fibers for the vasodilation; however, all activities are under hormonal regulation.

3.1.4 VAGINA (KOLPOS in Greek)

The **vagina** is a female copulatory organ, a passageway for blood and shed uterine epithelia during menstruation and a passageway for childbirth.

Position, relations and external description of the vagina

The vagina extends ventrocaudally from the uterus to the vestibule (see Fig. 64). It runs **behind the urinary bladder and the urethra and in front of the rectum**. It is connected to the rectum by fibroareolar tissue, rectovaginal septum (Denonvilliers' fascia).

The vagina is **anteroposteriorly flat** showing **shorter anterior wall** (7 – 8cm) and **longer posterior wall** (9 – 10cm).

The vaginal fornix is the upper part of the vagina that surrounds the vaginal portion of the cervix forms. It may also be defined as the space or recess between the vaginal portion of the cervix and the vaginal wall. The vaginal fornix is subdivided into **the anterior, posterior and lateral fornices**.

The **anterior fornix** is shallow. The **posterior fornix** is much deeper, covered by the peritoneum and separated from the rectum by a rectouterine pouch. The **lateral fornices** are related to the ureters.

The vaginal orifice is located **in the vestibule behind the urethral papilla**.

In virgins, the orifice is partially enclosed by the mucosal fold, **hymen**.

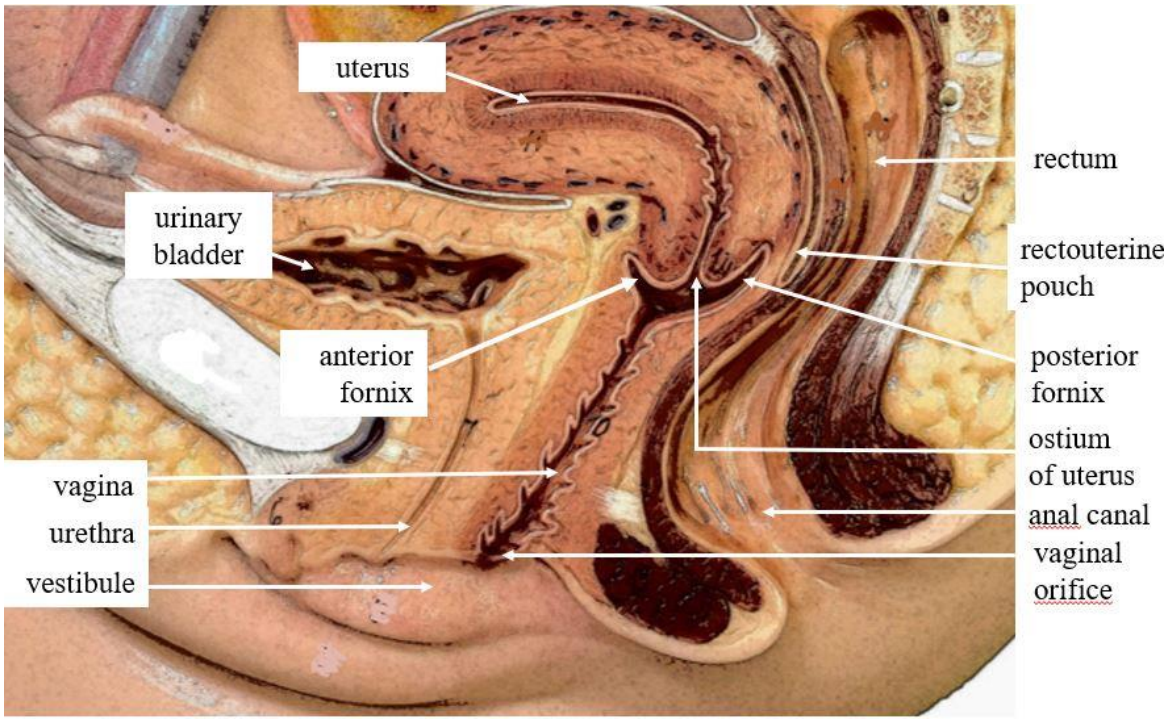

Fig. 64 Vagina in the female pelvis. Sagittal section.

Phototography of SOMSO model, modified by additional drawing, labeling and colorization.

The posterior fornix serves as a reservoir for semen after intravaginal ejaculation. In 25 - 30 minutes, the semen is liquefied, which allows easier passage through the cervical canal.

The posterior fornix is covered by the peritoneum and is related to the rectouterine pouch. The needle puncture of the rectouterine pouch (Douglas space) through the posterior fornix is a medical procedure called culdocentesis. It was widely used as a diagnostic technique for the determination of the pathological fluid (puss or blood) within the pelvic cavity, e.g. during pelvic inflammatory diseases or ectopic pregnancy. Nowadays, it has been widely replaced by transvaginal ultrasound, although, in countries without access to sonography, it is still used as the most common aid for the diagnosis of ectopic pregnancy. Ruptured ectopic pregnancy requires prompt diagnosis and often surgical intervention.

Internal structure of the vagina

The vaginal wall is composed of the **mucosa, muscular coat and adventitia**.

The mucosa of the vagina forms **the transverse ridges, rugae**. The mucosa adheres firmly to the muscular coat. The epithelium is similar to and continuous with the epithelium on the exocervix.

*There are **no mucous glands within the epithelium in vagina**. It is lubricated from the cervical glands and from the transudate of the blood vessels in the lamina propria.*

*The vaginal **epithelium** does not show visible changes during the menstrual cycle, however, the **glycogen content** increases significantly after ovulation and decreases at the end of the menstrual cycle.*

*The **vaginal microbiota** contains mainly **the Lactobacillus genus**. It grows and metabolizes the glycogen from desquamated cells to lactic acid and in this way **decreases pH to an acidic level**, which inhibits the growth of possible infectious agents. Lactobacillus is supposed to provide protection not only through the decrease of pH, but also through the other mechanisms, e.g. bacteriocin production.*

The muscular coat of the vagina is made up by the smooth muscle fibers arranged in inner circular and outer longitudinal layers.

Tunica adventitia covers the vagina externally.

The areolar tissue around the vagina is called the **paracolpium**. It connects the vagina to the urinary bladder, urethra and rectum.

Blood supply, lymph drainage and nerve supply of the vagina

The vaginal artery may be a branch of the uterine artery or it may arise directly from the internal iliac artery. The vagina also takes the blood from **the uterine artery and the middle rectal artery**.

The veins around the vagina form **the vaginal plexus** that conects with the uterine venous plexus. The venous blood from them is drained into **the internal iliac vein**.

Lymphatic vessels from the upper part of the vagina take the lymph to the **internal iliac lymph nodes** and from the lower part to the **superficial inguinal lymph nodes**.

The autonomic nerves for the vagina come from the uterovaginal autonomic plexus. The lower part of the vagina is the nerve supplied by **the pudendal nerve**, the upper part by the splanchnic nerves.

3.2 EXTERNAL FEMALE GENITAL ORGANS – PUDENDUM FEMININUM – VULVA

The external female genital organs include:
mons pubis, labia majora, labia minora,vestibule, clitoris, bulbs of vestibule and greater vestibular glands (see Fig. 65 and Fig. 66).

3.2.1 MONS PUBIS

Mons pubis is a triangular cutaneous prominence in front of the pubic symphysis. It is composed of the subcutaneous fatty tissue covered by hair – bearing skin. Sebaceous glands in the skin of mons pubis produce sex - attractant pheromones.

3.2.2 LABIA MAJORA

Labia majora are two longitudinal folds that border the pudendal cleft (fissure, in Latin rima pudendi). They extend from the mons pubis to the perineal region.

The folds unite in the **anterior and posterior commissure** (junction).

Labia majora are formed by the skin that envelopes the fatty tissue with the smooth muscle fibers homologic to tunica dartos. The skin on the outer surface is pigmented and contains hairs; on the inner surface there are numerous sebaceous glands. **The round ligaments of the uterus terminate within the labia majora**.

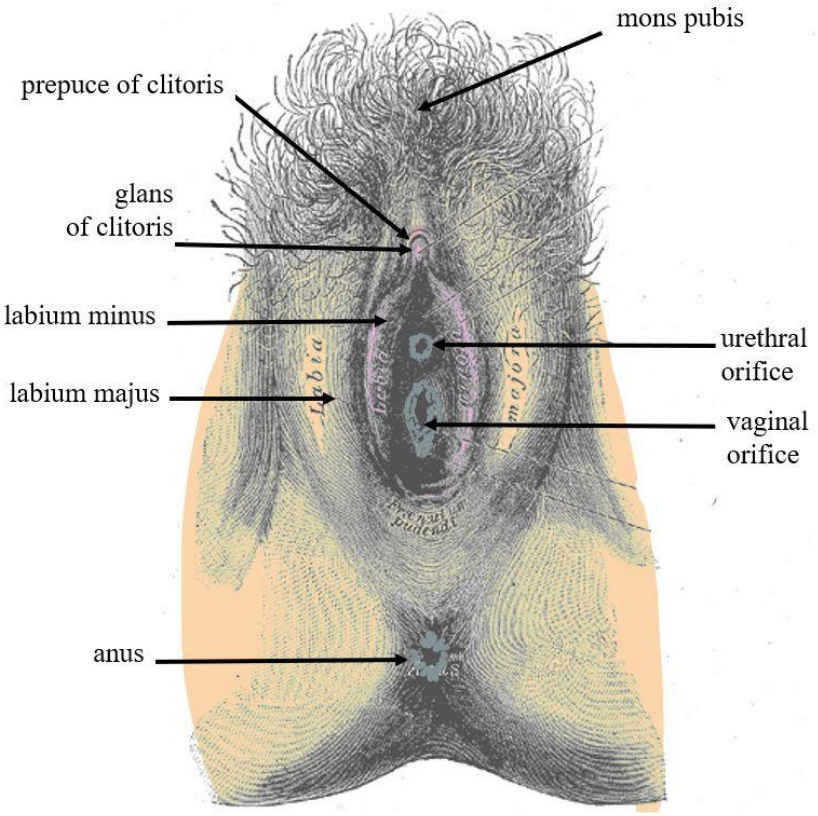

Fig. 65 Female external genital organs.

Original diagram from Gray's anatomy, 20th US edition which has now lapsed into the public domain (out of copyright). Gray H.: Anatomy of the Human Body. Philadelphia: Lea & Febiger, 1918. Available online: at Bartleby.com, 2000. www.bartleby.com. Modified by additional colorization and labeling.

3.2.3 LABIA MINORA

Labia minora are smaller longitudinal folds located medially to labia majora.

The outer surface of the labium minus is covered by the skin containing the sebaceous glands, the inner surface is lined by the mucosa. These folds do not contain fatty tissue.

Labia minora **anteriorly divide to form two layers**. The upper layers run above the clitoris and form the **prepuce of the clitoris**. Lower layers unite below the clitoris forming the **frenulum of the clitoris**.

Labia minora border the vestibule.

3.2.4 VESTIBULE

The vestibule is a space (cavity) **bordered by labia minora**. The mucosa lining the vestibule contains the minor vestibular glands.

The vestibule shows the **external urethral orifice, vaginal orifice and the openings of the greater vestibular glands, lesser vestibular glands and paraurethral glands** (paraurethral glands, Skene's glands).

The external urethral orifice (**urethral papilla**) is located the most anteriorly, approximately 2.5 cm below the clitoris.

Paraurethral glands (Skene's glands) are homologous to the prostate and have openings laterally in the urethral orifice.

The vaginal orifice is located behind the external urethral orifice.

The ducts of the greater vestibular glands (Bartholin's glands) open into the vestibule next to the vaginal orifice.

Lesser vestibular glands are within the mucosa of the vestibule.

3.2.5 CLITORIS

Clitoris is a homolog of the penis. It consists of **the crura, body and glans**.

The crura of the clitoris are attached to the phallic crests in the inferior pubic rami. Superficially they are covered by ischiocavernosus muscles.

Anteriorly crura unite forming the **body of clitoris**. The body is composed of two erectile bodies, **cavernous bodies (corpora cavernosa**) enclosed by fibrous tissue.

The suspensory ligament attaches the **body of clitoris to the pubic symphysis**, and the **fundiform ligament to the abdominal fascia**.

At the end of the body, there are the **glans of the clitoris** situated between the anterior ends of the labia minora. The upper layers of labia minora run above the

clitoris and form the **prepuce of the clitoris**. Lower layers unite below the clitoris forming the **frenulum of the clitoris**. The glans of clitoris has a venous connection with the commissure of the bulbs.

Glans of the clitoris is the only visible part of the clitoris. It has rich sensory innervation and blood perfusion.

3.2.6 BULBS OF THE VESTIBULE

The bulbs of the vestibule are formed by erectile tissue homologous with the bulb of penis. These two elongated masses are placed deep to labia minora, on the sides of the vaginal vestibule.They join anteriorly **in the commisure of the bulbs** (**commissura bulborum**) running between the glans of the clitoris and the urethral orifice. The slim stripes of this erectile tissue are continuous with the glans of the clitoris. There is also a venous connection between the glans of the clitoris and the compass of the bulbs.

Posterior ends of the bulbs diverge and **touch the greater vestibular glands** (Bartholin's glands).

The bulbs of the vestibule are **related to the inferior surface of the urogenital diaphragm**. Superficially they are covered by **the bulbospongiosus muscles**.

The bulbs of the vestibule are congested with blood during sexual excitement.

3.2.7 GREATER VESTIBULAR GLANDS (BARTHOLIN'S GLANDS)

The **greater vestibular glands (Bartholin's glands)** are homologous with the bulbourethral glands in male. These pea - sized yellowish glands are **related to the inferior surface of the urogenital diaphragm and the dorsal ends of bulbs of the vestibule**.

The **ducts of the glands** are quite long (around 1cm) and **open into the vestibule near** the **vaginal orifice** at the 4 and 8 o'clock position.

*The **greater vestibular glands produce mucous substance that serves as lubricant** for the vulva and vagina.*

*The opening of the **duct can be obstructed**, resulting in accumulation of mucus and swelling of the gland. The gland becomes prone to bacterial infection with the puss collection (abscess formation). **Bartholinitis** usually manifests itself by vulvar pain and dyspaurenia (painful sexual intercourse).*

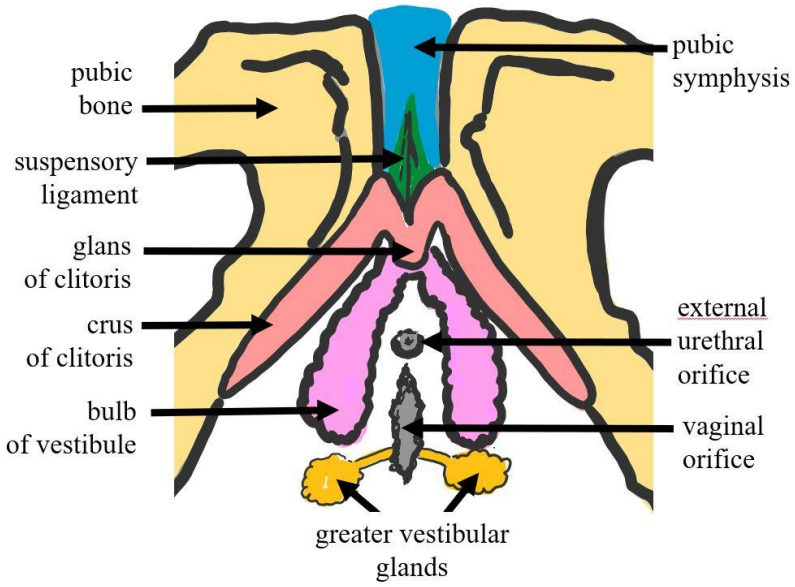

Fig. 68 Bulbs of vestibule, clitoris and greater vestibular glands - schema.

Redrawn from Čihák, R. (2016). Anatomie 2. Třetí, upravené a doplněné vydání. Grada Publishing, a.s.

3.2.8 BLOOD SUPPLY, LYMPH DRAINAGE, and NERVE SUPPLY OF THE EXTERNAL GENITAL ORGANS

External genital organs are **blood supplied** by the branches of **the femoral artery** that give **the external pudendal arteries** and by the branches of **the internal pudendal artery.**

The external pudendal arteries provide mainly the anterior aspect of labia majora.

The internal pudendal artery gives the posterior labial arteries, the dorsal artery of the clitoris, the artery of the vestibular bulb.

Venous blood is drained into **the external pudendal veins** (they open into the great saphenous vein) and to **the internal pudendal vein** (it opens into the common iliac vein).

The lymphatic collectors transport the lymph to the **superficial and deep inguinal lymph nodes**.

The external genitalia have autonomic and somatosensory innervation. **Parasympathetic fibers** come from the spinal segments S2 – S4 through the pelvic splanchnic nerves to the inferior hypogastric plexus. Then the cavernous nerves pierce the pelvic floor and reach erectile tissue in cavernous bodies of the clitoris and the greater vestibular glands.

Pudendal nerve provides sensory nerve supply for the dorsal two thirds of labia and clitoris. The anterior third of the labia is supplied by the sensory fibres of the **ilioinguinal nerve** and the **genital branch of the genitofemoral nerve**.

4 REVIEW QUESTIONS

4.1 REVIEW QUESTIONS - URINARY SYSTEM

Multichoice questions:

The kidney:
a/ renal medulla forms renal pyramids
b/ renal medulla forms renal columns
c/ each renal papilla is surrounded by a minor calyx
d/ left renal hilum is projected to the level of the 3rd lumbar vertebra
e/ parirenal fat encloses the kidney immediately outside the renal fascia

The kidney:
a/ renal cortex forms renal pyramids
b/ renal medulla forms an outer pale layer directly below the fibrous capsule
c/ left renal hilum projects to the level of the first lumbar vertebra (LI)
d/ right renal hilum projects to the level of the 12th thoracic vertebra (TXII)
e/ perirenal fat encloses the kidney immediately outside the fibrous capsule and inside the renal sinus

Relations of the kidney:
a / anterior surface of the right kidney is related to the diaphragm
b/ anterior surface of the left kidney is related to the spleen
c/ posterior surface of the right kidney is related to the descending part of the duodenum
d/ posterior surface of the left kidney is related to the pancreas
e/ posterior surface of both kidneys is related to the iliohypogastric nerve

Relations of the kidney:
a/ posterior surface of both kidneys is related to diaphragm
b/ anterior surface of both kidneys is related to the iliohypogastric nerve.
c/ anterior surface of the right kidney is related to the descending part of the duodenum
d/ anterior surface of the left kidney is related to the stomach
e/ inferior extremity of both kidneys is related to the suprarenal gland

Relations of the right kidney:
a/ its anterior surface is related to ilioinguinal nerve
b/ its anterior surface is related to the pancreas
c/ its anterior surface is related to the liver
d/ its posterior surface is related to the diaphragm
e/ its posterior surface is related to the rectus abdominis muscle

Relations of the left kidney:
a/ its anterior surface is related to the liver
b/ its anterior surface is related to the pancreas.
c/ its anterior surface is related to the spleen
d/ its posterior surface is related to the iliohypogastric nerve
e/ its posterior surface is related to the 10th rib (rib X)

Envelopes of the kidney:
a/ immediately outside the renal capsule there is pararenal (paranephric) fat
b/ immediately outside the perirenal (renal) fascia there is perirenal (perinephric) fat
c/ perirenal (perinephric) fat is contained in the renal sinus
d/ anterior and posterior layers of the renal (perirenal) fascia fuse medially
e/ suprarenal glands are also enclosed by the renal (perirenal) fascia

Envelopes of the kidney:
a/ immediately outside the renal capsule there is perirenal (perinephric) fat
b/ immediately outside the renal cortex there is renal fascia
c/ renal fascia also encloses suprarenal glands
d/ anterior and posterior layers of renal (perirenal) fascia are fused laterally and cranially
e/ pararenal (paranephric) fat surrounds the structures in the renal sinus

Renal calices, renal pelvis:
a/ one minor calyx surrounds one renal column
b/ major renal calices are drained into the renal pelvis
c/ renal calices are situated in renal sinus
d/ renal pelvis is related to gonadal vessels
e/ right renal pelvis is related to the ascending part of duodenum

Renal calices, renal pelvis:
a/ drops of urine are sent through the papillary foramina and received by the minor renal calices
b/ there are usually 3 major renal calices in renal sinus
c/ right renal pelvis is anteriorly related to the ascending part of duodenum
d/ renal pelvis is posteriorly related to transversus abdominis m.
e/ renal pelvis is related to gonadal vessels

Renal calices, renal pelvis:
a/ usually there are 7-14 minor renal calices in the renal sinus
b/ minor renal calices are directly drained into the renal pelvis
c/ renal pelvis is related to iliac vessels
d/ right renal pelvis is related to the descending part of duodenum
e/ left renal pelvis is related to the body of pancreas

The ureter :
a/ it is intraperitoneal in position
b/ it is related to iliac vessels
c/ left ureter is related to the attachment of the root of mesentery
d/ right ureter is related to the attachment of the root of sigmoid mesocolon
e/ it is constricted in the area where it is crossed by obturator vessels

The ureter :
a/ it is dilated in pelviureteric junction
b/ it is dilated at its intramural part
c/ the right ureter is related to the attachment of the root of mesentery
d/ the left ureter is related to the spleen
e/ in the male pelvis the ureter is related to the deferent duct

The ureter :
a/ its lumen has approximately 3 cm in diameter
b/ it is related to gonadal vessels
c/ the left ureter is related to the attachment of the root of mesentery
d/ the right ureter is related to the body of pancreas
e/ the ureter is constricted in the area where it crosses obturator vessels

The ureter :
a/ the ureter is retroperitoneal in position
b/ the lumen of the ureter is approximatelly 3cm in diameter
c/ the ureter is related to obturator vessels and nerve in pelvis
d/ the ureter is related to ilioinguinal nerve in abdomen
e/ the ureter is constricted in the area where it traverses the wall of the urinary bladder

The ureter :
a/ its intramural part is dilated
b/ in its pelvic part it is related to obturator vessels
c/ in its abdominal part it is related to ilioiguinal nerve
d/ in its abdominal part it is related to gonadal vessels
e/ it is constricted in pelviureteric junction

The urinary bladder:
a/ empty urinary bladder is situated directly behind anterior abdominal wall and overlaps the level of pubic symphysis
b/ the trigon of the urinary bladder is situated in fundus of the urinary bladder
c/ mucosa at the trigone forms numerous folds
d/ the apex of the urinary bladder directs downwards and backwards
e/ the neck is the inferior part of the urinary bladder which surrounds the origin of urethra

The urinary bladder:

a/ full urinary bladder overlaps the level of pubic symphysis and it is directly behind anterior abdominal wall
b/ maximal volume of urine in the urinary bladder is 100 ml
c/ fundus is the uppermost part of the urinary bladder
d/ median umbilical ligament arises from the apex to umbilicus
e/ detrusor muscle is voluntary striated muscle

Relations of the urinary bladder in male:

a/ prostate is below the urinary bladder
b/ deferent ducts are behind the urinary bladder
c/ rectum is in front of the urinary bladder
d/ dorsocranially there are the coils of jejunum
e/ inferolaterally there is the pelvic diaphragm

Relations of the urinary bladder in female:

a/ uterus is behind the urinary bladder
b/ rectum is in front of the urinary bladder
c/ vagina is behind the urinary bladder
d/ dorsocranially there are the coils of jejunum
e/ inferolaterally there is the pelvic diaphragm

The female urethra:

a/ the female urethra is longer than the male urethra
b/ the internal urethral orifice is surrounded by sphincter urethrae internus
c/ the external urethral orifice is situated in vaginal vestibule
d/ the external urethral orifice is surrounded by sphincter urethrae externus
e/ the external urethral sphincter is derived from the fibres of pelvic diaphragm

The female urethra:

a/ the internal urethral orifice is situated within the apex of the urinary bladder
b/ the average length of the female urethra is around 15 -20 cm
c/ the external urethral sphincter is derived from the fibres of the pelvic diaphragm
d/ the female urethra is directly related to rectum
e/ the female urethra runs behind vagina

The male urethra:

a/ the internal urethral orifice is situated in the apex of the urinary bladder
b/ the external urethral orifice is the most dilated (widest) part of the male urethra
c/ the ducts of bulbourethral glands open into the prostatic part of the male urethra
d/ the ejaculatory ducts open into the spongy part of the male urethra
e/ the external urethral sphincter surrounds the membranous part of the male urethra

Male urethra:
a/ the internal urethral orifice is surrounded by sphincter urethrae internus
b/ the external urethral orifice is surrounded by sphincter urethrae externus
c/ the ducts of bulbourethral glands open into the spongy part of the male urethra
d/ the prostatic part is the narrowest part of the male urethra
e/ the spongy part is the longest part of the male urethra

Open questions with short answer:

- **Write projection of the kidneys to the vertebral column (vertebrae).** You can use abbreviations for example: TX - TXII
- **Which nerves are related to the posterior surface of the kidney (which nerves run behind the kidney)?**
- **Describe general - inner structure of the kidney which is visible on the sectioned kidney:**
- **Which organ is related to the superior extremity of both kidneys?**
- **Name the organs which are related to the left kidney anteriorly:**
- **Which organ is related to the inferior extremity of both kidneys?**
- **What is contained in the space between the fibrous capsule of the kidney and perirenal fascia?**
- **Name the membrane that encloses the kidney surrounded by perirenal fat?**
- **What is immediately outside the perirenal fascia dorsally?**
- **What is contained in the renal sinus?**
- **What is contained in the renal hilum?**

- **Where (in which level) is the right and left renal hilum projected to the skeleton?**

  You can use abbreviations for example: TX - TXII
- **Which structures are crossed by the ureter in its abdominal part?**
- **Name the sites where the ureter is physiologically constricted:**
- **Which nerves are related to the ureter?**
- **Which peritonel attachment is related to the right ureter?**
- **Name vessels which are related to the ureter in female:**
- **Name the blood vessels which are related to the ureter in male :**
- **Which peritonel attachment is related to the left ureter?**
- **Name the area where the mucosa of the urinary bladder is always smooth (it does not form the folds).**
- **Name the parts of the urinary bladder:**
- **What is the position of the empty urinary bladder to peritoneum ?**
- **Write posterior relations of the urinary bladder in male:**
- **What is the position of the full urinary bladder to peritoneum ?**
- **Write posterior relations of the urinary bladder in female:**
- **Name the ligaments that fix the urinary bladder in male:**
- **Name the ligaments that fix the urinary bladder in female:**
- **Where (in which part of the urinary bladder) the trigone is situated?**
- **Where (in which part of the urinary bladder) the ureters enter the urinary bladder?**
- **Name the parts of the male urethra:**
- **Which part of the male urethra is the longest one°?**

- **Write the dorsal relations of the female urethra:**
- **Where is the male urethra narrowest?**
- **Which sphincter of the urethra is derived from the urogenital diaphragm?**
- **Where is the external urethral orifice situated in male?**
- **Where is situated the internal urethral sphicter?**
- **Where is the external urethral orifice situated in female?**
- **Where is the involuntary sphincter of the male urethra placed?**

4.2 REVIEW QUESTIONS - MALE GENITAL SYSTEM

Multichoice questions:

The testis:
a/ testes originally develop in abdominal cavity
b/ mediastinum testis contains rete testis and vessels for testis
c/ tunica vaginalis testis forms septa which separate the lobules of the testis
d/ convoluted seminiferous tubules are the site of spermatogenesis
e/ the epididymis is situated along the anterior border of the testis

The testis:
a/ the testis is endocrine gland
b/ tunica albuginea gives off septula testis which subdivide testis into the lobules
c/ tunica vasculosa immediately lines the external surface of tunica vaginalis testis
d/ hilum of testis is located at the anterior border of testis
e/ rete testis is situated in mediastinum testis

The testis:
a/ lobules of testis contain efferent ductules
b/ interstitial cells of Leydig produce testosteron
c/ tunica vasculosa immediately covers the internal surface of tunica albuginea
d/ straight seminiferous tubules open into rete testis
e/ tunica albuginea is the remnant of peritoneum

°The testis:
a/ lobules of testis contain seminiferous tubules
b/ interstitial cells of Leydig are situated in mediastinum testis
c/ tunica vasculosa immediately covers the internal surface of tunica albuginea (septula as well)
d/ efferent ductules arise from the seminiferous tubules and enter the rete testis
e/ the average weight of the testis is 150 – 250 g

The testis:
a/ there are usually 3 lobules in each testis
b/ mediastinum testis is situated at the inferior pole of the testis
c/ efferent ductules arise from rete testis and enter to the head of epididymis
d/ testosteron is produced by supportive Sertoli cells
e/ convoluted seminiferous tubules are the site of spermatogenesis

The epididymis:
a/ the epididymis is situated along the anterior border of testis
b/ the epididymis is covered by visceral layer of tunica vaginalis testis
c/ the epididymis consists of the head, body and tail
d/ the head of epididymis contains the duct of epididymis
e/ the tail of epididymis contains the efferent duct

°The epididymis:
a/ the epididymis is a reservoir of the sperm cells
b/ the epididymis lies along the posterior margin of the testis
c/ the head of epididymis lies at the inferior pole of the testis
d/ the head contains highly convoluted duct of epididymis
e/ the body and tail of epididymis contain deferent duct

The epididymis:
a/ the epididymis is covered by visceral layer of tunica vaginalis
b/ the duct of the epididymis is approximately 5 cm long
c/ the head of epididymis contains straight seminiferous tubules
d/ the body and tail of epididymis contains the efferent ductules
e/ the efferent ductules are drained directly into the deferent duct

The deferent duct:
a/ the deferent duct traverses the anterior abdominal wall through the inguinal canal
b/ the deferent duct is related to superior epigastric vessels in abdomen
c/ the deferent duct is related to the ureter in pelvis
d/ the terminal part of the deferent duct is constricted into the isthmus
e/ the deferent duct is related to bulbourethral glands

The spermatic cord:
a/ the spermatic cord runs from scrotum to inguinal canal
b/ the spermatic cord contains inguinal ligament
c/ the spermatic cord contains pampiniform plexus
d/ the spermatic cord contains testicular artery
e/ the spermatic cord is enveloped by dartos muscle

The deferent duct:
a/ it transports the sperm cells from the epididymis to ejaculatory duct
b/ in scrotum it runs behind the testis and epididymis
c/ it runs through the subinguinal hiatus
d/ in abdomen it is related to inferior epigastric vessels and external iliac vessels
e/ in pelvis it is related to obturator vessels and nerve

The ejaculatory duct:
a/ it runs in scrotum and inguinal canal
b/ it is formed by the union of the duct of the seminal vesicle with the ampulla of the deferent duct
c/ it traverses the isthmus of the prostate
d/ it opens into the spongy part of the male urethra
e/ it recieves the secret from the prostatic glands

Bulbourethral glands:
a/ bulbourethral glands are situated on inferior surface of the urogenital diaphragm
b/ bulbourethral glands are related to the bulb of penis
c/ bulbourethral glands produce smegma
d/ the ducts of the bulbourethral glands open into the prostatic part of the male urethra
e/ bulbourethral glands are superiorly covered by peritoneum of rectovesical pouch

Seminal glands and ejaculatory ducts:
a/ seminal glands are situated in front of the urinary bladder
b/ seminal glands are situated below the urogenital diaphragm
c/ seminal glands is related to ureter
d/ the duct of seminal gland joins with the deferent duct to form the ejaculatory duct
e/ the ejaculatory duct opens into the spongy part the urethra

Seminal glands (seminal vesicles, vesiculous glands):
a/ seminal glands are behind the urinary bladder
b/ seminal glands are cranially covered by peritoneum of rectovesical pouch
c/ seminal glands are related to gonadal vessels
d/ the ducts of seminal glands open into the spongy part of the male urethra
e/ seminal glands are the reservoir of the sperm cells

The prostate:
a/ the base of the prostate is related to the urinary bladder
b/ the apex of the prostate is related to the urogenital diaphragm
c/ the prostate is traversed by urethra and ejaculatory ducts
d/ the isthmus is the posterior part of the prostate situated behind urethra
e/ the middle lobe of the prostate contains no follicles – no prostatic glands

The prostate:
a/ the prostate is situated behind the rectum
b/ in physiologic conditions the average weight of the prostate is around 300 g
c/ the apex of the prostate is related to the urinary bladder
d/ the middle lobe of the prostate is situated in front of the prostatic part of urethra
e/ the isthmus of the prostate contains almost no prostatic glands (no follicles)

The prostate:
a/ the anterior surface of the prostate can by palpable during examination per rectum
b/ the posterior surface of the prostate can by palpable during examination per rectum
c/ the urethra passes between the anterior and middle third of the prostate
d/ the urethra passes between the middle and posterior third of the prostate
e/ the isthmus of the prostate can by palpable during examination per rectum

The prostate:
a/ the prostate is a pea - sized accessory gland
b/ the apex of the prostate directs upwards to the pubic symphysis
c/ th eprostate is related to the body of urinary bladder
d/ inferolateral surfaces of the prostate are related to the pelvic diaphragm
e/ the middle lobe of the prostate is situated behind urethra and between the ejaculatory ducts

Accessory glands of the male genital system:
a/ seminal glands are situated in rectovesical septum
b/ seminal gland is situated at the medial side of the ampulla of the deferent duct (more medially than the deferent duct)
c/ the duct of seminal vesicle joins with the deferent duct to form the ejaculatory duct
d/ bulbourethral glands are situated above the urogenital diaphragm (on its superior surface)
e/ the ducts of bulbourethral glands open into the spongy part of the male urethra

The penis:
a/ the root of the penis consits of corpora cavernosa and corpus spongiosum
b/ the body of the penis is connected to pubis by suspensory ligament
c/ the bulb of th epenis is attached to the urogenital diaphragm
d/ the glans of the penis is terminal enlargement of corpus cavernosum
e/ preputial glands produce smegma

The penis:
a/ the root of the penis consits of crura and bulb of penis
b/ corpus spongiosum is the ventral continuation of crura of the penis
c/ the bulb of the penis is related to bulbourethral glands
d/ the glans of the penis is terminal enlargement of corpus spongiosum
e/ immediately below the skin of the penis there is a subcutaneous fatty tissue

The body of penis:
a/ the body of the penis is attached to pubic bone by fundiform ligaments
b/ corpora cavernosa are ventral continuation of the bulb of the penis
c/ the glans of the penis is terminal enlargement of corpus cavernosum
d/ the glans of the penis is covered by mucosa
e/ frenulum of the prepuce connects the prepuce to the urethral surface of the glans

The wall of scrotum:
a/ dartos muscle is striated muscle
b/ dartos muscle is situated immediately below the skin
c/ cremaster muscle is smooth muscle
d/ cremaster muscle is situated immediately below the internal spermatic facsia
e/ external spermatic fascia is situated immediately below the dartos muscle

The wall of scrotum:
a/ dartos muscle is smooth muscle
b/ dartos muscle is situated immediately below the skin
c/ cremaster muscle is situated immediately below the internal spermatic facsia
d/ cremaster muscle play a role in thermoregulation of the testis
e/ external spermatic fascia is situated immediately below the dartos muscle

Open questions with short answer:

- **Which male genital organs are covered by the visceral layer of tunica vaginalis?**
- **What is contained in lobules of testis?**
- **What is situated in rete testis?**
- **Where is situated rete testis?**
- **Name the layer of the testis that is situated immediately below the tunica vaginalis testis?**

- **Name the layer that is situated immediately below the tunica albuginea and lines septula of the testis?**
- **Name the organ that runs along the posterior border of the testis?**
- **Which organ is the reservoir of sperm cells?**
- **Name the parts of the epididymis:**
- **Which parts of the epididymis contains eefferent ductules?**
- **What is a continuation of the duct of epididymis?**
- **Name the parts of the deferent duct:**
- **Write relations of the deferent duct in abdomen and pelvis:**
- **Write the relations of the deferent duct in spermatic cord:**
- **Name the envelopes of the spermatic cord:**
- **Which blood vessels run in spermatic cord?**
- **Where is the ejaculatory duct opened? Write exactly!**
- **Write superior relations of the prostate:**
- **Write posterior relations of the prostate:**
- **Write inferolateral relations of the prostate:**
- **Write anterior relations of the prostate:**
- **Write inferior relations of the prostate:**
- **Name the part of the prostate situated behind the urethra and between the ejaculatory ducts:**
- **Which part of the prostate is situated in front of the urethra?**
- **What is behind the prostate (which organ)?**
- **Which part of the prostate is usually hypertrofied in older age?**
- **Which part of the prostate is related to the urogenital diaphragm ?**

- **Which part/surface of the prostate is related to the pelvic diaphragm?**
- **Which accessory male genital gland lies within the rectovesical septum?**
- **Write relations of the seminal glands:**
- **How is the ejaculatory duct formed?**
- **Where is the duct of the bulbourethral gland opened?**
- **Write relations of the bulbourethral glands:**
- **Which ducts of the excretory glands are opened into the prostatic part of the urethra?**
- **Which accessory male genital gland is situated below the urogenital diaphragm?**
- **Which structures form the body of penis?**
- **Which glands produce smegma?**
- **Name surfaces of the body of the penis:**
- **Which ligaments fix the body of the penis to pubis?**
- **Name the parts of the root of the penis, where they are attached?**
- **Which part of the penis forms the glans of the penis?**
- **Name the muscles which are situated in the wall of the scrotum:**
- **Which layer of the scrotal wall helps to regulate the temperature of the testicles?**
- **What lines cavum serosum scroti?**

4.3 REVIEW QUESTIONS - FEMALE GENITAL ORGANS

Multichoice questions:

The ovary:
a/ after pregnancy the ovary is situated behind the ureter and internal iliac vessels
b/ the ovary is attached by the mesovarium to the posterior surface of the broad ligament of the uterus
c/ suspensory ligament of the ovary connects the uterine extremity of the ovary and the uterine horn
d/ ovarian medulla contains growing follicles
e/ the left ovary is related to the appendix

The ovary:
a/ in physiological condition, the size of the ovary is approximately 10 x 8 x 6 cm
b/ the ovary is attached by the mesovarium to the lateral pelvic walls
c/ ovarian ligament connects the uterine extremity of the ovary and uterine horn
d/ ovarian medulla is the site of oogenesis
e/ the right ovary is related to the coils of the jejunum

The ovary:
a/ after pregnancy the ovary is situated behind the ureter and internal iliac vessels
b/ the surface of the ovary is uneven before the puberty
c/ the suspensory ligament of the ovary contains ovarian vessels
d/ ovarian medulla contains highly vascular tissue
e/ the right ovary is related to sigmoid colon

The ovary:
a/ the average weight of the ovary in physiologic conditions is cca 150 – 200 g
b/ the surface of the ovary is smooth before the puberty
c/ the ovarian ligament contains ovarian vessels
d/ ovarian cortex is immediately below tunica albuginea
e/ the left ovary is related to sigmoid colon

The ovary:
a/ before pregnancy the ovary is situated in front of the external iliac vessels
b/ the surface of the ovary is smooth in postmenopausal women
c/ the ovarian ligament arises from tubal extremity of the ovary
d/ ovarian medulla contains growing follicles
e/ the right ovary is related to ileum

The uterine tube:
a/ the uterine tube is retroperitoneal in position
b/ the ampulla is narrow medial part of the uterine tube
c/ the margin of uterine opening is rimmed with fimbriae
d/ mucous coat of uterine tube is folded in numerous folds
e/ the left uterine tube is related to the sigmoid colon

The uterine tube:
a/ the uterine tube is intraperitoneal in position
b/the infundibulum is narrow medial part of the uterine tube
c/ the isthmus is the most lateral part of the uterine tube
d/ the right uterine tube is related to jejunum
e/ the uterine tube is related to ureter

The uterine tube:
a/ in physiological conditions the lumen of the uterine tube in isthmus is cca 1 cm
b/ margin of the infundibulum is rimmed with finger-like projections fimbriae
c/ the isthmus of uterine tube is situated more laterally than ampulla of uterine tube
d/ the uterine tube is covered by peritoneum
e/ the left uterine tube is related to appendix

The uterus:
a/ the uterus is situated behind the rectum and in front of the urinary bladder
b/ the uterine body is anteflexed on uterine cervix
c/ the ostium of the uterus (the external os) is round in parous woman (woman after the childbirth)
d/ the round ligament of uterus runs from the uterine cervix to the lateral pelvic wall
e/ endometrium forms the mucous coat of uterus

The uterus:
a/ the uterus is situated in front of the rectum
b/ the uterus is situated behind the urinary bladder
c/ the isthmus of uterus is convex upper part of the uterine body
d/ the round ligament of uterus runs from the uterine horn to labium majus
e/ parametrium forms the mucous coat of uterus

The uterus:
a/ the uterus is intraperitoneal in position
b/ the isthmus is the lowermost part of uterus
c/ the fundus is convex upper part of the uterine body extending above the level of the uterine horns
d/ myometrium is formed by striated muscles
e/ in physiologic conditions, the uterine fundus in non – pregnant woman extends at least 5 cm above the pubic symphysis

The uterus:
a/ the body of the uterus is related to the coils of the sigmoid colon
b/ the body of the uterus is retroflexed on uterine cervix
c/ mucosa of the cervical canal forms palmate folds
d/ transverse ligament (ligamentum cardinale) extends from the uterine body to the lateral pelvic wall
e/ the body of the uterus is less moveable than the uterine cervix

The uterus:
a/ the body of the uterus is related to the coils of the ileum
b/ the uterine cervix is less movable than the uterine body
c/ in nulliparous woman ostium of the uterus (the external os) appears as a transverse slit
d/ myometrium is formed by smooth musculature
e/ parametrium is the serous coat of uterus formed by peritoneum

The uterus:
a/ the uterus is attached to the lateral pelvic walls by the broad ligament
b/ the cavity of the uterine body is triangular and anteroposteriorly flattened
c/ in anulliparous woman the isthmus is a part of the uterine body
d/ the ovarian ligament is attached to the uterine horn
e/ endometrium undergoes regular changes during menstrual cycle

The uterus:
a/ the uterine body is related to the coils of the jejunum
b/ the canal of uterine cervix is fusiform in shape (spindle-like shape)
c/ the physiologic weight of the uterus in non – pregnant woman is cca 500–750 g
d/ perimetrium is the serous coat of uterus
e/ the pelvic diaphragm supports the uterus inferolaterally

The vagina:
a/ the lowermost part of the vagina forms the vaginal fornix
b/ the mucosa of the vagina forms transverse rugae
c/ the muscular coat of the vagina is formed by smooth muscle
d/ the vaginal orifice is situated in front of the clitoris
e/ in front of the vagina there is the urethra and the fundus of the urinary bladder

The vagina:
a/ the vaginal fornix is the space around the vaginal portion of the uterine cervix
b/ the posterior vaginal fornix is deeper than anterior one
c/ the posterior vaginal wall is longer than anterior one
d/ the vaginal mucosa forms longitudinal columns
e/ the anterior vaginal wall is 18 – 20 cm long

The vestibule:
a/ the vestibule is the space bordered by labia majora
b/ the vestibule is lined by mucosa
c/ Skene´s glands open near the vaginal orifice
d/ the external urethral orifice is situated in vaginal vestibule in front of the vaginal orifice
e/ mucosa of the vestibule contains minor vestibular glands

External female genital organs:

a/ the vestibule is the space around the vaginal portion of the uterine cervix
b/ crura of clitoris are attached to pubis
c/ the ducts of greater vestibular glands open into the vestibule near the vaginal orifice
d/ glans of clitoris is positioned at the end of the body of clitoris
e/ bulb of vestibule is covered by bulbospongiosus muscle

Open questions with short answer:

- **Characterize suspensory ligament of the ovary:**
- **Write relations of the left ovary:**
- **Write relations of the right ovary:**
- **Name the ligament that contains the ovarian vessels:**
- **Name the attachment that connects the ovary to the posterior surface of the broad ligament:**
- **Define position of the ovary to internal iliac vessels and ureter in a nulliparous woman:**
- **Define position of the ovary to internal iliac vessels and ureter in a parous woman:**
- **Name the layers of the ovary that can be seen in its crossection:**
- **Which layer of the ovary contains the growing follicles?**
- **Which layer of the ovary is the site of oogenesis?**
- **Name the openings of the uterine tube:**
- **Name finger – like projections which rim the infundibulum (abdominal opening) of the uterine tube:**
- **What is the mesosalpinx?**
- **Name the parts of the uterine tube:**

- **Which part of uterine tube is the narrowest?**
- **Name the ligament which extends from the uterine cervix to the lateral pelvic walls:**
- **Which organs are related to the uterus anteriorly?**
- **Which organs are related to the uterus posteriorly?**
- **Which organs are related to the intestinal surface of uterus?**
- **Name the parts of the uterus:**
- **Name convexity of the uterine body situated above the level of the uterine horns:**
- **Which part of the uterine body can be palpated through the anterior abdominal wall?**
- **Which part of the uterus can be seen through the vagina during the gynaecological examination with speculum?**
- **Shortly explain the physiologic position of the uterus:**
- **Name the ligament running from the uterine horn to labium majus:**
- **Name the ligament which connects the uterine cervix to the lateral pelvic wall:**
- **Name the ligament that connects the margines of uterus to the lateral pelvic walls:**
- **Define the shape of the cervical canal:**
- **Define the shape of the uterine cavity within the body:**
- **Which layer of the uterine wall undergoes the regular changes during the menstrual cycle?**
- **Name the layers of the uterine wall:**

- **Describe (draw) the shape of ostium of uterus (external os) before the first pregnancy (in a nullipara):**
- **Describe (draw) the shape of ostium of uterus (external os) after the pregnancy (in a parous woman):**
- **What is the vaginal fornix?**
- **Write relations of the vagina:**
- **Name the space of the vagina that encircles the vaginal portion of the uterine cervix:**
- **Name the part of the vagina that is related to the rectouterine pouch:**
- **Which part of the vagina is covered by the peritoneum?**
- **Which part of the external female genital organs is covered by mucosa?**
- **Name the space – external genital organ which is bordered by labia minora?**
- **Name the parts that form the clitoris:**
- **Where are crura clitoridis attached?**
- **Name elongated erectile masses placed on the sides of the vestibule:**
- **Where are the ducts of greater vestibular glands opened?**
- **What is parakolpium?**

4.4 REVIEW QUESTIONS - BLOOD SUPPLY, VENOUS AND LYMPHATIC DRAINAGE, AND NERVE SUPPLY OF ORGANS OF THE UROGENITAL SYSTEM

Multichoice questions:

Blood supply and venous drainage of the kidney:
a/ renal arteries arise from abdominal aorta
b/ the right renal artery is shorter than left renal artery
c/ renal veins opned into the portal vein
d/ the left renal vein receives blood from the left gonadal vein
e/ the left renal vein is shorter than the right renal vein

Blood supply of the kidney:
a/ in the renal sinus renal arteries run more ventrally than renal veins
b/ the renal artery usually subdivides into 5 segmental arteries
c/ renal veins open into the inferior vena cava
d/ renal arteries arise from the aorta higher than coeliac trunk
e/ the right renal vein usually receives the left gonadal veins

The ureter is blood supplied by branches of:
a/ the renal artery
b/ the gonadal artery
c/ the external pudendal artery
d/ the superior vesical artery
e/ the uterine artery

Lymph drainage:
a/ the lymph from the kidneys is drained into the lumbar lymph nodes
b/ the lymph from the ureter is drained into the lumbar lymph nodes
c/ the lymph from the ureter is drained into the internal iliac lymph nodes
d/ the lymph from the male urethra is drained into the superficial inguinal lymph nodes
e/ the lymph from the male urethra is drained into the internal iliac lymph nodes

Blood supply of the urinary bladder:
a/ the superior vesical artery is a branch of the renal artery
b/ the inferior vesical artery is a branch of the umbilical artery
c/ the inferior vesical artery supplies the apex of the urinary bladder
d/ the superior vesical artery supplies the fundus of the urinary bladder
e/ vesical veins are direct tributaries to the inferior vena cava

Which of following arteries give the branches for blood supply of the urinary bladder:
a/ the middle rectal artery
b/ the uterine artery
c/ the inferior mesenteric artery
d/ the internal pudendal artery
e/ the external pudendal artery

Which of following arteries give the branches for blood supply of the male urethra:
a/ the middle rectal artery
b/ the superior vesical artery
c/ the inferior vesical artery
d/ the internal pudendal artery
e/ the external pudendal artery

The testis:
a/ testicular arteries arise from the internal pudendal artery
b/ venous blood from the testis is drained to the paminiform plexus
c/ the right testicular vein opens into the inferior vena cava
d/ the lymph from testis is drained into the lumbar lymph nodes
e/ parasympathetic fibers for testis come from the vagus nerve

The epididymis:
a/ the epididymis is blood supplied by the testicular artery
b/ venous blood from the epididymis is drained into the pampiniform plexus
c/ the lymph from epididymis is drained into the lumbar lymph nodes
d/ the lymph from epididymis is drained into the superficial inguinal lymph nodes
e/ the epididymis takes sympathetic fibers from the vagus nerve

The deferent duct and seminal glands:
a/ the artery of the deferent duct is a branch of the testicular artery
b/ venous blood from the deferent duct is drained into the pampiniform plexus
c/ seminal glands are blood supplied by the testicular artery
d/ seminal glands are blood supplied by the external pudendal artery
e/ seminal glands are blood supplied by the middle rectal artery

The prostate:
a/ the prostate is blood supplied by the inferior vesical artery
b/ the prostate is blood supplied by the superior vesical artery
c/ the prostate is blood supplied by the superior rectal artery
d/ venous blood from the prostate is drained into the pampiniform plexus
e/ the lymph from the prostate is drained into the internal iliac lymph nodes

The penis:
a/ dorsal artery of penis is a branch of the external pudendal artery
b/ dorsal artery of penis runs at below the superficial fascia of penis
c/ venous blood from penis is drained into the pampiniform plexus

d/ blood from the superficial dorsal vein of the penis is drained into the internal pudendal veins
e/ blood from the deep vein of penis is drained into the prostatic plexus

The scrotum:
a/ posterior scrotal arteries are branches of the external pudendal artery
b/ anterior scrotal arteries are branches of the internal pudendal artery
c/ venous blood from the anterior part/surface of scrotum is drained into the external pudendal veins
d/ the lymph from scrotum is drained into the lumbar lymph nodes
e/ the lymph from scrotum is drained into the external iliac lymph nodes

The ovary:
a/ the ovarian artery arises from abdominal aorta
b/ the left ovarian vein is drained into the left renal vein
c/ the lymph from the ovaries is drained into the lumbar lymphatic nodes
d/ the uterine artery gives off the ovarian branch
e/ ovarian vessels run within the ligament of the ovary

The uterine tube:
a/ medial 1/3 of the uterine tube is blood supplied by the tubal branches of the ovarian artery
b/ lateral 1/3 of the uterine tube is blood supplied by the tubal branches of the uterine artery
c/ venous blood from the medial part of the uterine tube is drained into the uterine venous plexus
d/ the lymph from the uterine tube is drained into the internal iliac lymphatic nodes
e/ the isthmus of the uterine tube is blood supplied by the tubal branch of the ovarian artery

The uterus:
a/ the uterine artery comes from the abdominal aorta
b/ the uterine artery crosses with the ureter
c/ uterine veins open into the internal pudendal vein
d/ the lymph from the uterus is drained into the internal iliac lymph nodes
e/ the lymph from the uterus is drained into the superficial inguinal lymph nodes

Which of following arteries give the branches for blood supply of the vagina:
a/ the middle rectal artery
b/ the inferior rectal artery
c/ the superior rectal artery
d/ the uterine artery
e/ the external pudendal artery

External female genital organs:
a/ anterior labial branches come from the internal pudendal artery
b/ posterior labial branches come from the external pudendal artery
c/ bulb of the vestibule is supplied by the external pudendal artery
d/ the clitoris is blood supplied by the the internal pudendal artery
e/ the dorsal artery of the clitoris is a branch of the external pudendal artery

Open questions with short answer:

- **Name the arteries that supply the ureter:**
- **Name the artery/arteries that supply the fundus of the urinary bladder:**
- **Name the arteries that supply the male urethra:**
- **Name the arteries that supply the female urethra:**
- **Name the organs that are supplied by the inferior vesical artery:**
- **Name the organs that are supplied by the testicular artery:**
- **Name the organs that are supplied by the ovarian artery:**
- **Which arteries supply the uterine tube?**
- **Where are the vesical veins drained?**
- **Where are the uterine veins drained?**
- **Which organs may be supplied by the uterine artery?**
- **Where is drained the venous blood from the deferent duct?**
- **Where is drained the venous blood from the uterine tube?**
- **Which arteries supply pudendum femininum?**
- **Name the branches of the internal iliac artery that supply pudendum femininum?**
- **Name the branches of the external iliac artery that supply pudendum femininum?**

References:

Aguilar, H. N., & Mitchell, B. F. (2010). Physiological pathways and molecular mechanisms regulating uterine contractility. *Human Reproduction Update*, *16*(6), 725–744. https://doi.org/10.1093/humupd/dmq016

Al-Sunaidi, M., & Tulandi, T. (2007). Surgical Treatment of Ectopic Pregnancy. *Seminars in Reproductive Medicine*, *25*(2), 117–122. https://doi.org/10.1055/s-2007-970050

Arendt-Nielsen, L., & Svensson, P. (2001). Referred Muscle Pain: Basic and Clinical Findings. *The Clinical Journal of Pain*, *17*(1), 11–19. https://doi.org/10.1097/00002508-200103000-00003

Balerna, M., Medici, G., Mazzucchelli, L., Bianda, T., Marossi, L., & Colpi, G. M. (2009). Analytical biochemistry of seminal vesicle secretion: a challenge to andrological laboratories: Analytische Biochemie des Bläschendrüsensekrets: eine Herausforderung für das andrologische Labor. *Andrologia*, *22*(S1), 166–177. https://doi.org/10.1111/j.1439-0272.1990.tb02082.x

Bradley, Desai, & Mamtora. (1998). The relevance of parity to ureteric dilatation. *BJU International*, *81*(5), 682–685. https://doi.org/10.1046/j.1464-410x.1998.00641.x

Bukovsky, A., Caudle, M. R., Svetlikova, M., & Upadhyaya, N. B. (2004). Origin of germ cells and formation of new primary follicles in adult human ovaries. *Reproductive Biology and Endocrinology*, *2*(1), 20. https://doi.org/10.1186/1477-7827-2-20

Bolla, S. R., Hoare, B. S., & Varacallo, M. (2021). Anatomy, Abdomen and Pelvis, Deep Perineal Space. In *StatPearls*. StatPearls Publishing.

Burden, H., Holmes, C., Persad, R., & Whittington, K. (2005). Prostasomes—their effects on human male reproduction and fertility. *Human Reproduction Update*, *12*(3), 283–292. https://doi.org/10.1093/humupd/dmi052

Burks, F. N., & Santucci, R. A. (2014). Management of iatrogenic ureteral injury. *Therapeutic Advances in Urology*, *6*(3), 115–124. https://doi.org/10.1177/1756287214526767

Caplan, M. (2014). *Reference Module in Biomedical Research*. Elsevier Gezondheidszorg.
Chughtai, B., Sawas, A., O'Malley, R. L., Naik, R. R., Ali Khan, S., & Pentyala, S. (2005). A neglected gland: a review of Cowper's gland. *International Journal of Andrology*, *28*(2), 74–77. https://doi.org/10.1111/j.1365-2605.2005.00499.x

Cirstoiu, M., & Munteanu, O. (2012). Strategies of preventing ureteral iatrogenic injuries in obstetrics-gynecology. *Journal of medicine and life*, *5*(3), 277–279.

Crawford, P., & Crop, J. A. (2014). Evaluation of scrotal masses. *American family physician*, *89*(9), 723–727.

Čihák, R. (2016). *Anatomie 2. Třetí, upravené a doplněné vydání*. Grada Publishing, a.s.

Dauber, W., & Feneis, H. (2007). *Pocket atlas of human anatomy* (5th ed.). Thieme.

Devins, K., & Shwartz, L. (2021, May 7). *Cervix*. PathologyOutlines.Com. Retrieved October 16, 2021, from https://www.pathologyoutlines.com/topic/cervixnormalhistology.html

Dixon, J. S., & Gosling, J. A. (1982). The musculature of the human renal calices, pelvis and upper ureter. *Journal of Anatomy*, *135*(Pt 1)

Drake, R., Vogl, W., & Mitchell, A. (2012). *Gray's basic anatomy*. Churchill Livingstone.

Drake, R., Vogl, W., & Mitchell, A. (2010). *Gray´s Anatomy for Students* (2nd ed.). Churchill Livingstone.

Dylevský, I. (2009). *Funkční anatomie*. Grada Publishing, a.s.

Franz, M. C., Anderle, P., Bürzle, M., Suzuki, Y., Freeman, M. R., Hediger, M. A., & Kovacs, G. (2013). Zinc transporters in prostate cancer. Molecular aspects of medicine, 34(2-3), 735–741.

Gilbert, S. F. (Ed.). (2000). *Developmental Biology* (6th ed.). Sinauer Associates.
Gilroy, A. (2013). *Anatomy: An Essential Textbook*. Thieme.

Gonzales G. F. (2001). Function of seminal vesicles and their role on male fertility. *Asian journal of andrology*, *3*(4), 251–258.

Gray, H. (1918). *Anatomy of the human body*. Lea & Febiger.

Guimarães Gonçalves, M. A., Anschau, F., Martins Gonçalves, D., & da Silva Marc, C. (2012). Ureter: How to Avoid Injuries in Various Hysterectomy Techniques . In A. Al-Hendy (Ed.), *Hysterectomy* (pp. 285–292). Intech.

Guru, N., Patil, S., Kundargi, V., Patil, B., Patil, N., & Ranka, K. (2017). Posthysterectomy ureteric injuries: Presentation and outcome of management. *Urology Annals*, *9*(1), 4. https://doi.org/10.4103/0974-7796.198838

Hartshorne, G., Lyrakou, S., Hamoda, H., Oloto, E., & Ghafari, F. (2009). Oogenesis and cell death in human prenatal ovaries: what are the criteria for oocyte selection? *Molecular Human Reproduction*, *15*(12), 805–819. https://doi.org/10.1093/molehr/gap055

Hashitani, H., & Lang, R. (2020). ATYPICAL or INTERSTITIAL, take your PIC. *The Journal Of Physiology*, *598*(15), 3061-3062. https://doi.org/10.1113/jp280080

Jenkins, T. (2004). Laparoscopic supracervical hysterectomy. *American Journal Of Obstetrics And Gynecology*, *191*(6), 1875-1884. https://doi.org/10.1016/j.ajog.2004.06.096

Jones, R. E., & Lopez, K. H. (2014). The Female Reproductive System. *Human Reproductive Biology*, 23–50. https://doi.org/10.1016/b978-0-12-382184-3.00002-7

Lafans, K., & Kok, S. J. (2021). Culdocentesis. In *StatPearls*. StatPearls Publishing.

Laszczyńska, M., Brodowska, A., Starczewski, A., Masiuk, M., & Brodowski, J. (2008). Human postmenopausal ovary--hormonally inactive fibrous connective tissue or more?. *Histology and histopathology*, *23*(2), 219–226. https://doi.org/10.14670/HH-23.219

Lau, G. (2007). Iatrogenic Injury. In M. Tsokos (Ed.), *Forensic Pathology Reviews Vol 3* (pp. 351–439). Humana.

Lee, M. Y., Dalpiaz, A., Schwamb, R., Miao, Y., Waltzer, W., & Khan, A. (2015). Clinical Pathology of Bartholin's Glands: A Review of the Literature. *Current Urology*, *8*(1), 22–25. https://doi.org/10.1159/000365683

Lee, R. A., Symmonds, R. E., & Williams, T. J. (1988). Current status of genitourinary fistula. *Obstetrics and gynecology*, *72*(3 Pt 1), 313–319.

Libretexts. (2020, August 15). *43.3C: Gametogenesis (Spermatogenesis and Oogenesis)*. Biology LibreTexts. https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/Book%3A_General_Biology_(Boundless)/43%3A_Animal_Reproduction_and_Development/43.3%3A_Human_Reproductive_Anatomy_and_Gametogenesis/43.3C%3A__Gametogenesis_(Spermatogenesis_and_Oogenesis)

McKay, A. C., Odeluga, N., Jiang, J., & Sharma, S. (2021). Anatomy, Abdomen and Pelvis, Seminal Vesicle. In *StatPearls*. StatPearls Publishing.

MacKinnon, A. E. (2005). The undescended testis. *The Indian Journal of Pediatrics*, *72*(5), 429–432. https://doi.org/10.1007/bf02731742

Magoffin, D. A. (2005). Ovarian theca cell. *The International Journal of Biochemistry & Cell Biology*, *37*(7), 1344–1349. https://doi.org/10.1016/j.biocel.2005.01.016

Mellick, L. B., Mowery, M. L., & Al-Dhahir, M. A. (2021). Cremasteric Reflex. In *StatPearls*. StatPearls Publishing.

Mirmonsef, P., Hotton, A. L., Gilbert, D., Gioia, C. J., Maric, D., Hope, T. J., Landay, A. L., & Spear, G. T. (2016). Glycogen Levels in Undiluted Genital Fluid and Their Relationship to Vaginal pH, Estrogen, and Progesterone. *PLOS ONE*, *11*(4), e0153553. https://doi.org/10.1371/journal.pone.0153553

Mohiedean Ghofrani, M. D. (2021, September 9). *Ovary*. PathologyOutlines.Com. Retrieved October 15, 2021, from https://www.pathologyoutlines.com/topic/ovarynontumornormalhistology.html

Moore, K., Agur, A., & Dalley, A. (2018). *Clinically oriented anatomy*. Wolters Kluwer.

Myers, R. P. (2002). Detrusor apron, associated vascular plexus, and avascular plane: relevance to radical retropubic prostatectomy—anatomic and surgical commentary. *Urology*, *59*(4), 472–479. https://doi.org/10.1016/s0090-4295(02)01500-5

Mráz P. et al.: Anatómia ľudského tela 1. Slovac Academic Press, 2004.

Nah, S. A., Yeo, C. S. W., How, G. Y., Allen, J. C., Lakshmi, N. K., Yap, T. L., Jacobsen, A. S., Low, Y., & Ong, C. C. P. (2013). Undescended testis: 513 patients' characteristics, age at orchidopexy and patterns of referral. *Archives of Disease in Childhood*, *99*(5), 401–406. https://doi.org/10.1136/archdischild-2013-305225

Nepal, P., Kumar, D., & Ojili, V. (2018). Abnormal descent of the testis and its complications: A multimodality imaging review. *South African Journal of Radiology*, *22*(1). https://doi.org/10.4102/sajr.v22i1.1374

Nguyen, J. D., & Duong, H. (2021). Anatomy, Abdomen and Pelvis, Female External Genitalia. In *StatPearls*. StatPearls Publishing

Nishida, T., & Nishida, N. (2006). Reinstatement of "germinal epithelium" of the ovary. *Reproductive Biology and Endocrinology*, *4*(1). https://doi.org/10.1186/1477-7827-4-42

Ogah, J. A. (2008). Urinary Tract Complications. In P. O'Donovan (Ed.), *Complications in Gynecological Surgery*. Springer

Omole, F., Simmons, B. J., & Hacker, Y. (2003). Management of Bartholin's duct cyst and gland abscess. *American family physician*, *68*(1), 135–140.

Parker, W. H. (2007). Etiology, symptomatology, and diagnosis of uterine myomas. *Fertility and Sterility*, *87*(4), 725–736. https://doi.org/10.1016/j.fertnstert.2007.01.093

Parmigiani, S., Gianotti, D., & Bevilacqua, G. (2012). General Characteristics of Preterm and Term Newborn. *Neonatology*, 17–20. https://doi.org/10.1007/978-88-470-1405-3_3

Paulsen, F., & Waschke, J. (2017). *Sobotta atlas of human anatomy* (17th ed.). Urban & Fisher.

Pietro, P., Ludovica, P., Astrid, B., Paolo, P., & Michele, P. (2017). Sepsis secondary to Cowper's gland abscess. *Urology Case Reports*, *15*, 48–49. https://doi.org/10.1016/j.eucr.2017.09.005

Prendiville, W., & Sankaranarayanan, R. (2017). *Colposcopy and Treatment of Cervical Precancer*. International Agency for Research on Cancer.

Rato, L., Alves, M. G., Socorro, S., Duarte, A. I., Cavaco, J. E., & Oliveira, P. F. (2012). Metabolic regulation is important for spermatogenesis. *Nature Reviews Urology*, *9*(6), 330–338. https://doi.org/10.1038/nrurol.2012.77

Schulman, A., & Herlinger, H. (1975). Urinary tract dilatation in pregnancy. *The British Journal of Radiology*, *48*(572), 638–645. https://doi.org/10.1259/0007-1285-48-572-638

Sharlip, I. D., Belker, A. M., Honig, S., Labrecque, M., Marmar, J. L., Ross, L. S., Sandlow, J. I., & Sokal, D. C. (2012). Vasectomy: AUA Guideline. *Journal of Urology*, *188*(6S), 2482–2491. https://doi.org/10.1016/j.juro.2012.09.080

Snell, R. (2007). *Clinical anatomy by systems*. Lippincott Williams & Wilkins.

Snodgrass, W., Bush, N., Holzer, M., & Zhang, S. (2011). Current Referral Patterns and Means to Improve Accuracy in Diagnosis of Undescended Testis. *PEDIATRICS*, *127*(2), e382–e388. https://doi.org/10.1542/peds.2010-1719

Sokwala, S. (2020). Reproductive endocrine physiology. In R. Rehman & A. Sheikh (Eds.), *Subfertility* (1st ed., pp. 39–64). Elsevier Gezondheidszorg.

Standring, S. (2008). *Gray's Anatomy: The Anatomical Basis of Clinical Practice* (40th ed.). Churchill and Livingstone.

Sullivan, R., & Mieusset, R. (2016). The human epididymis: its function in sperm maturation. *Human Reproduction Update*, *22*(5), 574–587. https://doi.org/10.1093/humupd/dmw015

Schwarz, G. M., & Hirtler, L. (2017). The cremasteric reflex and its muscle - a paragon of ongoing scientific discussion: A systematic review. *Clinical Anatomy*, *30*(4), 498–507. https://doi.org/10.1002/ca.22875

Tasian, G. E., Copp, H. L., & Baskin, L. S. (2011). Diagnostic imaging in cryptorchidism: utility, indications, and effectiveness. *Journal of Pediatric Surgery*, *46*(12), 2406–2413. https://doi.org/10.1016/j.jpedsurg.2011.08.008

Tepper, S. L., Jagirdar, J., Heath, D., & Geller, S. A. (1984). Homology between the female paraurethral (Skene's) glands and the prostate. Immunohistochemical demonstration. *Archives of pathology & laboratory medicine*, *108*(5), 423–425.

The Editors of Encyclopaedia Britannica. (2019, February 17). *oogenesis*. *Encyclopedia Britannica*. https://www.britannica.com/science/oogenesis

The Editors of Encyclopaedia Britannica. (2020, May 27). *spermatogenesis*. *Encyclopedia Britannica*. https://www.britannica.com/science/spermatogenesis

Vijayaraghavan, S. B. (2011). Sonographic localization of nonpalpable testis: Tracking the cord technique. *Indian Journal of Radiology and Imaging*, *21*(02), 134–141. https://doi.org/10.4103/0971-3026.82298

Virant-Klun, I. (2015). Postnatal oogenesis in humans: a review of recent findings. *Stem Cells and Cloning: Advances and Applications*, 49. https://doi.org/10.2147/sccaa.s32650

Waschke, J., Bo̎ckers, T., & Paulsen, F. (2018). *Sobotta anatomy textbook* (1st ed.). Urban &Fischer.

Wong, S. L., & Abdul Hamid, H. (2010). Observation of ureteric diameter in negative intravenous urogram in hospital universiti kebangsaan malaysia. *The Malaysian journal of medical sciences : MJMS*, *17*(2), 4–9.

Ye, L., Li, X., Li, L., Chen, H., & Ge, R. S. (2017). Insights into the Development of the Adult Leydig Cell Lineage from Stem Leydig Cells. *Frontiers in Physiology*, *8*. https://doi.org/10.3389/fphys.2017.00430

Yilmaz, U., Yang, C. C., & Berger, R. E. (2006). Dartos reflex: A sympathetically mediated scrotal reflex. *Muscle & Nerve*, *33*(3), 363–368. https://doi.org/10.1002/mus.20476

Young, R. C. (2007). Myocytes, Myometrium, and Uterine Contractions. *Annals of the New York Academy of Sciences*, *1101*(1), 72–84. https://doi.org/10.1196/annals.1389.038

Zelenko, N., Coll, D., Rosenfeld, A. T., & Smith, R. C. (2004). Normal Ureter Size on Unenhanced Helical CT. *American Journal of Roentgenology*, *182*(4), 1039–1041. https://doi.org/10.2214/ajr.182.4.1821039

Zhang, X. D., & Jin, B. F. (2007). The role of seminal vesicles in male reproduction and sexual function. *Zhonghua nan ke xue = National journal of andrology*, *13*(12), 1113–1116.

Zirkin, B. R., & Papadopoulos, V. (2018). Leydig cells: formation, function, and regulation†. *Biology of Reproduction*, *99*(1), 101–111. https://doi.org/10.1093/biolre/ioy059

https://prostates.com.au/wp-content/uploads/2016/09/essential-urology-for-bond-medical-students-the-prostate-clinic-australian-prostate-doctor-charles-chabert.pdf

https://www.kenhub.com/en/library/anatomy/cowper-s-gland Kenhhub anatomy Shahab Shahid MBBS Bulbourethral gland September 30, 2021

https://bio.libretexts.org/@go/page/14124___Gametogenesis (Spermatogenesis and Oogenesis). (2020, August 15).

https://www.cancer.gov/publications/dictionaries/cancer-terms/def/pap-smear

https://www.imaios.com/en/e-Anatomy/Anatomical-Parts/seminal-gland-seminal-vesicle

https://prostates.com.au/wp-content/uploads/2016/09/essential-urology-for-bond-medical-students-the-prostate-clinic-australian-prostate-doctor-charles-chabert.pdf