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Anatomy of the Urinary and Reproductive Systems. Structural Features in Childhood. Abnormalities

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The study giude logically combines modern scientific data relating to the normal anatomy of the urinary and genital systems of an adult, as well as children. The mechanisms of developmental anomalies and pathologies of the human urogenital system are thoroughly elucidated. All this should greatly facilitate students of the international faculty to find the necessary information in preparation for practical classes in anatomy, histology, pathological anatomy, urology, gynecology and other clinical disciplines.

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У посібнику логічно об'єднані сучасні наукові дані, що стосуються нормальної анатомії сечової й статевої систем дорослої людини, а також дитячого періоду. Досконально освітлені механізми виникнення аномалій розвитку й патологій сечостатевої системи людини. Все це повинно значно полегшити студентам міжнародного факультета пошук необхідної інформації при підготовці до практичних занять з анатомії, гістології, патологічної анатомії, урології, гінекології та інших клінічних дисциплін.

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PREFACE

This textbook is intended for undergraduate, postgraduate and continuing education for health care professionals from a variety of clinical disciplines (medicine, pediatrics, dentistry) as it includes the basic concepts of human anatomy of genitourinary system in adults and newborns. The neonatal period is the most crucial one in the human life as well as the critical and determinative period for the postnatal ontogenesis.

This textbook covers not only the normal anatomy of genitourinary system in neonates but its variants and abnormalities which seem to be the commonest in medical practice.

Anomalies of kidneys and excretory organs are much more common in humans that in any other species. For the last decades due to the wide application of new diagnostics techniques these abnormalities have being increasingly detected in the early age that is of great medical and social significance.

This textbook comprises scientific data referring the normal anatomy of genitourinary system in adults and neonates as well as outlines the mechanisms triggering human genitourinary abnormalities. This might be helpful and supportive for the readers in searching the information needed for the lectures and practical training in anatomy, histology, anatomical pathology, urology, gynecology, and some other medical disciplines.

At the end of each chapter there are review questions, tests, and clinical case studies designed for self-study to control and to stimulate thought about the issues and problems described. 118 illustrations occur in each chapter to present pertinent data.

We hope the textbook helps medical students to master the basic concepts of human anatomy that are needed before progressing to more difficult material. It also meets Bologna requirements of ECTS for teaching and learning.

We will be particularly grateful for endorsements, suggestions, and critical remarks.

THE URINARY SYSTEM, SYSTEMA URINARIUM

The urinary system consists of the following parts: a pair of glandular kidneys, which remove substances from the blood, form urine, and help regulate various metabolic processes; a pair of tubular ureters, which transport urine away from the kidneys; a saclike urinary bladder, which serves as a urine reservoir; and a tubular urethra, which conveys urine to the outside of the body (Fig. 1).

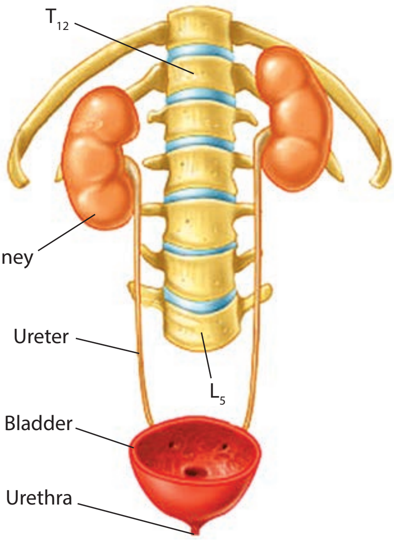


Fig. 1. The view of the urinary system

Development of the urinary organs in human

Excretory organs in vertebrates. Evolution of excretory organs in vertebrates features a successive development and replacement of three different types of organs – the pronephros (primary kidney), mesonephros (intermediate kidney), and metanephros (definitive kidney).

Structure of pronephros. The pronephros forms in all vertebrates but persists only in cyclostomes.

Pronephros is a system of segmental convoluted tubules (nephridia). Proximal ends of tubules open into the body cavity and distal merge to form the excretory canal, which terminates in the caudal segment of digestive tube. The orifices of proximal ends feature cilia that direct the flow to nephridia. Subserous blood vessels form glomerules that filter the fluid. The fluid therefore first collects in the body cavity and then proceeds to the canaliculi. The canaliculi are responsible for urine concentration due to epithelium functioning.

Structure of mesonephros. Further development of renal canaliculi leads to degeneration of the orifices that open into the body cavity. Mesonephral canaliculi thus come into intimate contact with capillary glomerules. Each canaliculus develops a blind double-walled capsule, which enfolds the glomerule to form a renal corpuscle well resembling that of the definitive kidney. The canaliculi become longer, convoluted and acquire more complex structure. They open into common mesonephric duct, ductus mesonephricus, which in turn opens into the cloaca. Generally, the mesonephros appears as a paired elongated organ, which runs along the body. It lies retroperitoneally on the dorso-lateral wall of the body cavity. Mesonephros persists in fish, amphibians and some reptiles.

Relations of the mesonephros to the genitals. The internal genital organs are closely related to the mesonephros. The mesonephric duct in male fish, amphibians and reptiles communicates with the genitals and thus serves to transport semen. Females develop paired paramesonephric ducts, which serve to transport the oocytes. The mesonephros separates into two compartments – the cranial, which loses excretory function and becomes related to the genital organs and caudal, which retains excretory function.

The definitive kidney (**metanephros**). The birds and mammals develop the definitive kidney appearing as a compact bean-shaped organ. The metanephros retains only excretory function leaving transporting of reproductive products to mesonephros.

The definitive kidney arises from two sources. The projection in the caudal compartment of the mesonephric duct (the ureter) grows cranially and enters the nephrogenic mass where venal corpuscle and tubules form. The metanephros thus separates from the mesone phros, which in turn becomes responsible for reproductive products transport. In view of the fact that the definitive kidney forms in the lesser pelvis cavity it is also called the pelvic kidney.

Formation of the urinary organs from mesoderm. Formation of the renal canaliculi is observed by the 4^{th} week of development in so-called intermediate mesoderm (which lies between the ventral and dorsal mesoderm). The canaliculi lie in each segment and generally appear as dense mass called the nephrogenic strand. The nephrogenic mass is a source for all kidney generations.

Recapitulation of kidney phylogeny. During embryonic period, the kidneys successively pass through all evolutional stages i.e. embryo develops the pronephros, mesonephros and metanephros. As development progresses, the pronephric canaliculi degenerate rapidly to become replaced with mesonephric canaliculi. Finally, the metanephros develops so the most part of mesonephros also degenerates except for the canaliculi that give rise to seminiferous tubules.

The pronephros. At the beginning of the 4th week of development, the embryo develops 7 pairs of pronephric canaliculi. They form at the level of cervical and upper thoracic somites. The canaliculi open into the common duct that grows lengthwise and terminates in the cloaca. Orifices of the proximal ends open into the coelomic cavity. Very soon, the pronephros undergoes involution and completely disappears by the 1st month of development.

The mesonephros in human embryo exhibits intensive development and unlike pronephros fully performs excretory function. The mesonephros also arises from the nephrogenic strand. It forms as paired S-shaped convoluted canaliculi, which join the pronephric duct. The latter henceforth is called the mesonephric duct, ductus mesonephricus (the Wulfs duct). The nephrogenic strand gives rise to approximately 30 canaliculi but they do not exist simultaneously because as new canaliculi appear in the caudal portion of mesonephros the older ones undergo involution.

Blood vessels of mesonephros. The intermediate kidney receives numerous segmental arterial branches that arise from aorta. Inside the organ, each branch forms a capillary glomerule. The dilated proximal ends of the canaliculi enfold the glomerules and form double-walled capsule. Another arteriole leaves the capsule and again splits into capillary network that enfolds the canaliculi. These capillary collect into the efferent veins.

Maximum development and degeneration of mesonephros. By the end of the 2nd month of embryo life, the mesonephros reaches maximum development. At this period, it appears as an elongated organ, which runs along the body cavity by its dorsal wall. Protruding into the body cavity, the mesonephros gives rise to paired urogenital ridge, plica urogenitales that run along the dorsal mesentery. Further, each ridge splits into lateral mesonephric fold and medial genital fold. The latter gives rise to genitals.

After formation of the metanephros, the mesonephros undergoes involution yet its duct and canaliculi residua give rise to genitals.

Double source of metanephros formation. The metanephros appears caudally to the mesonephros and arises from two sources:

- projection of the mesonephros gives rise to the ureter, renal calices, pelvis, papillary ducts and collecting ducts;
- the metanephrogenic mass gives rise to nephron ducts.

Formation of the voiding passages. By the end of the 4th week, the caudal portion of mesonephric duct develops a projection, which is the ureter primordia. Very soon, the end of projection becomes dilated; this dilation corresponds to renal pelvis and calices. The primordia grows cranially and incorporates into the caudal portion of the nephrogenic strand. The metanephrogenic mass enfolds the primordia from all sides. Further, the renal calices primordias give rise to the papillary ducts and collecting ducts.

Formation of the nephrons. Internal differentiation of the metanephrogenic mass constitutes formation of nephron ducts. The renal artery incorporates into the mass and branches off to form the glomerules. The ducts enfold glomerules and form the double-walled capsule. Growing on, the ducts develop segments and eventually join the collecting ducts that arise from calices primordias (Fig. 2–4).

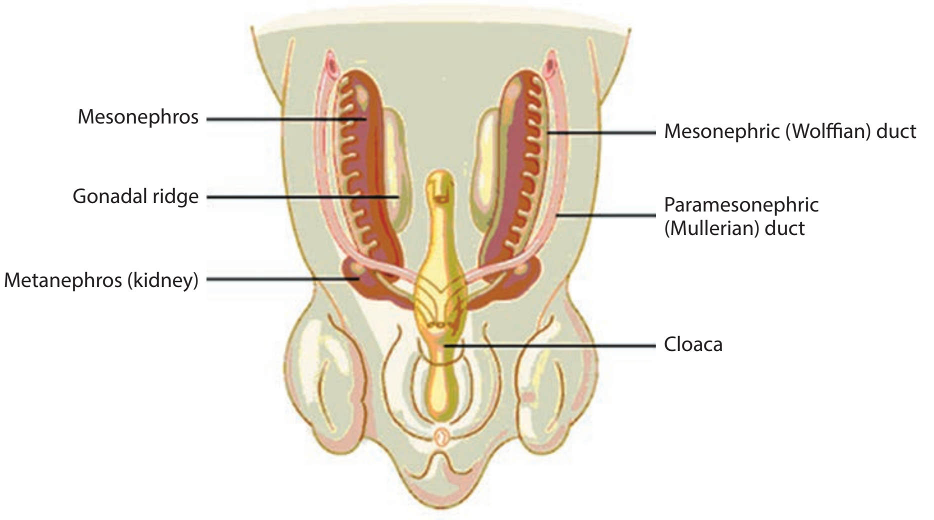


Fig. 2. The development of the urinary system

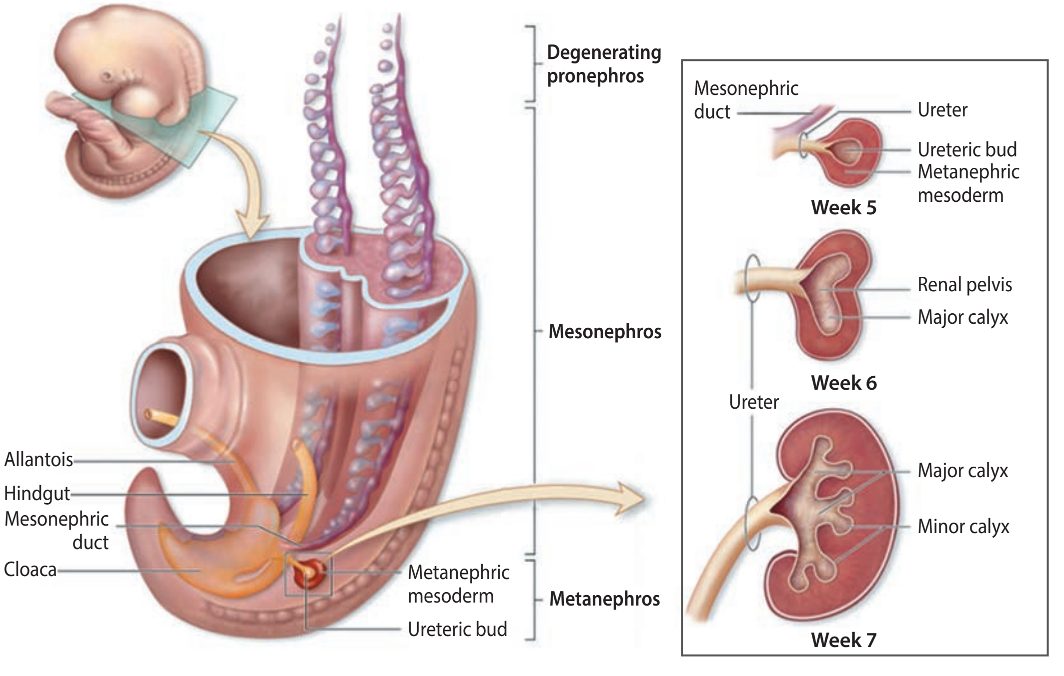


Fig. 3. The development of the kidney

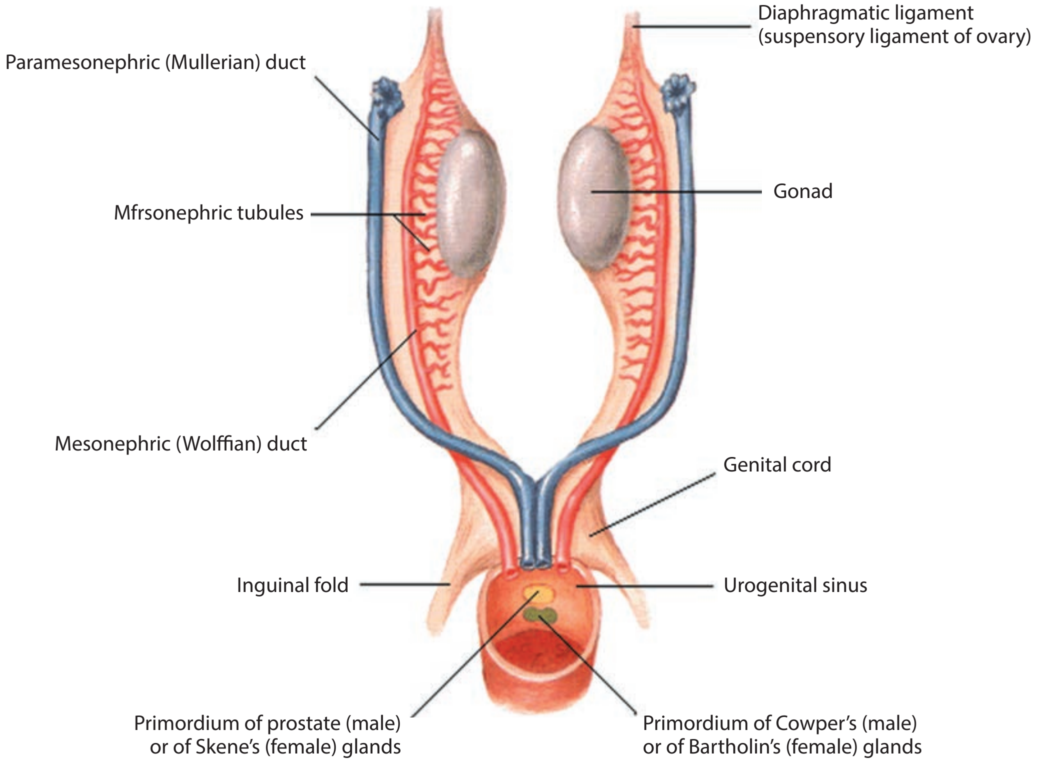


Fig. 4. The development of the urogenital organs

THE KIDNEY, REN

Synonym 'nephros' (Greek) gives birth to 'nephritis', nephrology' and other medical terms (Fig. 5).

A kidney is a reddish brown, bean-shaped organ with a smooth surface. It is about 12 centimeters long, 6 centimeters wide and 3 centimeters thick in an adult, and it is enclosed in a tough, fibrous capsule (tunic fibrosa). It`s mass ranges from 120 to 200 grams. The kidneys lie on either side of the vertebral column in a depression high on the posterior wall of the abdominal cavity.

Although the positions of the kidneys may vary slightly with changes in posture and with breathing movements, their upper and lower borders are generally at the levels of the twelfth thoracic and third lumbar vertebrae, respectively. The left kidney is usually about 1.5 to 2 centimeters higher than the right one.

The kidneys are positioned retroperitoneally, which means they are behind the parietal peritoneum and against the deep muscles of the back. They are held in position by connective tissue (renal fascia) and masses of adipose tissue (renal fat) that surround them.

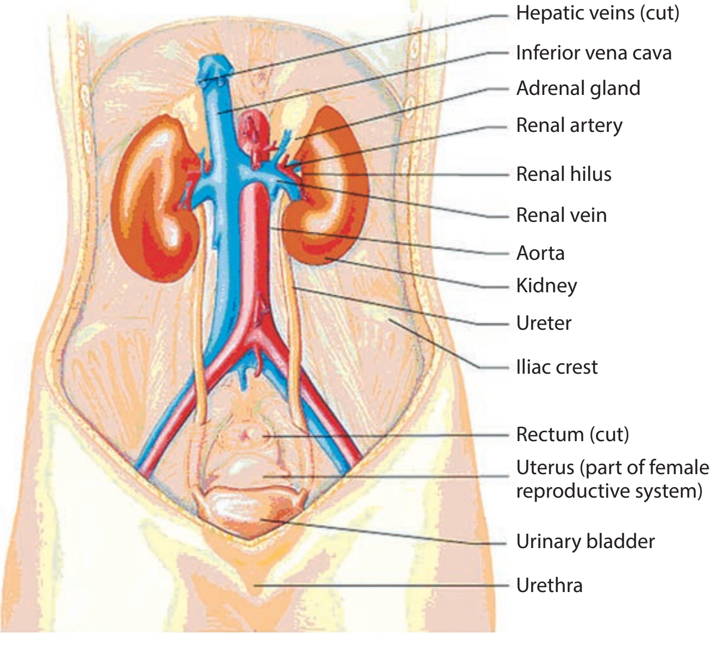


Fig. 5. Organs of the urinary system

The exterior of the kidney. Each kidney has two borders, two surfaces and two extremities (poles):

- the lateral border, margo lateralis, a convex one directed laterally and slightly posteriorly;
- the medial border, margo medialis, the opposite concave border directed medially and slightly anteriorly;
- the hilum of kidney, hilum renalis, a deep notch situated in the middle of medial border; the hilum contains the vessels, nerves, the renal pelvis and ureter;
- the renal sinus, sinus renalis, a cavity within the kidney, which contains the renal calices, the renal pelvis, blood and lymphatic vessels, nerves and fat;
- the anterior surface, facies anterior, more convex than posterior surface;
- the posterior surface, facies posterior, rather flat compared to the anterior;
- the superior extremity (pole), extremitas superior, rather thin, it lies superomedially;
- the inferior extremity (pole), extremitas inferior, thicker than the opposite one (Fig. 6).

Skeletotopy. The kidneys are related to Th_{12} through L_2. The right kidney lies 1–1.5 cm lower than the left (Fig. 7, 8). The upper extremities reach the XI ribs. Relations to the XII ribs are not identical: the left kidney is crossed by the XII rib in the middle, while the right – between the upper and middle thirds. The inferior extremities lie 3–5 cm above the iliac crest. The longitudinal axes of kidneys run slantwise downwards and laterally so the upper poles approximate while the lower are distant from each other. Apart from this the kidneys versed so that the lateral borders are directed slightly posteriorly and the medial – anteriorly (Fig. 9).

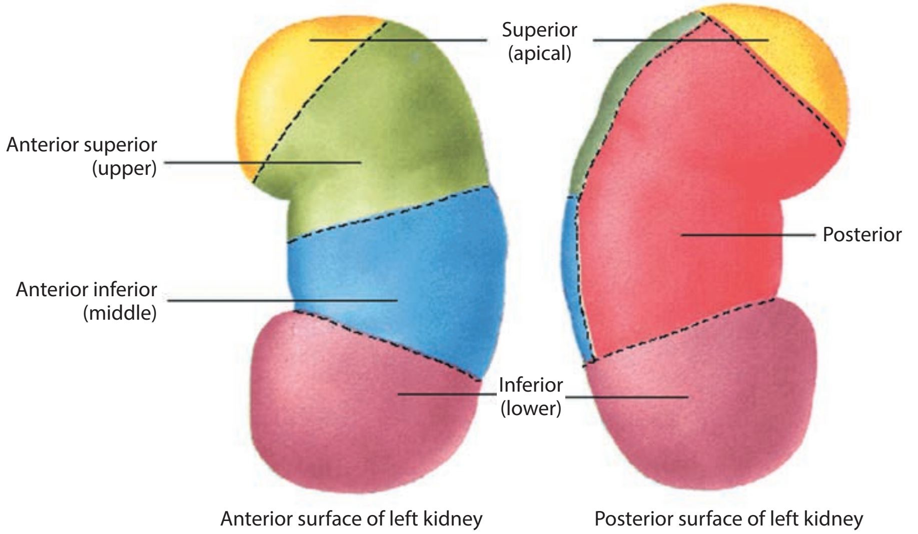


Fig. 6. The exterior of the kidney

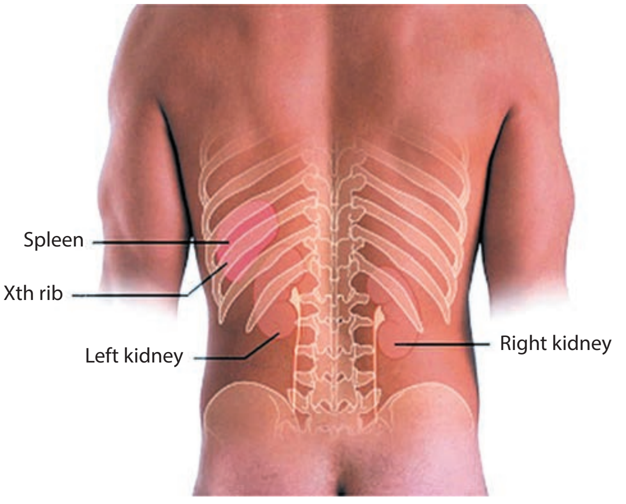


Fig. 7. The projection of the kidneys on the back

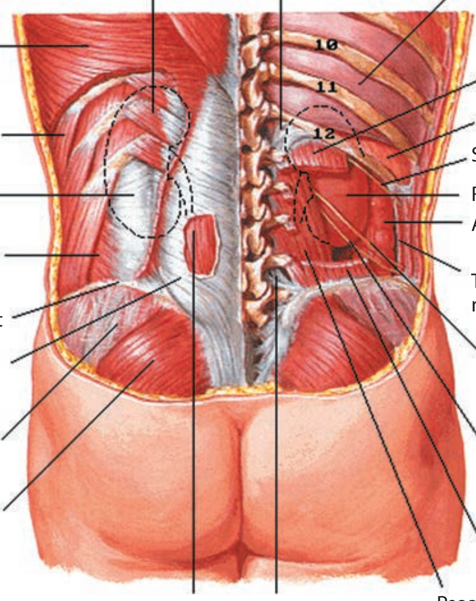
Syntopy. The right kidney neighbors the right suprarenal gland, the liver, the descending part of duodenum and the right colic flexure (Fig. 10).

The left kidney neighbors the left suprarenal gland, the pancreas, the stomach, the left colic flexure and the small intestine.

Peritoneal relations. The kidneys lie posterior to the visceral layer of peritoneum (extraperitoneally). Only small portions of anterior surface retain serous coating.

Kidneys' support. The most important role in support of kidneys belongs to abdominal pressure and to the following structures:

- the renal bed – the excavation bounded by the psoas major, the diaphragm, the quadratus lumborum and the transversus abdominis;
- the perinephric fat (the perirenal fat capsule), capsula adiposa, abundant fat tissue, which enfolds the kidney. Its medial and posterior portions are better developed than the rest;
- the fibrous capsule, capsula fibrosa, a dense connective tissue coating, which fixes directly to the renal substance and may easily be removed. It also fixes to the perinephric fat and renal fascia;
- the renal stalk, a bundle of the renal vessels, which fix the kidney to large vessels and ureter. The renal vein lies anteriorly, next lies the renal artery and the renal pelvis lies posteriorly (Fig. 11);
- the renal fascia, fascia renalis, which covers the perinephric fat from outside. It has two layers – the prerenal and postrenal. The layers merge superior to the suprarenal gland and along the lateral border. Inferior edges do not merge and run down gradually thinning to disappear in the retroperitoneal fat. The prerenal layer passes from one kidney to another anterior to the aorta and inferior vena cava and the post-renal layer fixes to the vertebral column.



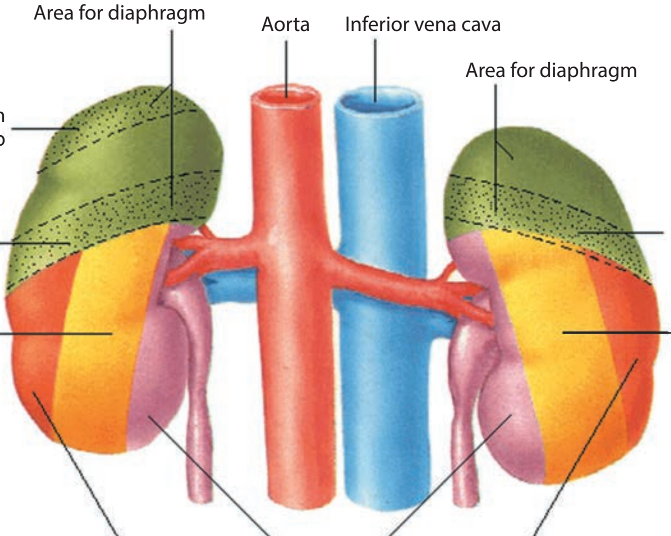
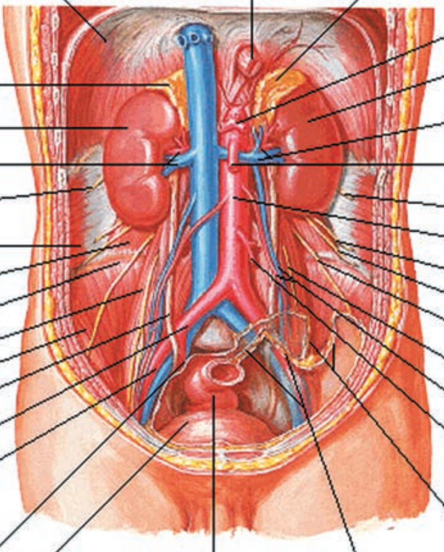


Fig. 8. Posterior relation of the kidneys



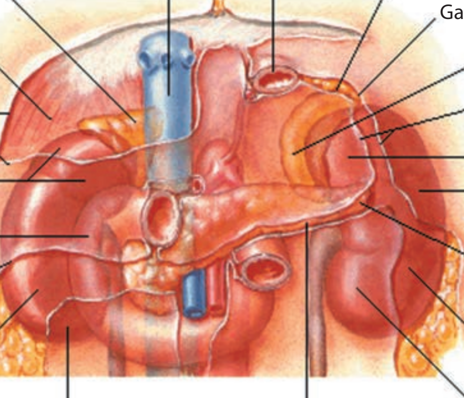


Fig. 9. Anterior relation of the kidneys

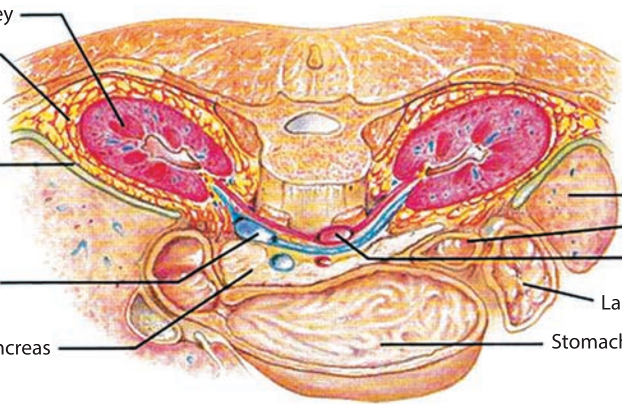


Fig. 10. Syntopy of the kidneys (transverse sections of the kidneys)

Functions of the kidneys

The kidneys remove metabolic wastes from the blood and excrete them to the outside. They also carry on a variety of equally important regulatory activities including helping control the rate of red blood cell formation by secreting the hormone erythropoietin, helping regulate the blood pressure by secreting the enzyme renin, and helping regulate the absorption of calcium ions by activating vitamin D. The kidneys also help regulate the volume, composition, and pH of body fluids. These functions involve complex mechanisms that lead to the formation of urine.

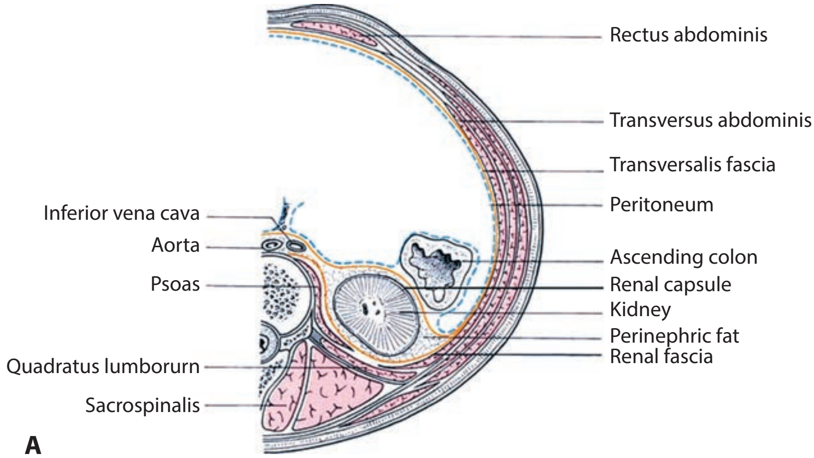
Clinical applications

1. Reduced perinephric fat (common in weight loss) or decreased abdominal pressure (in abdominal muscles weakness) may result in abnormal kidneys descent (renal ptosis). In this case, the kidney (usually right) descends between the fascial layers to the greater pelvis. Treatment of the condition is aimed at suturing the fascial layers inferior to the kidney and fixation of the organ to the XII rib (nephropexy).

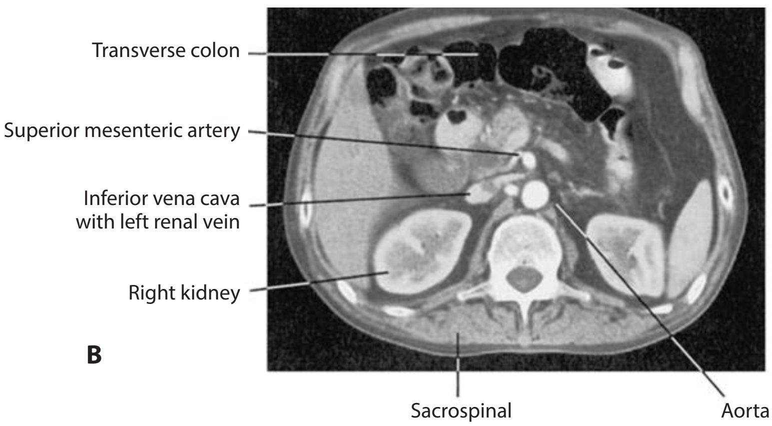
2. Blood from a ruptured kidney or pus in a perinephric abscess first distend the renal fascia, then force their way within the fascial compartment downwards into the pelvis. The midline attachment of the renal fascia prevents extravasation to the opposite side.

3. In hypermobility of the kidney ('floating kidney'), this organ can be moved up and down in its fascial compartment but not from side to side. To a lesser degree, it is in this plane that the normal kidney moves during respiration.

4. Exposure of the kidney via the loin. An oblique incision is usually favoured midway between the 12th rib and the iliac crest, extending laterally from the lateral bor-



A



B

Fig. 11. Syntopy of the kidneys.

A – transverse section demonstrating the fascial compartments of the kidney. **B** – CT scan of the same region. Note that CT scans, by convention, are viewed from below, so that the aorta, for example, is seen on the right side. The blood vessels have been enhanced by an intravenous injection of contrast

der of erector spinae. Latissimus dorsi and serratus posterior inferior are divided and the free posterior border of external oblique is identified, enabling this muscle to be split along its fibres. Internal oblique and transversus abdominis are then divided, revealing peritoneum anteriorly, which is pushed forward. The renal fascial capsule is then brought clearly into view and is opened. The subcostal nerve and vessels are usually encountered in the upper part of the incision and are preserved. If more room is required, the lateral edge of quadratus lumborum may be divided and also the 12th rib excised, care being taken to push up, but not to open, the pleura, which crosses the medial half of the rib.

Interior of the kidney. The renal substance consists of the renal cortex and the renal medulla. The lateral surface of each kidney is convex, but its medial side is deeply concave. The resulting medial depression leads into a hollow chamber called the renal sinus. The entrance to this sinus is termed the hilum, and through it pass various blood vessels, and the ureter. The superior end of the ureter is expanded to form a funnel-shaped sac called the renal pelvis, which is located inside the renal sinus. The pelvis is subdivided into two or three tubes, called major calyces (sing. calyx), and they, in turn, are subdivided into several (eight to fourteen) minor calyces.

A series of small elevations project into the renal sinus from its wall. These projections are called renal papillae, and each of them is pierced by tiny openings that lead into a minor calyx.

The substance of the kidney includes two distinct regions: an inner medulla and an outer cortex. The renal medulla is composed of conical masses of tissue called renal pyramids, whose bases are directed toward the convex surface of the kidney, and whose apexes form the renal papillae. The tissue of the medulla appears striated due to the presence of microscopic tubules leading from the cortex to the renal papillae.

The renal cortex, which appears somewhat granular, forms a shell around the medulla. Its tissue dips into the medulla between adjacent renal pyramids, forming renal columns. The granular appearance of the cortex is due to the random arrangement of tiny tubules associated with the nephrons, the functional units of the kidney.

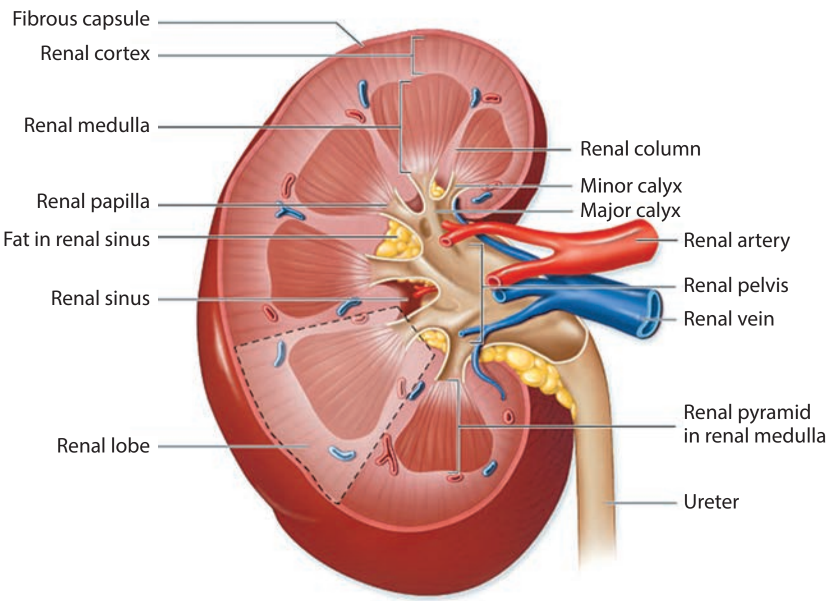


Fig. 12. The right kidney (coronal section)

The renal segments. Renal segmentation is based on arterial branching within the organs:

- the superior segment, segmentum superius;
- the anterior superior segment, segmentum anterius superius;
- the anterior inferior segment, segmentum anterius inferius;
- the posterior segment, segmentum posterius;
- the inf erior segment, segmentum inferius.

The renal lobes, *lobi renalis*. A renal lobe is a renal pyramid together with neighboring segment of the cortex separated by the interlobular arteries and veins running in the renal columns.

The ***cortical lobules****, lobuli corticales*. The renal lobules are the cortical segments separated by the interlobular arteries. Each lobule consists of the *radiate part,* pars radiata surrounded by the cortex corticis (Fig. 12).

The radiate part contains the straight portions of renal tubules and collecting ducts and the cortex corticis contains the renal corpuscles and distal portions of renal tubules.

The nephron

Structure of a Nephron. A kidney contains about one million nephrons, eachconsisting of a **renal corpuscle** and a **renal tubule.** A renal corpuscle (Malpighian corpuscle) is composed of a tangled cluster of blood capillaries called a **glomerulus,** which is surrounded by a thinwalled, saclike structure called a **glomerular capsule** (Bowman's capsule) (Fig. 13).

The glomerular capsule is an expansion at the closed end of a renal tubule. It is composed of two layers of squamous epithelial cells: a visceral layer that closely covers the glomerulus, and an outer parietal layer that is continuous with the visceral layer and with the wall of the renal tubule. The cells of the parietal layer are typical squamous epithelial cells; however, those of the visceral layer are highly modified epithelial cells called podocytes (Fig. 14, 15).

Each podocyte has several primary processes extending from its cell body, and these processes, in turn, bear numerous secondary processes, or pedicels. The pedicels of each cell interdigitate with those of adjacent podocytes, and the clefts between them form a complicated system of slit pores.

The renal tubule leads away from the glomerular capsule and becomes highly coiled. This coiled portion of the tubule is named the proximal convoluted tubule.

The proximal convoluted tubule dips toward the renal pelvis to become the descending limb of the loop of Henle. The tubule then curves back toward its renal corpuscle and forms the ascending limb of the loop of Henle (Fig. 16).

The ascending limb returns to the region of the renal corpuscle, where it becomes highly coiled again and is called the distal convoluted tubule. This distal portion is shorter than the proximal tubule, and its convolutions are less complex.

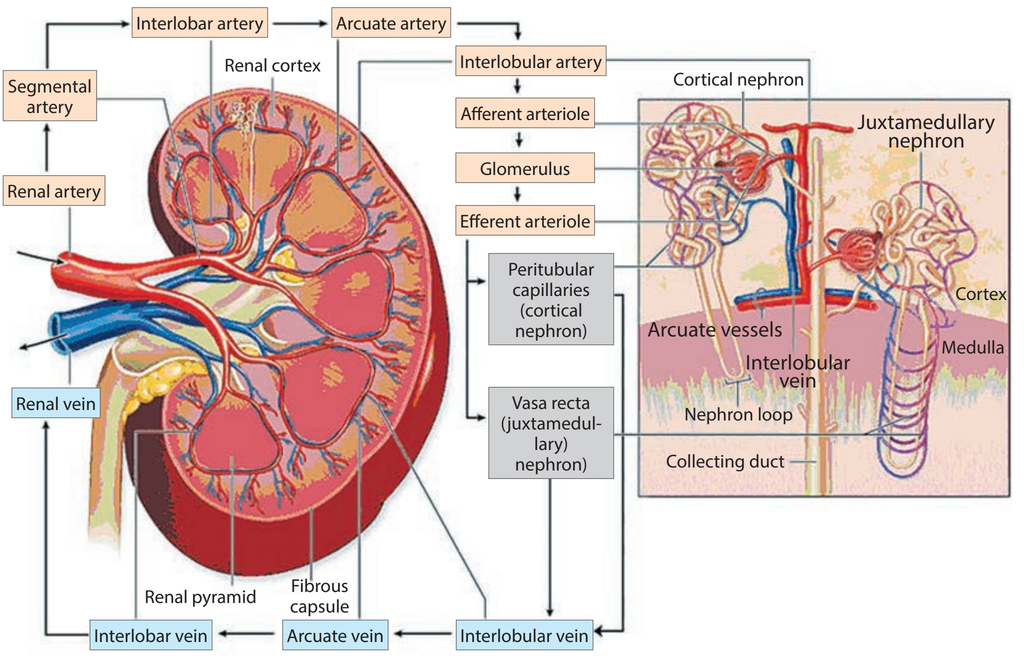


Fig. 13. The structure of the nephrons

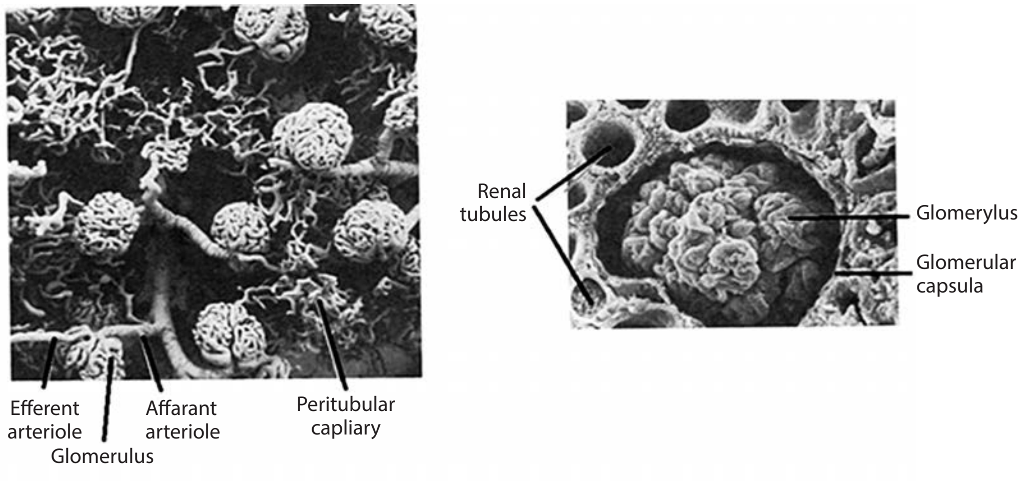


Fig. 14. A scanning electron micrograph (SEM) of a cast of the renal blood vessels associated with the glomeruli (×260) and SEM of a glomerular capsule

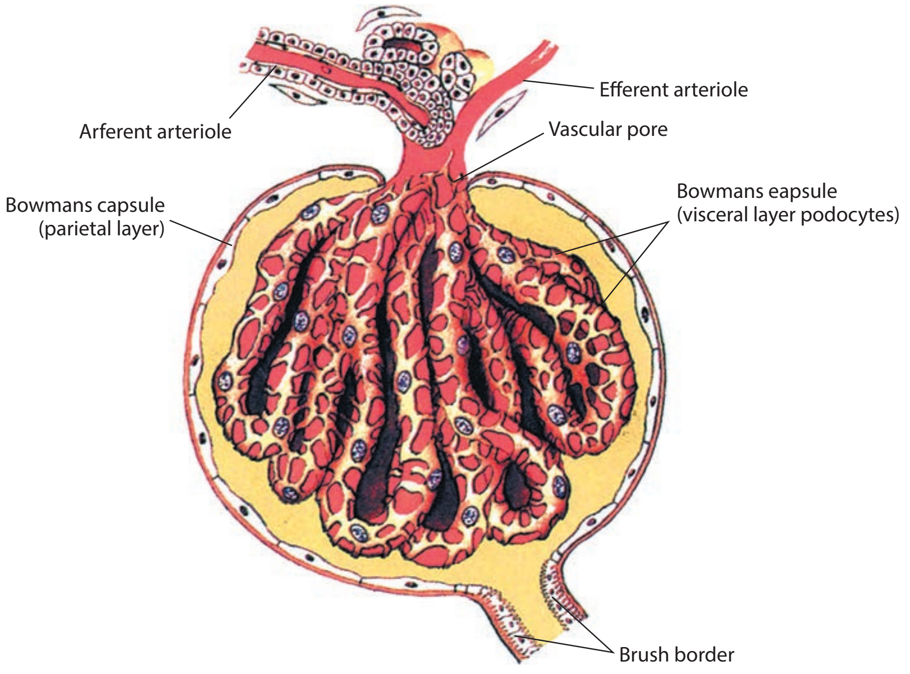


Fig. 15. Glomerulus and Bowman's capsule (renal corpuscle)

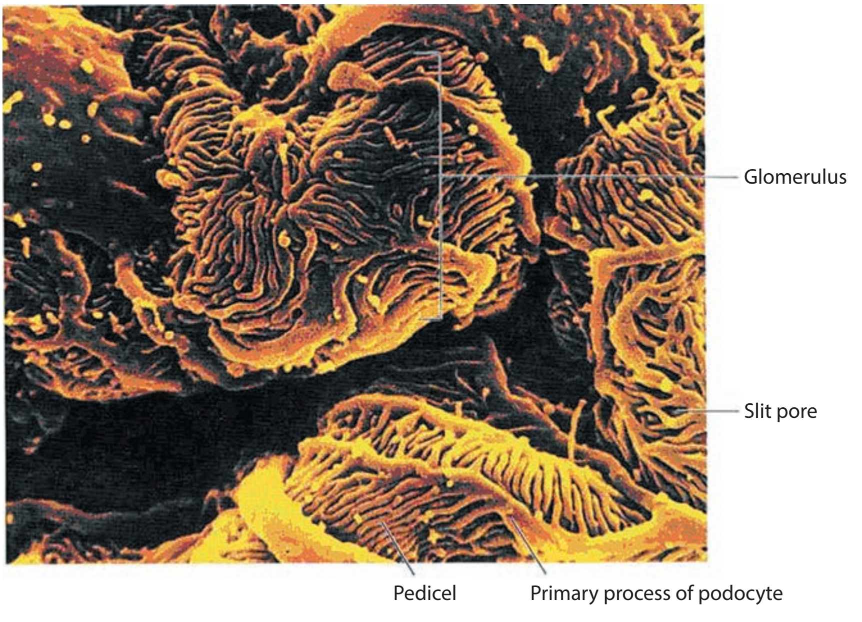


Fig. 16. Scanning electron micrograph of a glomerulus (×8.000).
Note the slit pores between the pedicels a complicated system of slit pores

Several distal convoluted tubules merge in the renal cortex to form a collecting duct, which, in turn, passes into the renal medulla, becoming larger and larger as it is joined by other collecting ducts. The resulting tube (papillary duct) empties into a minor calyx through an opening in a renal papilla (Fig. 17).

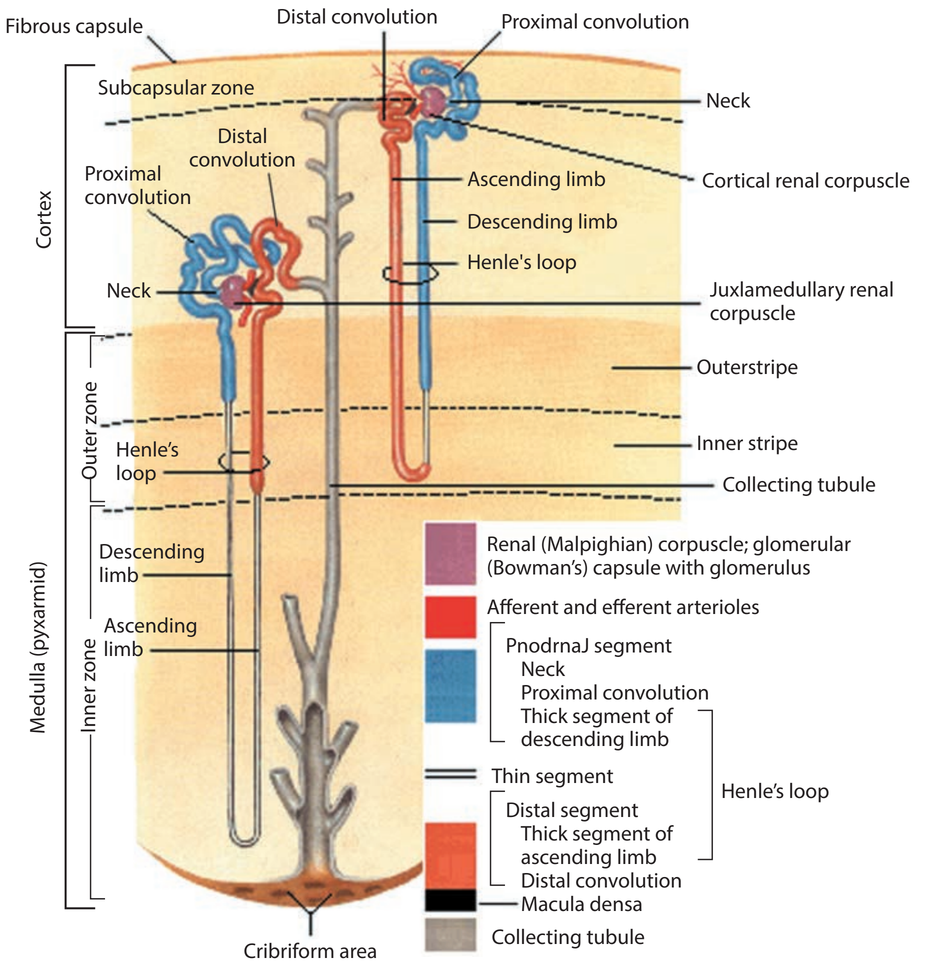


Fig. 17. Structure of a nephron and the blood vessels associated with it

Juxtaglomerular Apparatus

Near its beginning, the distal convoluted tubule passes between the afferent and efferent arterioles and contacts them. At the point of contact, the epithelial cells of the distal tubule are quite narrow and densely packed. These cells comprise a structure called the macula densa.

Close by, in the walls of the arterioles near their attachments to the glomerulus, are some large, smooth muscle cells. They are called juxtaglomerular cells, and together with the cells of the macula densa, they constitute the juxtaglomerular apparatus (complex). This structure plays an important role in regulating the flow of blood through various renal vessels (Fig. 18).

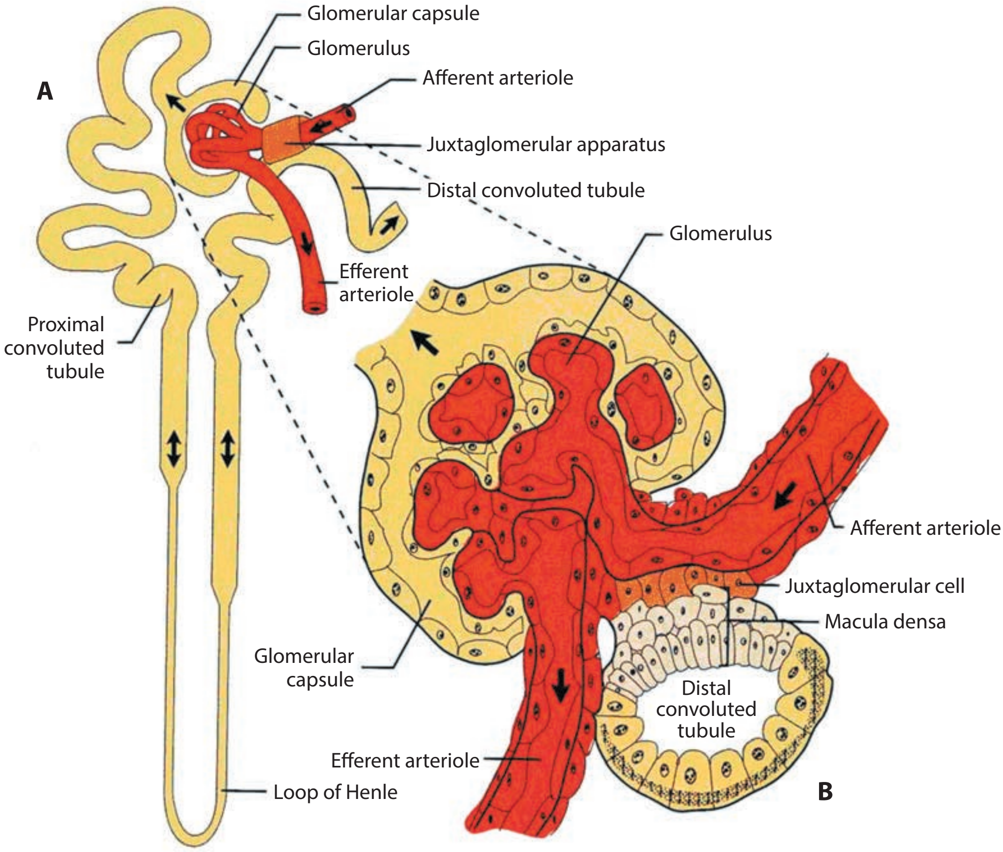


Fig. 18.
A – location of the juxtaglomerular apparatus. **B** – enlargement of a section of the juxtaglomerular apparatus, which consists of the macula densa and the juxtaglomerular cells

Types of nephrons

Depending on location the nephrons are subdivided into three groups as follows:

- the subcapsular nephrons (2–3 %), their glomeruli lie right under the capsule and the tubular portions (including the loop) lie within the renal cortex;

- the intermediate nephrons (80 %) that lie in the middle of the cortex, their loops reach the medulla;
- the juxtamedullary nephrons (18 %), which have large glomeruli lying adjacent to the medulla, their nephron loops descend deep to the medulla and reach apices of pyramids (Fig. 19).

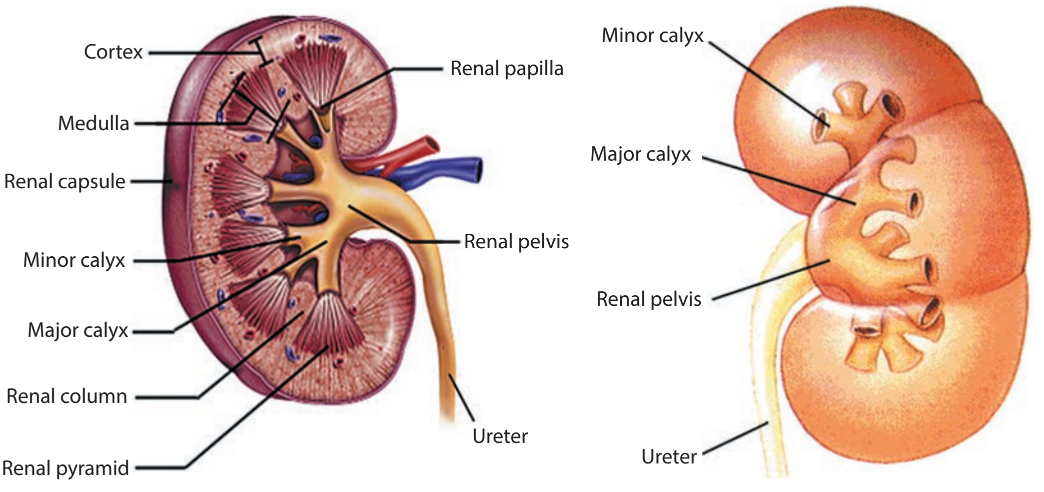


Fig. 19. Urine ducts

Clinical applications

Under conditions of rapid blood loss (e.g. in hemorrhagic shock) the small arterioles of outer nephrons contract leaving renal circulation to juxtamedullary nephrons. Blood circulation thus becomes restricted to the medulla. This may result in renal insufficiency though renal blood circulation remains undisturbed.

The most significant place among renal diseases belongs to tubular degeneration (nephrosis) and inflammatory diseases of glomerular tubular system (nephritis and glomerulonephritis). These pathologies often develop as complications of infectious diseases and intoxications. The branch of medicine that studies diagnostics and treatment of renal diseases is called nephrology. The renal calices, calices renales and the renal pelvis are related to the renal sinus. The calices are subdivided into the major and minor.

Sphincters. Walls of the calices and pelvis contain non-striated circular muscle fibers, which resemble sphincters. These sphincters reside in the fornix and pelvic outlet. The sphincters assist in forcing urine through the calices and pelvis and prevent urine backflow. Pathologies of calices and pelvis may result in urinary congestion. The calices and pelvis are the common places where renal stones (calculi) form. Dislodged stone may block the pelvis or ureter lumen. Very often, the stone-affected pelvis exhibits purulent inflammation complicated with nephritis (pyelonephritis). Passing stone causes severe pain called the renal colic. This state requires surgery. Recent treatment modalities include ultrasound techniques of stones fragmentation suitable for outpatient use.

Arterial blood is supplied to the kidney via paired renal arteries (the branches of abdominal aorta). Within the hilum, each artery splits into three branches to both poles and central part. In the parenchyme, these branches give interlobar arteries, *a. interlobares,* which run to renal cortex (Fig. 20). In the area of pyramids' bases, the

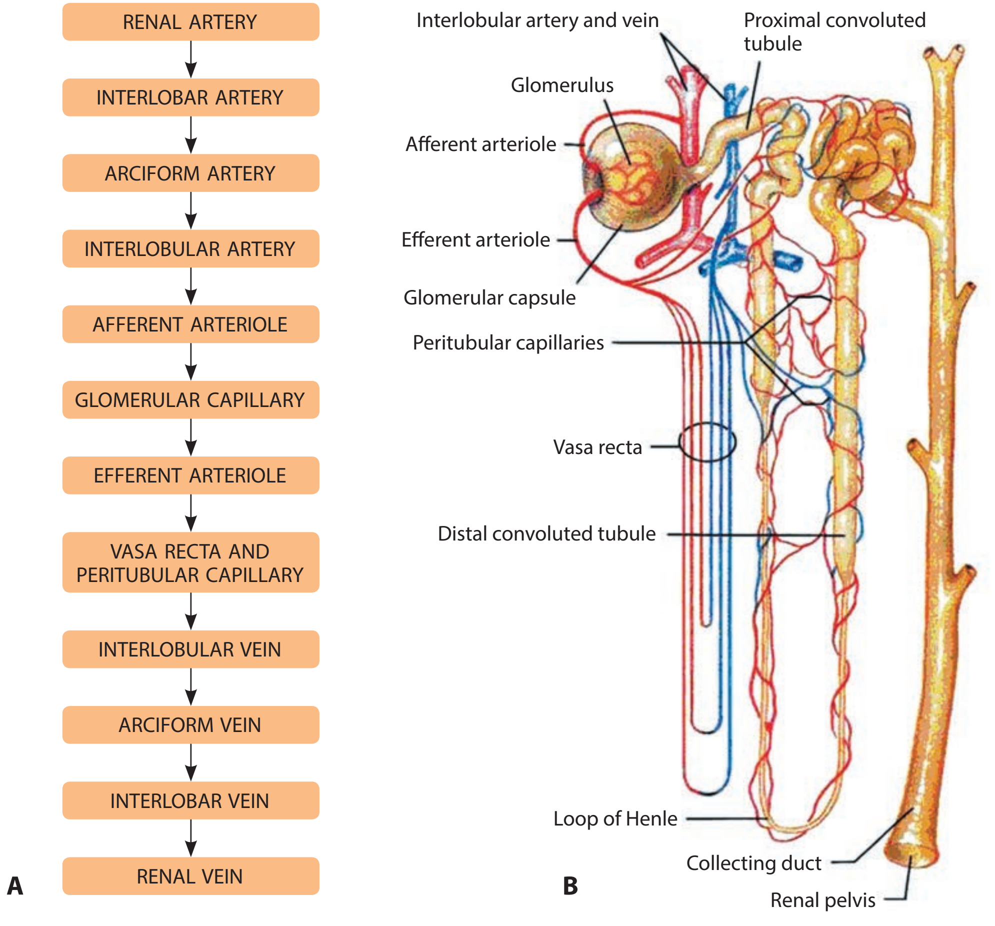


Fig. 20.

A – pathway of blood through the blood vessels of the kidney and nephron. **B** – the capillary loop of the vasa recta is closely associated with the loop of henle of a juxtamedullary nephron interlobar arteries pass into the arcuate arteries, a. arcuatae, which in turn give numerous branches to cortex and medulla. Cortex related branches are the cortical radiate arteries, *aa. corticales radiatae*, which give small branches to each renal corpuscle and larger afferent glomerular arteriole, arteriola glomerularis afferens. The afferent arteriole passes into the glomerular capillaries, which again collect into arteriole – the efferent glomerular arteriole, arteriola glomerularis efferens. The efferent arteriole eventually passes into capillary network, which collects into venous system. Medulla related branches are the straight arterioles, arteriolae rectae, which run along the renal tubules and join the capillary network.

The blood flowing within cortex thus passes the capillaries twice: in the glomerules, where it slows down to ensure proper filtration and in peritubular renal capillary network.

Venous system begins in renal cortex with the stellate veins, w.stellatae well distinguishable in sectioned kidney; in medulla, venous system begins with the straight venules, venae rectae. Further divisions of venous system simply accompany the arteries. Renal lobules and corpuscles lack lymphatic capillaries, which run only in interlobular connective tissue. The efferent lymphatic capillaries take their routes to the lumbar nodes, nodi lymphatici lumbales.

Innervation: branches of the renal plexus (plexus renalis), coeliac plexus, (plexus coeliacus) and the vagus nerve (nervus vagus).

Anatomical features of children's kidneys

In children:

- in kidneys of newborns and infants retain rather high lobulation, which disappears up to the age of 2–4 years old. The kidney of children is relatively larger in size and weight than the kidney of adults, their weight is 1/100 of body weight, whereas in adults – 1/200–1/230 of body weight. Newborns have the round kidney. Their length does not exceed a total height of the four bodies of the lumbar vertebrae. The right kidney is larger than the left. The width of an infant's kidney infants is 65 % of their length. With age, the growth of renal length is faster than the growth of the width. So that, the width of older children's kidney is about 50 % of the length of the body, as for adults it is only 30–35 % (Fig. 21);
- infants have their kidneys at the level of the IVth lumbar vertebrae, where as an older children, as adults have kidneys between the XIth thoracic and the IVth lumbar vertebrae. Relatively low position of the kidneys in children determined to 7–8-year-olds. In addition, the kidneys are placed in a way that their lateral edges are turned a little posteriorly, while their medial edges are placed a bit forward;
- adipose capsule is absent in infants;
- infants have very thin fibrous capsule, which is directly adjacent to the parenchyma;

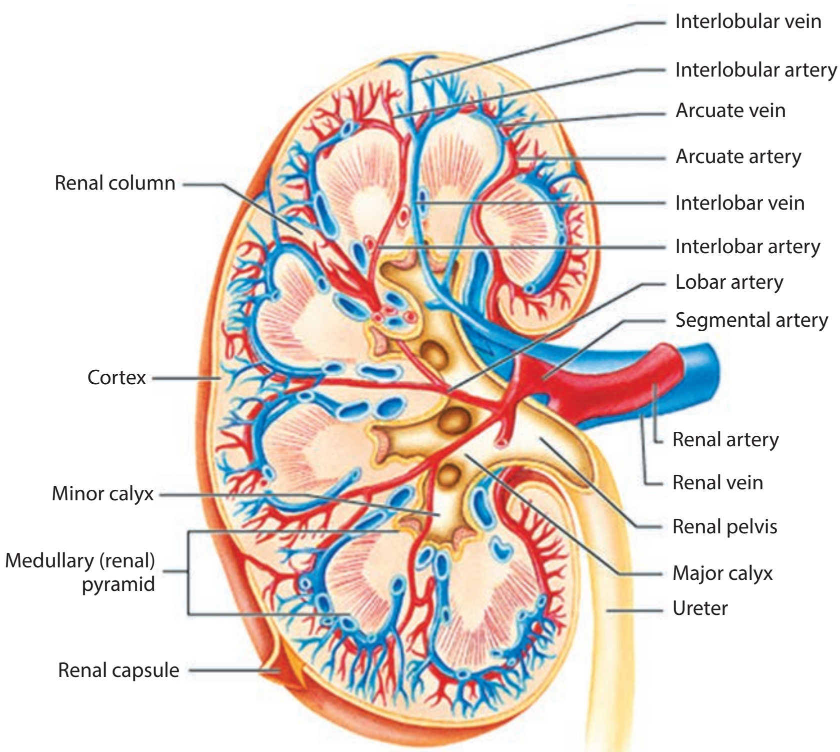


Fig. 21. The internal structure of the kidney

- fixing apparatus of infants and young children is not developed enough, which leads to greater physiological mobility of the kidneys. The kidney of newborns corresponds to the height of the body of one lumbar vertebrae and in average it is about 1–2 cm. In children of early years, the kidney may be available for palpation due to their increased mobility and correspondingly low position. The mechanism of kidney's fixing ends by the age of 5–8 years old. The kidney displacement in a child of 1.5 and greater than the height of the lumbar vertebrae down favors pathological mobility of the kidney (nephroptosis);
- in postnatal onthogenesis nephrons remain morphological signs of immaturity. In particular, the glomeruli at the moment of birth are poorly differentiated and have a small diameter of 85 mm, whereas in adults it is about 200mm. Glomerular epithelium is not flat as in adults, but cylindrical. Tubules relatively short in length and the diameter is half of adult tubules. The loop of Henle is underdeveloped and looks like a small curl. These features of the structure of the nephrons in young children influence the functionality of the kidneys. The features of the anatomical and histological structure of the children are not specific to the kidney, but also to the urinary tract;

- the kidneys of infants and young children are unable to concentrate urine and conserve water as effectively as those of adults. Consequently, such young persons produce relatively large volumes of urine and tend to lose water rapidly, which may lead to dehydration;
- renal pelvises in newborn and infants are relatively large in size, the walls are weakly developed, and hypotonic due to poor development of muscle and elastic fibers. The mentioned features can favor the stagnation of urine and the appearance of inflammatory processes.

Developmental anomalies of kidneys

Incidence and clinical significance. Kidney development features complex processes (two different primordias, kidney ascent etc.) so renal malformations incidence constitutes 1 % of all occurrences in neonates. Some anomalies are asymptomatic and remain undiagnosed throughout the life while some require immediate treatment. Studying of renal malformations thus is of great significance for urology (Fig. 22).

Number anomalies. Absence of primordia or growth failure results in unilateral or bilateral renal agenesia (complete absence). Bilateral agenesia is a fatal pathology, while unilateral agenesia or underdevelopment is more common. It becomes important in cases when pathology develops in the single kidney.

Double kidney is another common deformity, which results from unilateral formation of two ureteric buds. The kidney as a rule is enlarged and has two functional ureters. Less common is the smaller accessory (third) kidney.

Size anomalies. Unilateral reduction (hypoplasia) of one kidney as a rule combines with enlargement (hyperplasia) of the contralateral organ. Bilateral hypoplasia is uncommon and features severe malfunctioning.

Number anomalies and position anomalies of the renal arteries. In this group, additional renal arteries are the most frequent. It has a smaller diameter and goes to the upper or lower segment of the kidney from the abdominal aorta or from the trunk of the kidney, suprarenal, common iliac arteries. Additional renal arteries can be six or more. They are one of the main causes of violation of urodynamics and development of hydronephrosis. Additional arteries can be found in 21.4 % of patients operated because of hydronephrosis. The main clinical sign of additional vessels of the lower pole of the kidney is the pain syndrome of varying intensity (attack of renal colic), complicated by pyelonephritis. Diagnosis of additional vessel can be based on X-ray and other methods. The treatment should be surgical.

Double kidney artery. Kidney is supplied with blood by two identical diameter arteries. One of the two renal artery lies behind the pelves. It branches into the form of a network. The pelves is blocked by the renal artery and its branches of a large diameter. This can prevent from removing of the stone through an incision in the back of the kidney.

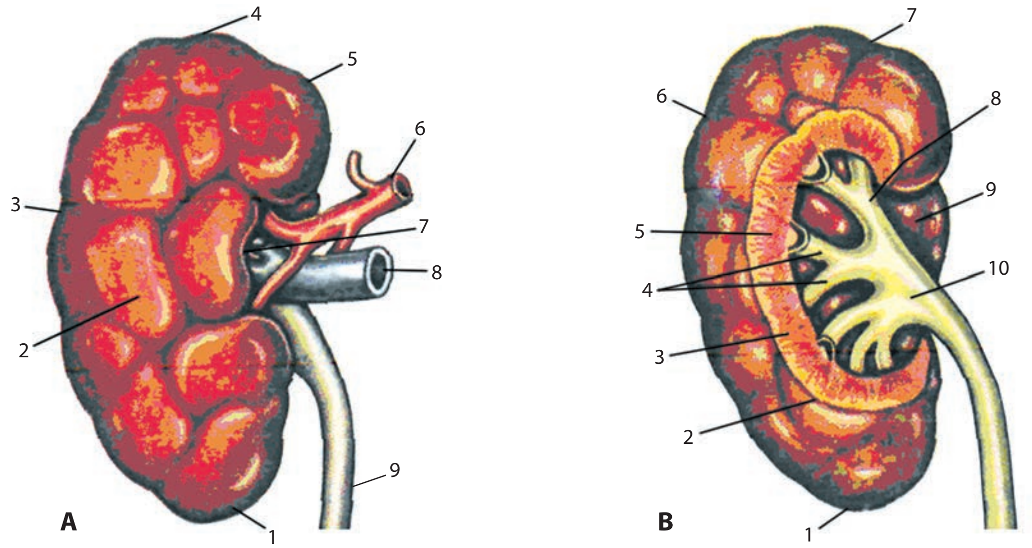


Fig. 22. The right kidney of a newborn. (Anterior surface).

A: 1 – the lower end (extremitas inferior); 2 – anterior surface (facies anterior); 3 – lateral margin (margo lateralis): 4 – the upper end (extremitas superior); 5 – medial border (margo medialis): 6 – renal artery (a. renalis); 7 – renal hilum (hilus renalis); 8 – renal vien (v. renalis); 9 – ureter (ureter).
B: 1 – the lower end (extremitas inferior); 2 – kidney's cortex (cortex renalis); 3 – renal column (columnae renales); 4 – minor renal calyx (calices renales minores); 5 – renal pyramids (pyramides renales); 6 – lateral margin (margo lateralis): 7 – the upper end (extremitas superior); 8 – major kidney calyx (calices renales majores); 9 renal sinus (sinus renalis); 10 – renal pelvis (pelvis renalis); 11 – ureter (ureter)

Multiple kidney arteries. There are common for the kidney in a shape of a horseshoe and other types of dystopia kidney, but can also occur in the normally developed kidney. Renal artery aneurysm are also corresponded to the anomalies of shape and structure of the renal arterial trunks. Renal artery aneurysm is represented in the shape of sack or fusiform enlargement of the vessel. Moreover, they are of an unilateral. Aneurysms have a certain symptomatology detected in 60–80 % of cases (Fig. 23).

The absence of the kidneys on both sides is incompatible with life. The absence of one kidney or hypoplasia are frequent and have important clinical implications in cases where only one pathologic process develops in the kidney (Fig. 24).

The doubling of the kidneys also happens quite often, it is associated with two ureteral outgrowths on one side (Fig. 25, 26). Such a kidney is enlarged and has 2 ureters.

Rare anomaly is the presence of an extra (third) kidney, which is much smaller by size (Fig. 27).

The abnormal sizes. Decrease (hypoplasia) of the size of one kidney with its normal structure usually combines with an increase (hyperplasia) of the opposite kidney.

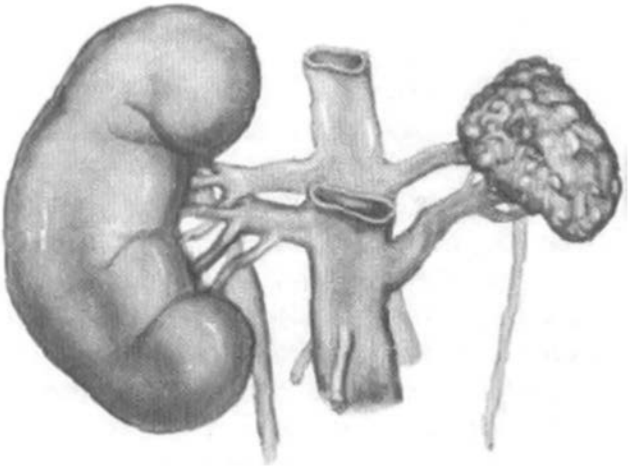
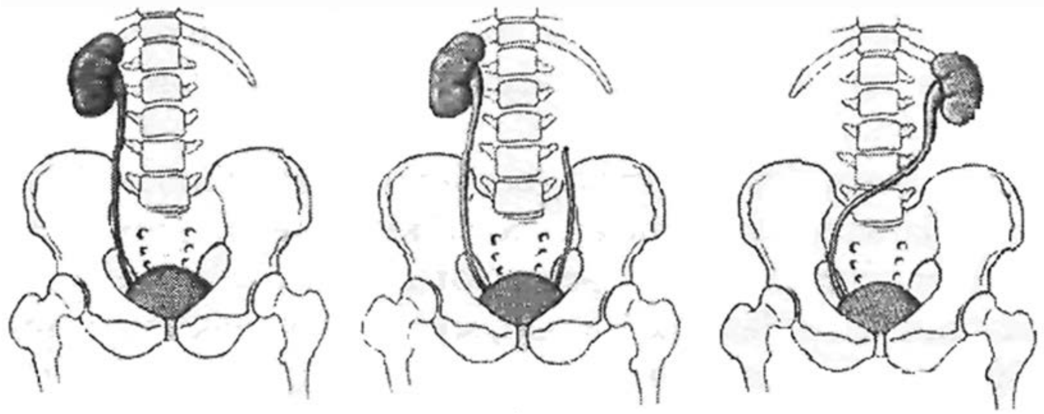


Fig. 23. Aplasia of the left kidney



A B C

Fig. 24. Variants of agenesis and aplasia of the left kidney.
A – agenesis with absence of ureter. **B** – aplasia with the presence of a rudimentary ureter. **C** – crossed dystopia of the right kidney with agenesis of left kidney

Hypoplasia of both kidneys includes severe disruption of their functions, which is rather uncommon.

Shape and position anomalies. Abnormal position (ectopia) constitutes 25 % of all congenital anomalies. Ectopia may be unilateral and bilateral. Lumbar and iliac ectopias are the most common types of abnormal position of kidneys. Pelvic ectopia occurs as the result of complete ascent failure. Abnormal position usually combines with deformities and incomplete rotation (Fig. 28, 29).

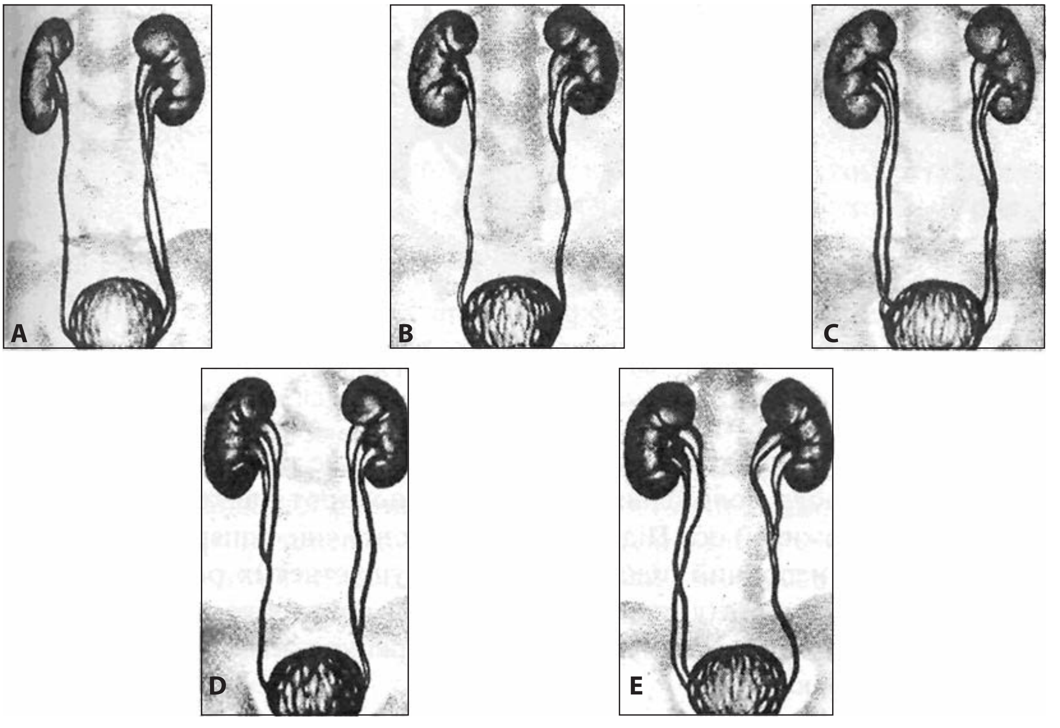


Fig. 25. Variants of a double kidney and ureter.

A – full doubling of the left pelvis and ureter. **B** – doubling of the the left pelvis with splitting of the ureter. **C** – bilateral doubling of pelvises and ureters. **D** – bilateral doubling of pelvises and ureters splitting. **E** – bilateral doubling of pelvises, doubling of the right ureter and splitting of the left one

The kind of dystopia determines the blood supply of the kidney. The vessels of lumbo-dystopic kidney are placed normally, but more often they can be doubled and originate from the aorta, from the level of the second lumbar vertebra before the bifurcation of the abdominal aorta (Fig. 30).

If the kidney is above the sacrum bone or in the pelvic cavity, the vessels may deviate from the common iliac and the external iliac, median sacral or inferior mesenteric arteries. The arteries are accompanied by corresponding veins. Kidney dystopia combined with anomalies of genital organs.

Intrathoracic dystopia of a kidney is very rare and is called epiphrenic dystopia. A healthy kidney is placed above the diaphragm and it is not clinically detected.

Pelvic dystopia is characterized by deep-seated kidney positioned in the pelvic cavity. It can be placed in the sacral groove. In these cases, the fatty tissue, sacral nervous plexus, pyramidal and sacrococcygeal muscle are located between the sacral bone and the kidney (Fig. 31, 32).

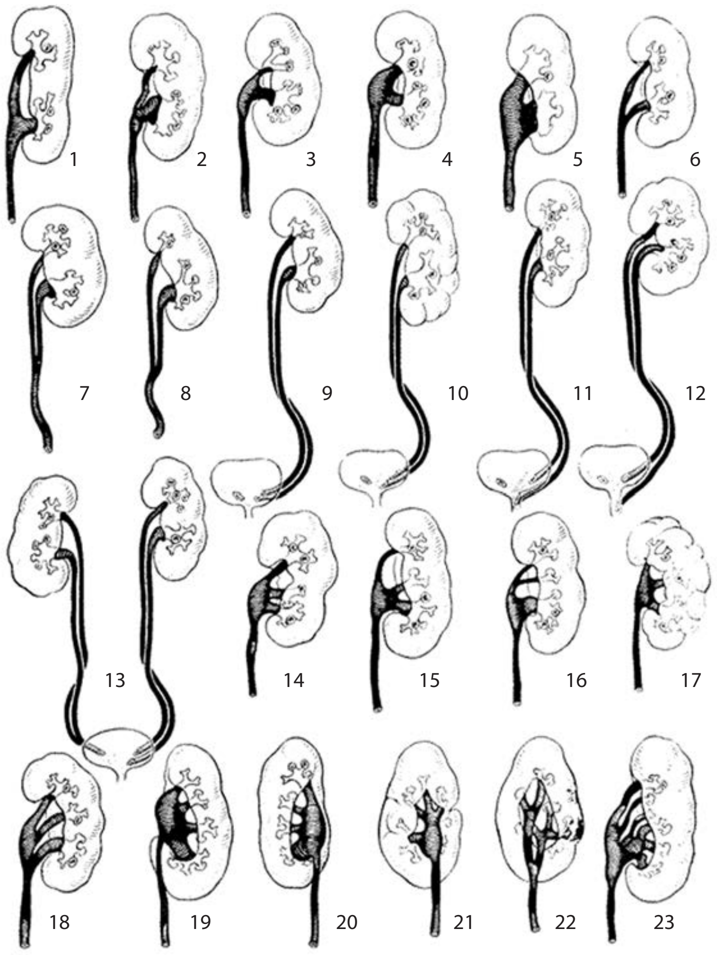


Fig. 26. Common variants of kidney doubling and renal pelvises

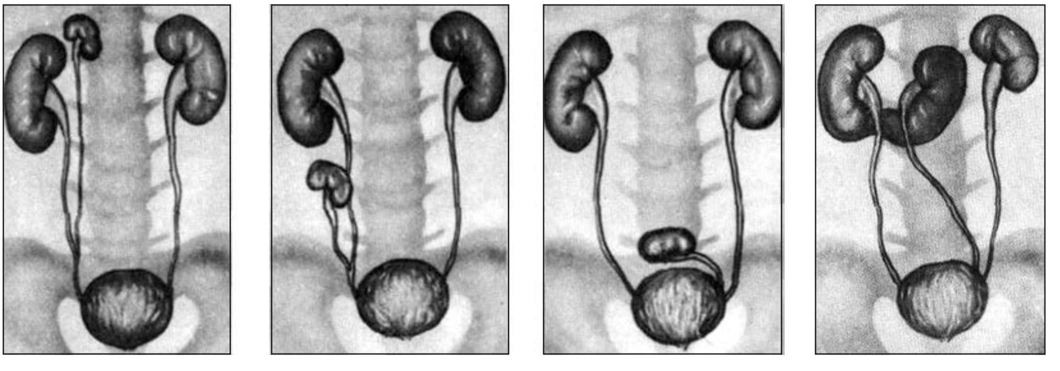


Fig. 27. Schemes of an additional (third) kidney localization

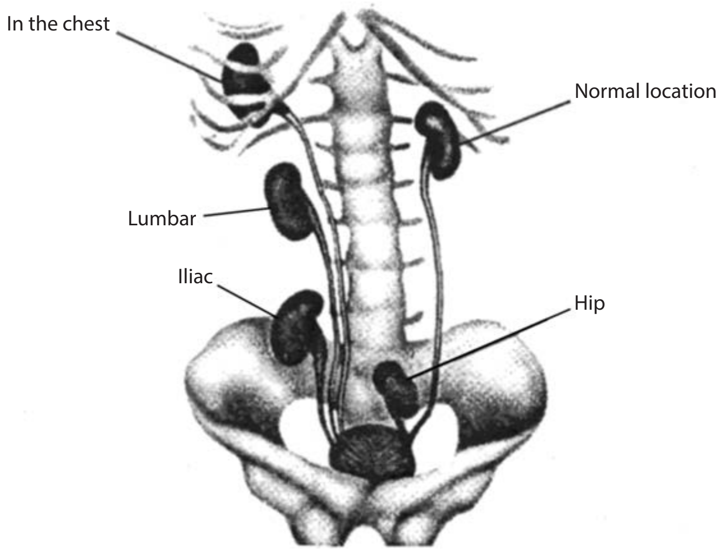


Fig. 28. Variants of kidney dystopia

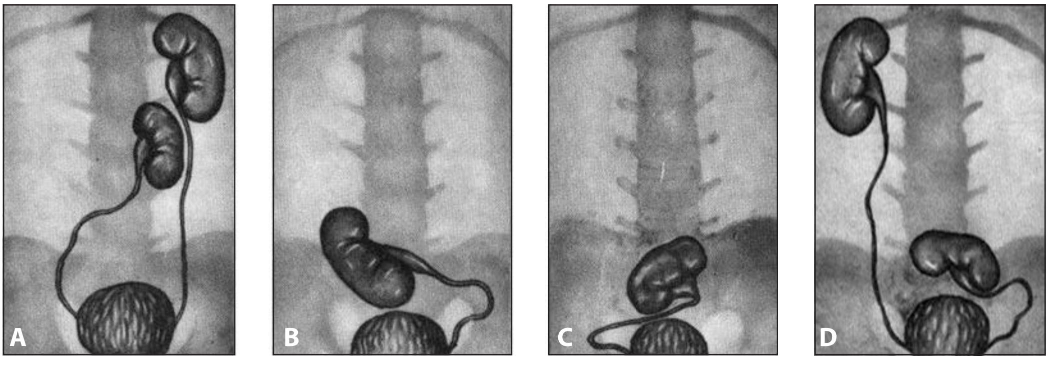


Fig. 29. The anomalies of kidney position.
A – heterolateral dystopia. **B** – cross iliac dystopia of the one kidney. **C** – pelvic dystopia of one kidney. **D** – pelvic dystopia

In severe pelvic kidney dystopia, the kidney is located between the rectum and the bladder in men and between the uterus and rectum in women. The upper pole of the kidney is covered by peritoneum, and the lower one is on the pelvic diaphragm, and the middle part of the kidney is bordered with the prostate gland in men or the back of the vagina in women. Pelvic dystopia can be uni- or bilateral. At bilateral dystopia it is possible the fusion of the kidneys. The form of the kidney can be round, flattened, galette-like and partial (Fig. 33).

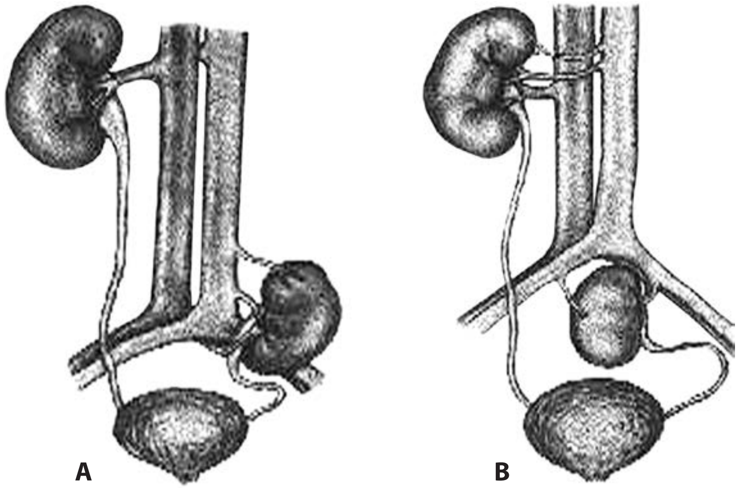


Fig. 30. Variants of the blood supply of the anomalously located kidneys.
A – iliac dystopia of the left kidney. **B** – lumbar dystopia of the right kidney and pelvic dystopia of the left kidney

Kidneys fusion. Fusion of two renal primordia results in formation of single organ with two ureters. Most common is fusion of inferior poles called horseshoe kid-

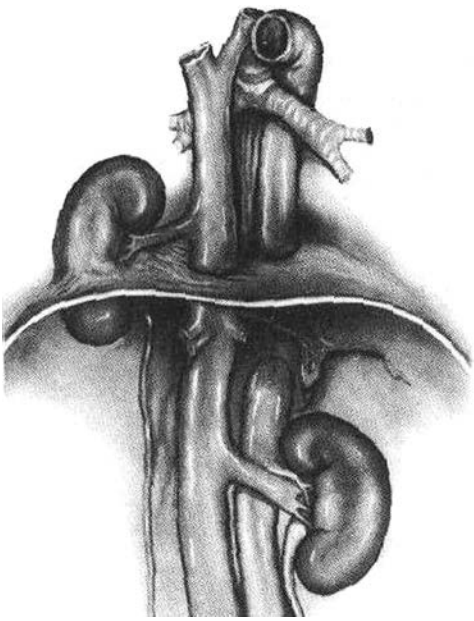


Fig. 31. Intrathoracic dystopia of the right kidney

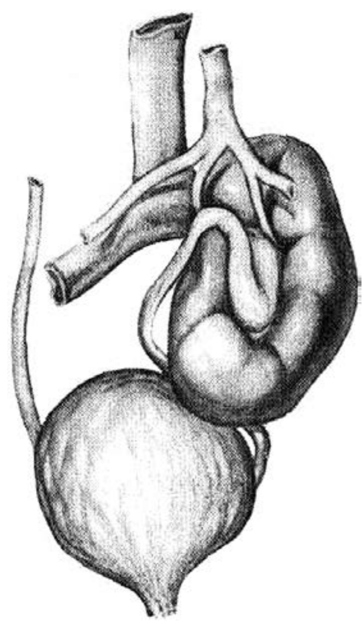


Fig. 32. Pelvic dystopia of the left kidney

ney (90 % of all occurrences). This malformation as a rule is associated with lumbar or pelvic ectopia. Less common are rosette kidney, S-shaped kidney, L-shaped kidney, hook-like kidney, etc (Fig. 34–36).

Multicystic kidney.This is a rare anomaly which amounts to 1.1 % of all the anomalies of the kidney (Fig. 37). This anomaly is characterized by a total replacement of the renal parenchyma by cystic formations. In 50 % of cases older children and adults in the projection multicystic kidney can be determined by round shadows, calcified cysts in the X-ray.

Polycystic kidney disease. This is a severe abnormality of both kidneys, which is characterized by replacement of renal parenchyma by multiple cysts of different sizes (Fig. 38). There are two forms of polycystic kidney disease: the first one with increasing dimensions of the kidney (detected more often) and second one with no increasing or with some decreasing size of the kidneys.

Neonatal polycystic manifests during the first month of life cause a progressive renal and the pulmonary failure of both kidneys. For polycystic process of infants, in general it is characterized by increasing of both kidneys, splenomega-

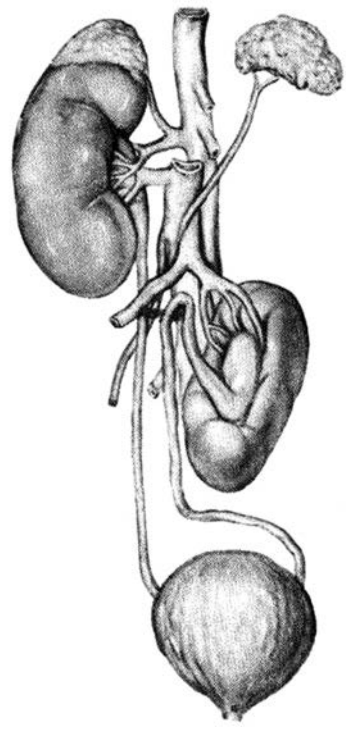


Fig. 33. The right kidney is located on the usual place. Pelvic dystopia of the left kidney. Ureter of the left kidney is compressed by one of the numerous branches of the renal artery

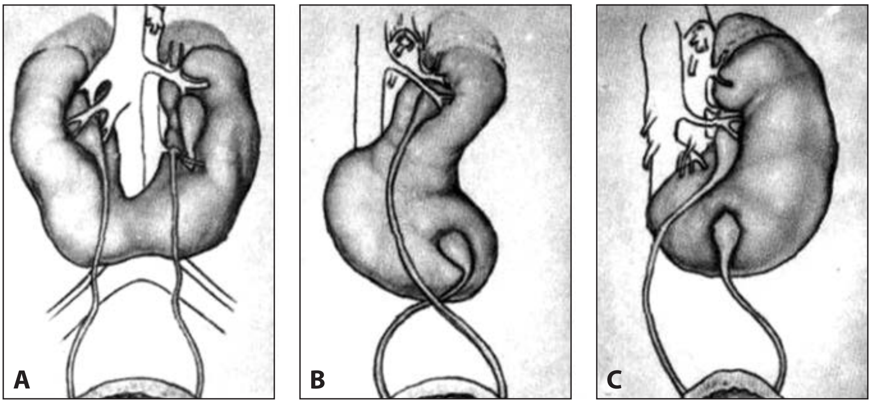


Fig. 34. Anomalies of kidney interposition.
A – horse-shoe kidney. **B** – S-shaped kidney. **C** – L-shaped kidney

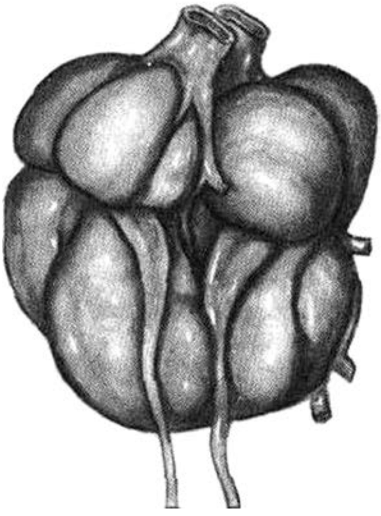


Fig. 35. A galette-shaped kidney

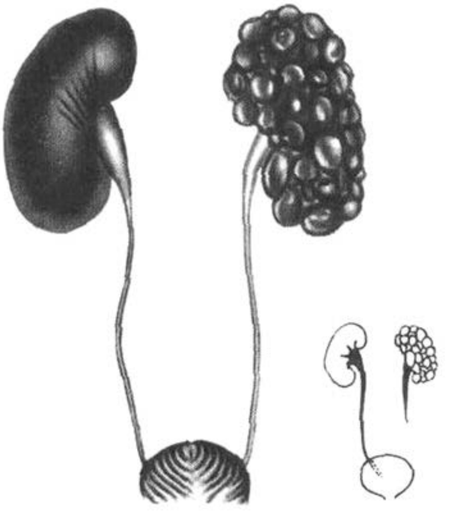


Fig. 37. Multicystic kidney

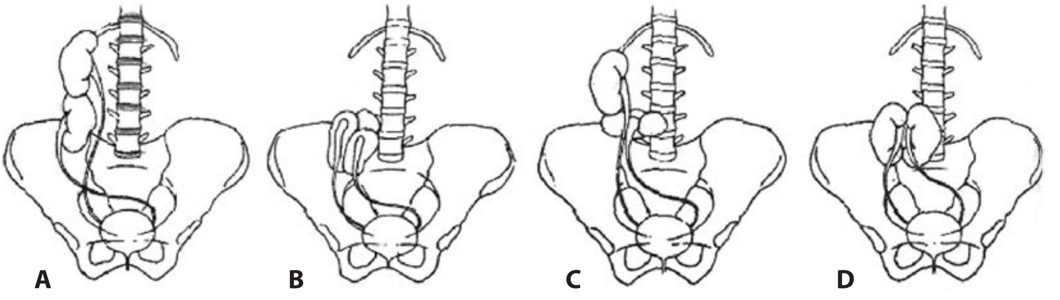


Fig. 36. Anomalies of kidney interposition.
A – S-shaped. **B** – tumor-shaped. **C** – L-shaped. **D** – disk-shaped

ly, liver failure, and progressive chronic renal failure. According to this anomaly the 25 % of the tubules replaced cysts. At polycystic kidney in adolescence parenchyma is not changed, and about 10 % of the tubules are affected by cystic dysplasia. In older children polycystic kidneys are small and have heavily tuberous surface with cysts ranged through the fibrous capsule. On a section kidney parenchyma is dotted with lots of cysts of varying size (Fig. 39).

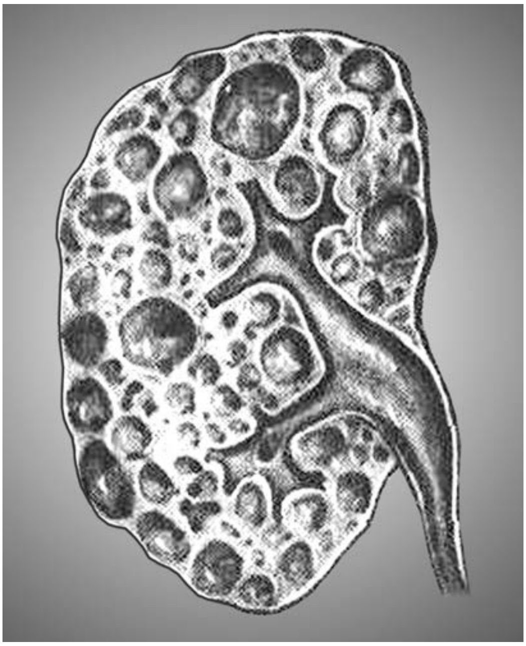


Fig. 38. Polycystic kidney

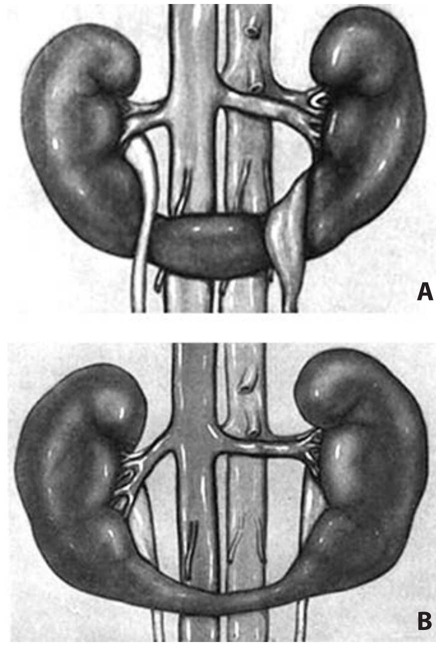


Fig. 39. A horseshoe kidney with wide isthmus (**A**), which compresses the urethra and narrow (**B**) of the isthmus

Elimination of Urine

After being formed by nephrons, urine passes from the collecting ducts through openings in the renal papillae and enters the major and minor calyces of the kidney. From there it passes through the renal pelvis and is conveyed by a ureter to the urinary bladder. Urine is excreted to the outside by means of the urethra.

THE URETER, URETER

The ureter connects the renal pelvis with the urinary bladder. It is 30 cm long, 5–6 mm of diameter and lies extraperitoneally (i.e. devoid of peritoneal investment).

Relative positioning of ureters. Each ureter has three parts:

- **the abdominal part,** pars abdominalis;
- **the pelvic part,** pars pelvica;
- **the intramural part,** pars intramuralis.

The abdominal part is 12–15 cm long; it runs along the anterior surface of the quadratus lumborum on each side. Relations of the abdominal parts of ureters are not identical. Upon leaving the sinus, the right ureter runs posterior to the descending part of duodenum and the left runs posterior to the duodenojejunal flexure. Running on, both ureters cross either ovarian (in females) or testicular vessels (in males). In the lowermost portion of abdomen, the right ureter runs posterior to the root of mesentery while the left runs posterior to the of sigmoid mesocolon. The pelvic part is 13–14 cm long. Relations of these parts are side-independent but sex-related. Entering the pelvic inlet the right ureter crosses the right external iliac artery and the left crosses the left common iliac artery (Fig. 40).

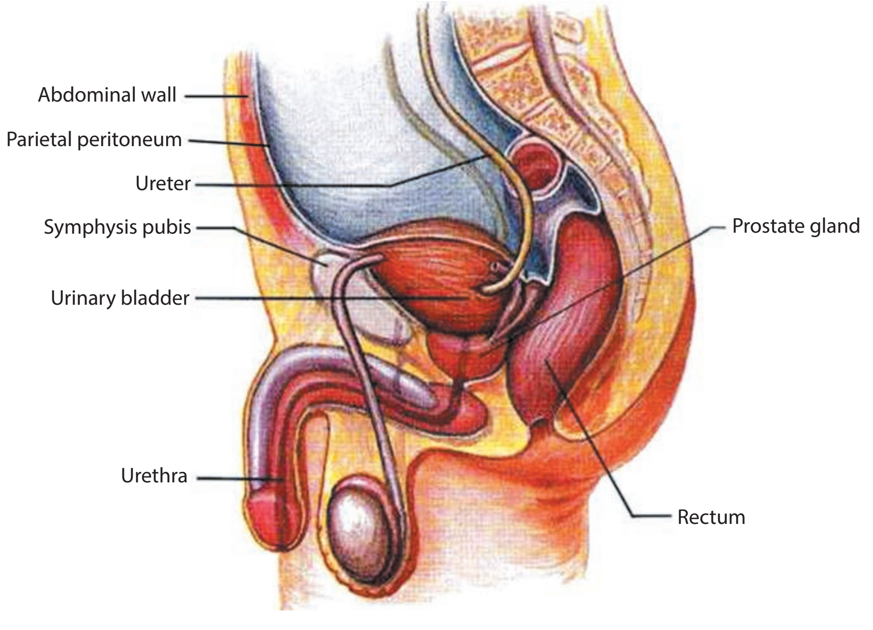


Fig. 40. Relations of pelvic viscera and perineum in male (sagittal section)

In females, the ureters run posterior to the broad ligament of uterus and then along the free border of ovary. Laterally to the cervix of uterus, the ureters loop around the inferior border of the broad ligament cross the uterine vessels at a right angle and pass between the anterior wall of vagina and the urinary bladder to reach the fornix of the latter posteriorly.

In males, the ureter on each side runs laterally to the ductus deferens then crosses it inferiorly to enter the bladder wall anteroinferiorly to the seminal vesicle.

The intramural part is 1.5–2 cm long; it takes a skewed route through the bladder wall to open in the fundus of bladder with slit-like orifice.

The constrictions of ureter. First constriction appears at the junction of the ureter and renal pelvis, the second – where it enters the lesser pelvis (at the terminal line) and the third – within the urinary bladder wall. Renal stones often lodge in these constrictions. The segments between the constrictions are somewhat dilated.

Layers of ureter wall. The layers distinguishable in the ureter wall are like the following: 1) the mucosa and submucosa; 2) the muscular layer and 3) adventitia (Fig. 41).

The mucosa forms small longitudinal folds and contains mucous glands and solitary lymphatic nodules. The muscular tunic consists of external longitudinal and internal circular layers. The lower portion features the third internal longitudinal layer. Within the bladder wall, the muscular fibers run spirally. Contracting, the muscles cause ureter orifices to open.

Fig. 41. Cross section of a ureter (× 160)

Arterial blood is supplied to the ureters from three sources:

- the ureteric branches (rr. ureterici) from renal, testicular (or ovarian) arteries supply the superior parts of ureters;
- branches of the same name arising from the internal iliac artery and abdominal aorta supply middle part of the organs;
- ureteric branches of the inferior vesical arteries (a. vesicales inferior) and middle rectal artery (a. rectalis media) supply inferior parts of the organs.

Lymph drains into lumbar and iliac lymph nodes.

Innervation: branches of renal and inferior hypogastric plexuses and the vagus nerve.

Clinical applications

Because the linings of the ureters and the urinary bladder are continuous, infectious agents such as bacteria may ascend from the bladder into the ureters. An inflammation of the bladder, which is called cystitis, occurs more commonly in women than m men because the female urethral pathway is shorter. An inflammation of the ureter is called ureteritis.

Although the ureter is simply a tube leading from the kidney to the urinary bladder, its muscular wall helps move the urine. Muscular peristaltic waves, originating in the renal pelvis, force the urine along the length of the ureter. These waves are initiated by the presence of urine in the renal pelvis, and their frequency is related to the rate of urine formation. If the rate of urine formation is high, a peristaltic wave may occur every few seconds; if the rate is low, a wave may occur every few minutes. When such a peristaltic wave reaches the urinary bladder, it causes a jet of urine to spurt into the bladder. The opening through which the urine enters is covered by a flaplike fold of mucous membrane. This fold acts as a valve, allowing urine to enter the bladder from the ureter but preventing it from backing up from the bladder into the ureter.

If a ureter becomes obstructed, as when a small kidney stone (renal calculus) is present in its lumen, strong peristaltic waves are initiated in the proximal portion of the tube. Such waves may help move the stone into the bladder. At the same time, the presence of a stone usually stimulates a sympathetic reflex (ureter- orenal reflex) that results in constriction of the renal arterioles and reduces the production of urine in the kidney on the affected side.

Kidney stones, which are usually composed of calcium oxalate, calcium phosphate, uric acid, or magnesium phosphate, sometimes form in the renal pelvis. If such a stone passes into a ureter, it may produce severe pain. This pain commonly begins in the region of the kidney and tends to radiate into the abdomen, pelvis, and legs. The pain may also be accompanied by nausea and vomiting. Although about 60 % of kidney stone patients pass their stones spontaneously, the others must have the stones removed. In the past, such removal required surgery or tubular instruments that could be passed through the *tubes of the urinary tract and used to capture or crush the stones. More recently, kidney stones have often been fragmented by shock waves generated outside the body. The resulting sandlike fragments can then be eliminated with the urine. This procedure, called extracorporeal shock-wave lithotripsy (ESWL), involves placing the patient in a stainless steel tub filled with water. The shock waves are produced underwater by a spark-gap electrode, and the waves are focused on the stones by means of a reflector that concentrates the shock-wave energy.*

In children:

- in infants the length of ureters can be about 5–7 cm, and during the first years of life it increases to 13–15 cm. In children and adults the left ureter is 2–3 cm longer than the right one;
- newborn ureters have are 5–7 cm long. At the age of 6 months old the ureter reaches 9.1 cm, and at the age of two years – 12 cm, at the age of 4 years old – 15 cm. The ureters of young children are long enough and wider than those of adults. They are twisted, elements of the muscle tunic are mild and elastic fibers are absent, as a result their wall is atonic. The mucous membrane of the ureters has folds, which disappear only at the end of the first year of life. These features also favor the emergence of inflammatory processes, and are also the basis for the development of megalouretera and hydronephrosis;
- another important clinical implication concerning the structure of the distal, intramural segment and intravesical segment, which is located in the submucosal layer of the bladder and considered to be essential. In infants this segment is very short and the length of the intravesical segment does not exceed 0.5 cm. With age, the length of this segment increases, reaching a maximum size of 1.5 cm by the age of 10–12 years old. It is believed that a short intravesical ureteral segment can influence the development of vesicoureteral reflux, i.e. reverse throwing urine in the ureter, and even pelves;
- in newborns ureteral valves do not break the flow of urine because of the big diameter of ureter. At the age of 4 months, old valves tend to disappear. Slow reduction of these structures, maintaining valves at older age can lead to a violation of the urine flow. These disorders begin to develop during the second or third years of life and lead to the development of hydronephrosis or ureterohydronephrosis.

Ureters anomalies

The basis of classification involves outward signs: the number of ureters, their shape and diameter.

Anomalies of the number include aplasia, doubling, trippling (complete and incomplete) (Fig. 42, 43).

Anomalies of position. Retrocavall ureter, retroiliac ureter, ectopic ureteral orifice.

Anomalies of form. Annular and spiral ureter.

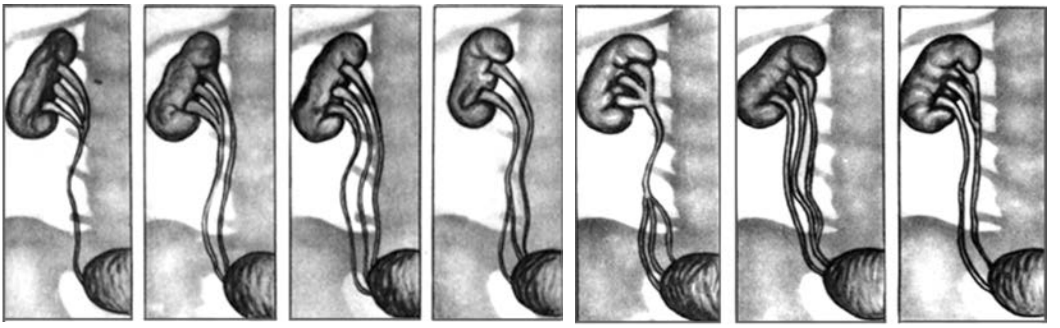


Fig. 42. Anomalies of the ureter number

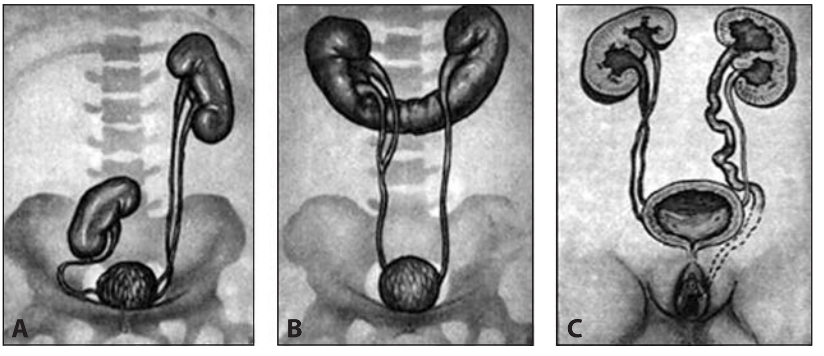


Fig. 43. The combination of ureter doubling with other abnormalities.
A – the doubling of the left kidney and ureter in combination with iliac dystopia of the right kidney. **B** – the splitting of the right ureter of the horseshoe-like kidney. **C** – the doubling of the kidneys and ureters in conjunction with the ectopy of the orifice of the left ureter

Anomalies of structure. Hypoplasia, neuromuscular dysplasia, achalasia, megaloureter, gidroureteronephrosis, valves, diverticula, ureterocele.

Aplasia (agenesis) is found in 0.2 % of patients with abnormalities of the kidneys. Aplasia of the ureters – the result of a lack of development of the germ of the ureter.

The ureter doubling is an anomaly that is detected in 1 of 140 newborns. The occurrence of this anomaly is due to the simultaneous growth of the two ureters from two ureteral nephrogenic blastomas or splitting of a single ureteral germ. Doubling of the ureter (complete and incomplete) happens as unilateral more often.

On the right – retrokaval ureter, on the left – bilateral retroiliac ureterohydronephrosis.

Retrokaval ureter is a rare anomaly of development (Fig. 44). The upper third of the right ureter spirally covers the inferior vena cava.

Retroiliacal ureter is also a rare anomaly. In this case, the ureter is located behind the iliac vessels.

Ectopic ureteral orifice is an abnormal location of one or both of the orifices of the ureters in the bladder or extravesical position (Fig. 45).

Hypoplasia of the ureter is usually combined with hypoplasia of the kidney, polycystic kidney.

Neuromuscular ureteral dysplasia is one of the very severe abnormalities of the upper urinary tract. The basis of congenital ureteral expansion is insufficient development of the neuromuscular system of the ureter, functional or organic obstruction that is located at the prebladder (juxtavesicale) or intramural ureter.

Ureteral stenosis occurs in 0.7 % of children who can be in any part of the ureter, but more often in vesical-ureteral segment.

Ureteral valves are doubling mucosa. Sometimes valves are formed of all layers of the wall of ureter.

In newborns, ureteral valves do not break the flow of urine because of the big diameter

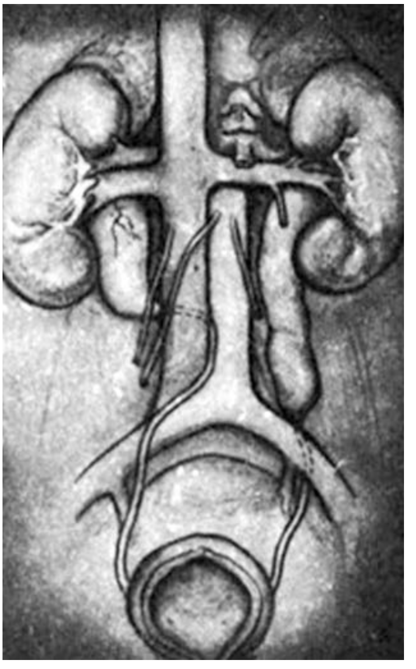


Fig. 44. Anomalies of ureter position

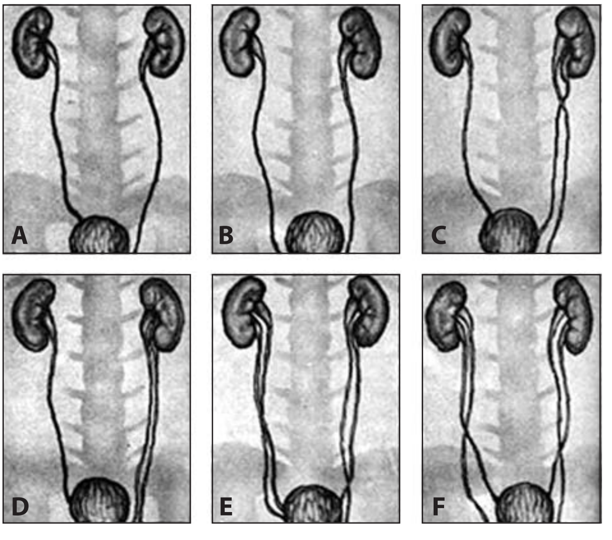


Fig. 45. Types of the ectopic ureter orifices.

A – the orifice of one of the ectopic ureter. **B** – retrovesical ectopic ureter orifices and. **C** – complete doubling of the orifice of the ureter with retrovesical additional ureter. **D** – complete doubling of ureteral ectopia with unilateral orifice. **E** – complete doubling of both ureters with one retrovesical orifice. **F** – complete doubling of both ureters with bilateral single retrovesical orifice

of ureter. At the age of 4 months old valves tend to disappear. Slow or none reduction of these structures and maintaining of valves at older age can lead to a violation of the urine flow. These disorders begin to develop on the second or third year of life and lead to the development of hydronephrosis or ureterohydronephrosis.

Diverticulum ureter is a sacciform ureteral wall protrusion of varying size and location. It is often located in the pelvic part of the ureter on the right.

Annular ureter is ring-shaped middle third of the ureter. It occurs rarely.

Ureterocele is a racemose expansion of intravesical ureteral segment (Fig. 46). It is caused by a congenital anomaly of the terminal part of the ureter, a sharp narrowing of ureteral orifice and intramural extension segment. In some cases this pathology is combined with persistent pyuria.

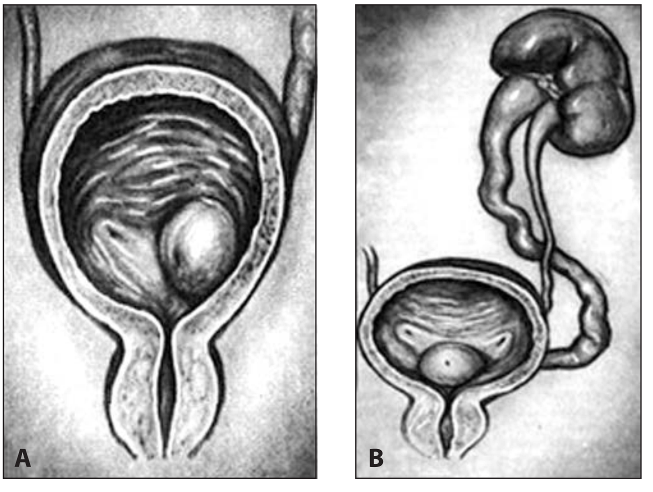


Fig. 46. Ureterocele.
A – simple. **B** – ectopic

THE URINARY BLADDER; VESICA URINARIA

Synonym is Greek 'cystus', which stands for 'blister'. It gives rise to 'cystitis' (inflammation of the bladder mucosa) and other medical terms.

The urinary bladder serves as temporary urine storage container. It is a hollow organ, which resides in the anterior portion of lesser pelvis posterior to the pubic symphysis. Maximum capacity of the bladder reaches 500–700 ml and normally it contains about 350 ml. Full bladder assumes ovoid shape.

Parts of bladder are like the following:

- the apex of bladder, apex vesicae, is the superior pointed portion directed anterosuperiorly. The apex becomes continuous with the median umbilical ligament, lig. umbilicale medianum, which runs along the anterior abdominal wall and reaches the umbilical ring. The ligament is a residue of urachus, which functions during embryonic period;
- the body of bladder, corpus vesicae is the middle portion of the organ;
- the fundus of bladder, fundus vesicae is the lower wide and dense portion;
- the neck of bladder, cervix vesicae is the narrow portion of fundus, which becomes continuous with the urethra.

Topography. Empty bladder normally never ascends over the pubic symphysis. When empty, the bladder has the anteroinferior wall fixed loosely to the symphysis. The wall is surrounded with loose connective tissue and the vesical venous plexus. The posteroinferior wall neighbors the small intestine and – in females – the uterus, the ureters and the vagina; in males it neighbors the ampulla of ductus deferens, the ureters, the seminal vesicles and the rectum. The fundus in males adheres to the prostate and in males – to the vagina. The lateral surfaces of bladder neighbor the levator ani.

Peritoneal relations. Full bladder lies mesoperitoneally (the inferior surface is devoid of serosa) while empty bladder lies extraperitoneally (serosa remains only on the posterosuperior surface). In males, the peritoneum passes from the bladder directly onto the rectum forming rather deep recto-vesical pouch, excavatio rectovesicalis and in women – onto the uterus forming the vesico-uterine pouch, excavatio vesicouterina. Full bladder ascends over the pubic symphysis andelevates peritoneum exposing so a small (3–4 cm long) area on the anterior surface adherent to the anterior abdominal wall (Fig. 47).

Clinical applications

Acute urinary retention, primarily a postoperative condition requires immediate urine withdrawal. Catheterization is the most common method yet inapplicable in

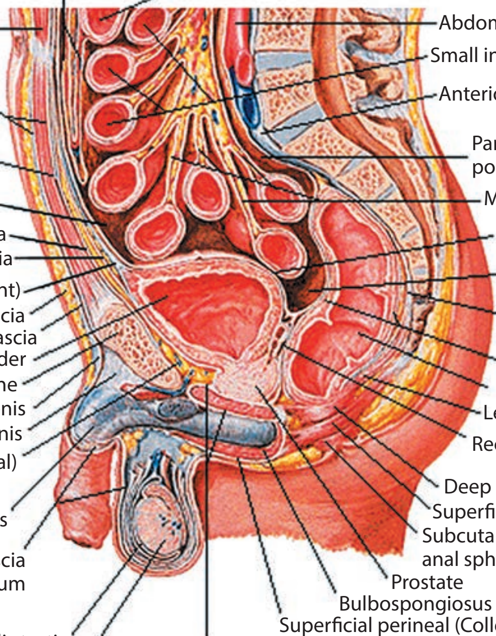


Fig. 47. Relations of pelvic viscera and perineum in male (sagittal section)

some cases so the full bladder may be punctured at that small peritoneum-devoid area to form a suprapubic fistula. The method prevents puncturing of peritoneum and thus possible development of peritonitis.

Layers of bladder wal

The layers of bladder wall are like the following:

1) the mucosa and submucosa;
2) the muscular layer;
3) adventitia (or peritoneum).

The mucosa contains the following structures:

- **the vesical rugae**, *plicae vesicae*, thin net-shaped folds, invisible in full bladder;
- **the ureteric orifice**, *ostium ureteris*, a paired slit-like opening in the fundus of bladder;
- **the interureteric crest**, *plica interureterica*, which expands between the ureteric orifices. Posterior to it, there is a small fossa; the internal urethral orifice, ostium urethrae internum, which lies in the neck of bladder. Posterior to the orifice there is a smallprojection – the uvula of bladder, uvula vesicae (Fig. 48);

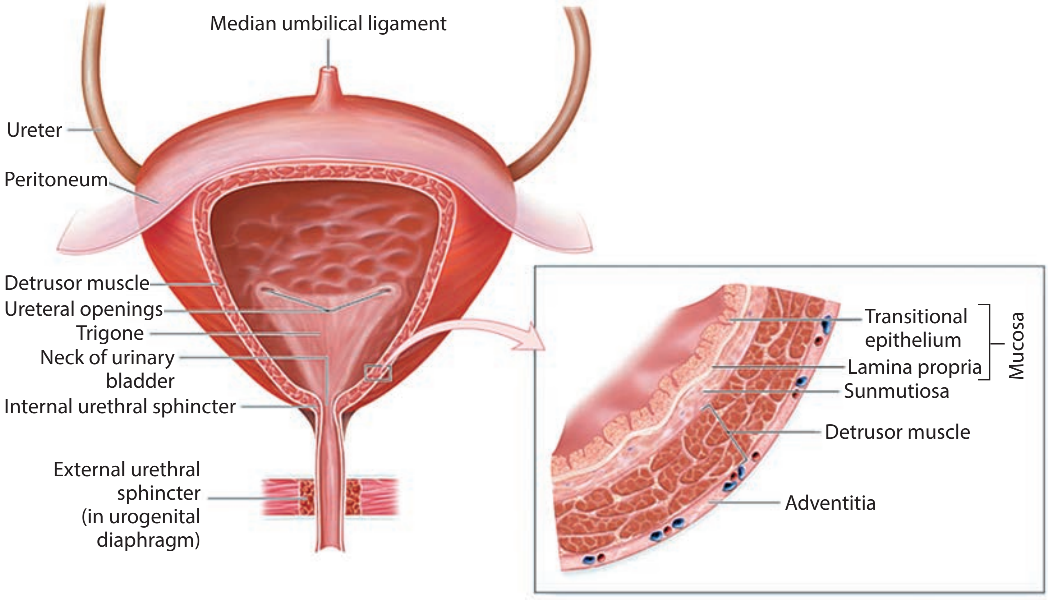


Fig. 49. Microscopic structure of the urinary bladder

- **the trigone of bladder**, *trigonum vesicae*, a well distinguishable smooth triangular area at the fundus of bladder. The vertices of trigone are related to the ureteric orifices and the internal urethral orifice. The trigone lacks the rugae as the submucosa is scarce here and mucosa adheres directly to the muscular layer.

The muscular layer consists of non-striated muscle fibers, which form three well distinguishable layers:

- the external longitudinal layer, which fixes to pubic symphysis with the pubovesicalis, m. pubovesicalis and – in males – to the rectum with the rectovesicalis, m. rectovesicalis;
- the middle circular layer better developed around the internal urethral orifice, where it forms a sphincter-like structure[2];

The internal longitudinal layer. The muscle fibers interlace to form a united muscle – the detrusor, m. detrusor vesicae (Fig. 49).

Micturition

Micturition (urination) is the process by which urine is expelled from the urinary bladder. It involves the contraction of the detrusor muscle, and may be aided by contractions of muscles in the abdominal wall and pelvic floor, and by fixation of the thoracic wall and diaphragm. Micturition also involves the relaxation of the external urethral sphincter. This muscle, which is part of the urogenital diaphragm, surrounds the

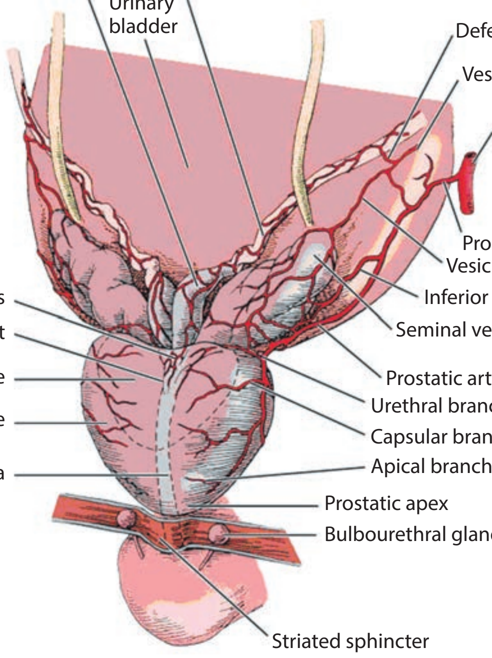


Fig. 49. Diagrammatic representation of posterior vascular supply to prostate

urethra about 3 centimeters from the bladder and is composed of voluntary skeletal muscle tissue.

The need to urinate is usually stimulated by distension of the bladder wall as it fills with urine. When the wall expands, stretch receptors are stimulated, and the micturition reflex is triggered.

The micturition reflex center is located in the sacral portion of the spinal cord. When the reflex center is signaled by sensory impulses from the stretch receptors, parasympathetic motor impulses travel out to the detrusor muscle, which undergoes rhythmic contractions in response. This action is accompanied by a sensation of urgency.

Although the urinary bladder may hold as much as 600 milliliters of urine, the desire to urinate is usually experienced when it contains about 150 milliliters. Then, as the volume of urine increases to 300 milliliters or more, the sensation of fullness becomes increasingly uncomfortable.

As the bladder fills with urine, and its internal pressure increases, contractions of its wall become more and more powerful. When these contractions become strong enough to force the internal urethral sphincter to open, another reflex begins to operate. This second reflex signals the external urethral sphincter to relax, and the bladder may empty.

However, because the external urethral sphincter is composed of skeletal muscle, it can be consciously controlled. Thus, the sphincter muscle ordinarily remains contracted until a decision is made to urinate. This control is aided by nerve centers in the brain stem and cerebral cortex that are able to inhibit the micturition reflex. When a person decides to urinate, the external urethral sphincter is allowed to relax, and the micturition reflex is no longer inhibited. Nerve centers within the pons and the hypothalamus function to make the micturition reflex more effective. Consequently, the detrusor muscle contracts, and urine is excreted to the outside through the urethra. Within a few moments, the neurons of the micturition reflex seem to fatigue, the detrusor muscle relaxes, and the bladder begins to fill with urine again.

Damage to the spinal cord above the sacral region may result in the loss of voluntary control of urination. However, if the micturition reflex center and its sensory and motor fibers are uninjured, micturition may continue to occur reflexly. In this case, the bladder collects urine until its walls are stretched enough to trigger a micturition reflex, and the detrusor muscle contracts in response. This condition is called an automatic bladder.

Major events of micturition:

1. Urinary bladder becomes distended as it fills with urine.
2. Stretch receptors in the bladder wall are stimulated, and they signal the micturition center in the sacral spinal cord.
3. Parasympathetic nerve impulses travel to the detrusor muscle, which responds by contracting rhythmically.
4. The need to urinate is sensed as urgent.
5. Urination is prevented by voluntary contraction of the external urethral sphincter and by inhibition of the micturition reflex by impulses from the brainstem and the cerebral cortex.
6. Following the decision to urinate, the external urethral sphincter is relaxed, and the micturition reflex is facilitated by impulses from the pons and the hypothalamus.
7. The detrusor muscle contracts, and urine is expelled through the urethra.
8. Neurons of the micturition reflex center fatigue, the detrusor muscle relaxes, and the bladder begins to fill with urine again.

Cystoscopy

The interior of the bladder and its three orifices (the internal meatus and the two ureters) are easily inspected by means of a cystoscope. The ureteric orifices lie 1 in (2.5 cm) apart in the empty bladder, but when this is distended for cystoscopic examination, the distance increases to 2 in (5 cm).

The submucosa and mucosa of most of the bladder are only loosely adherent to the underlying muscle and are thrown into folds when the bladder is empty, smoothing out during distension of the organ. Over the trigone, the triangular area bounded by the ureteric orifices and the internal meatus, the mucosa is adherent and remains smooth even in the empty bladder.

Between the ureters, a raised fold of mucosa can be seen called the interureteric ridge which is produced by an underlying bar of muscle.

Blood supply of the urinary bladder: the apex and body of bladder are supplied by the superior vesical arteries (aa. vesicales superiores), which arise from umbilical artery; lateral walls and fundus are supplied by the inferior vesical arteries (aa. vesicales inferiores) – the branches of internal iliac artery. Vein blood flows via the accompanying veins to the vesical venous plexus.

Lymph drains to the internal iliac nodes.

Innervation: branches of inferior hypogastric plexus, sacral plexus and pelvic splanchnic nerves (Fig. 50).

In children:

- in newborns the urinary bladder is shaped like a spindle or a pear, the mass of it is 5–7g, the volume is 50–80 cm^3, children at 6 months old have its volume of 135 cm^3, at the age of 1 year old – 200 cm^3, at 3–4 years old – 400 cm^3, at 8–9 years old – 500 cm^3, at 12–13years old – 900 cm^3. In early childhood the urinary bladder is located above the pubic symphysis, with age the urinary bladder falls; at elderly age it is below the symphysis. Bladder capacity is 500–700 ml while physiological capacity is about 350 ml. When filled, the bladder has an egg-shape;
- in infants and children of the early years the bladder mucosa is soft and friable, which can lead to the frequent development of inflammatory processes;

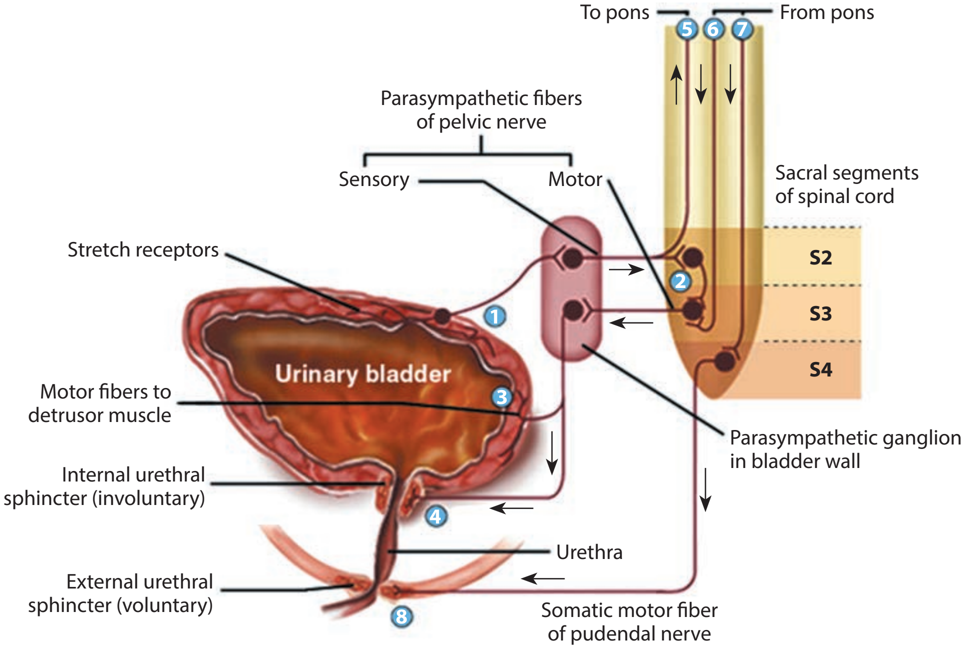


Fig. 50. The diagram of the micturition

- muscle and elastic fibers of the bladder wall are undeveloped in young children, this is especially true for the circular layer, which develops only after 6 years old. The peritoneum does not cover the anterior wall of the bladder, and this makes surgery possible in children without abdominal incision, while adults need to dissect the peritoneum. Newborn's peritoneum covers completely the posterior surface of the bladder. In boys, it reaches the posterior surface of the prostate gland.

Anomalies of the urinary bladder

Anomalies of the urinary duct. By the birth, urachus is overgrown. But in premature babies this duct can be opened and only heals by the first year of life. Partial or complete cleft of urachus is an abnormality of development. Cases of cleft of a section of the urinary duct are more often: umbilical – umbilical fistula, middle – a cyst or diverticulum of the urinary bladder.

Agenesia of the urinary bladder. The absence of the urinary bladder. This anomaly develops together with other anomalies and generally is incompatible with life.

Double bladder. In this pathology there is a septum between the right and left half of the bladder. In each of them there is a hole of ureter orifice. Full double urinary bladder is combined with a doubling of the urethra.

Diverticulum of the urinary bladder. The cause of this anomaly is abnormal formation of the bladder wall. Diverticulum is bulging of the bladder wall. It can be single or multiple and is often located in the region of the ureter orifice or in the lateral walls of the bladder.

Exstrophy of the urinary bladder. Congenital absence of the anterior wall of the bladder and abdominal wall. This anomaly occurs at a ratio of 1:40000 newborns. In boys, it happens 3 times more often than in girls. The treatment is surgical.

Contracture of the bladder neck. Congenital anomaly, which is characterized by the development of fibrous tissue in the submucosal and muscular layer (Fig. 51).

Practic questions

1. What organs belong to urinary system?
2. Describe the exterior of kidney.
3. Describe relations of both kidneys (holotopy, syntopy and skeletotopy).
4. Describe peritoneal relations of kidneys.
5. Name the structures responsible for kidney support.
6. Describe interior of the kidney on frontal section.
7. Name the renal segments.
8. Describe microscopic structure of kidney parenchyme.
9. Discuss features of intrarenal arterial branching. What is arterial rete mirabile?
10. Give definition of renal lobes and lobules. Give definition of nephron and describe its structure.

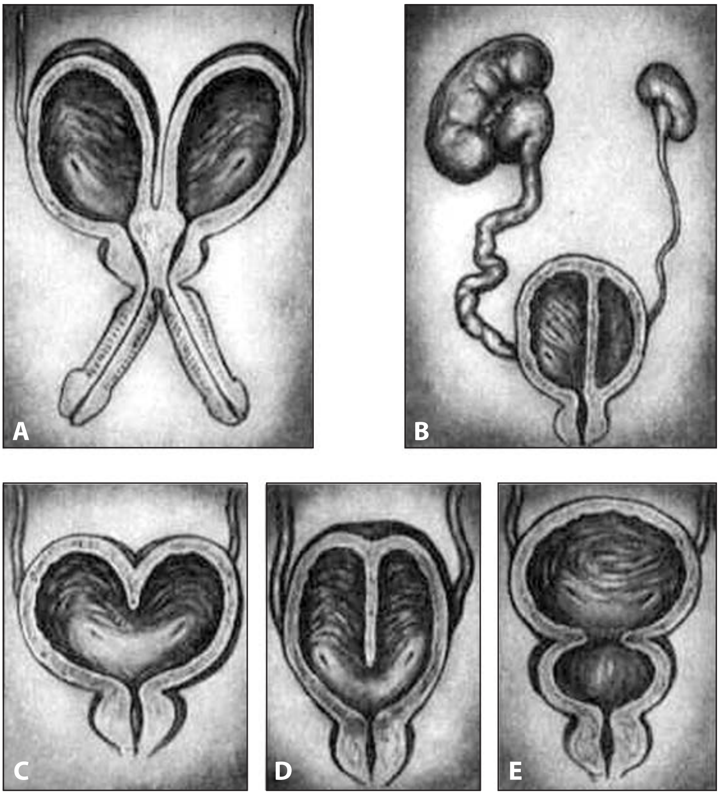


Fig. 51. Full and partial doubling of the urinary bladder:
A – complete doubling of the bladder and urethra. **B** – complete frontal septum of the bladder (its complete doubling), hypoplasia of the left kidney. **C, D, E** – the variants of incomplete doubling

11. What groups of nephrons are distinguishable in renal cortex?
12. What is the length of ureters and what parts are distinguishable in them.
13. Describe relations of the abdominal parts of ureters. Are relations of left and right ureters identical?
14. Describe relations of the pelvic parts of ureters in males and females.
15. Name constrictions of ureters and discuss their practical significance.
16. Name the wall layers of ureter.
17. Describe the exterior of urinary bladder.
18. Name the wall layers of urinary bladder.
19. Describe relations of bladder in males and females.
20. Describe peritoneal relations of empty and full bladder.
21. Discuss features of excretory organs in invertebrates.
22. What features constitute complications of excretory organs in vertebrates?
23. What embryonic plate gives rise to urinary organs in humans?

24. Describe structure and location of pronephros.
25. Discuss features of mesonephros.
26. What primordia give birth to the metanephros and where does it develop?
27. What developmental anomalies occur in humans (Fig. 52)?

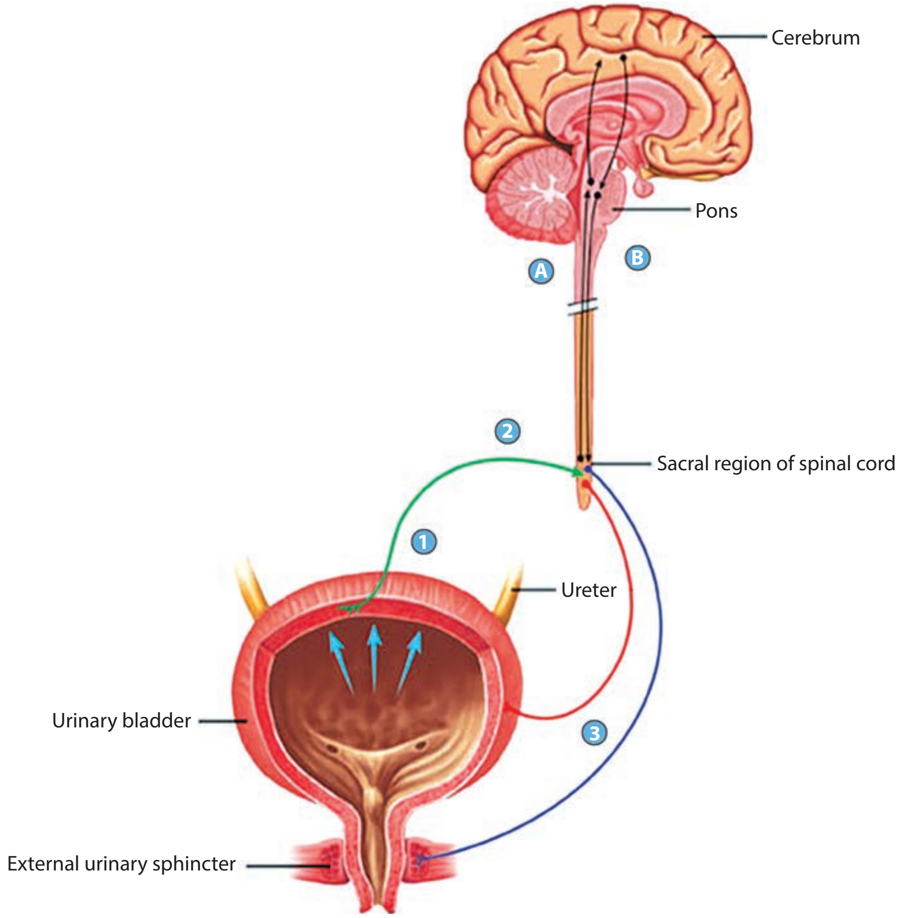


Fig. 52. Micturition reflex

THE GENITAL SYSTEM, SYSTEMA GENITALIA

The genitals produce gametes and thus are responsible for reproduction. Female reproductive system is also responsible for pregnancy and delivery. The organs of the male and female reproductive systems are adapted to produce sex cells, to sustain these cells, and to transport them to a location where fertilization may occur. Some of the reproductive organs also secrete hormones that play vital roles in the development and maintenance of sexual characteristics and in the regulation of reproductive physiology. In addition, specialized organs of the female system are adapted to support the life of an offspring that may develop from a fertilized egg and to transport this offspring to the outside of the female's body. Both male and female genitalia are subdivided into external and internal.

The male internal genitalia, *organa genitalia masculina* interna comprise the testis, the epididymis, the prostate and the bulbo-urethral gland. **The male external genitalia**, ***organa genitalia masculina* externa** comprise the penis and the scrotum.

Evolution of reproductive organs

Reproductive organs in invertebrates. In inferior invertebrates, the primordial gametes are scattered diffusely about the entire body. These primordias may differentiate into both oocytes and spermatozoids (in coelenterates). Higher animals develop specialized gonads with ducts open to ambient. In many species (e.g. in mollusks), these gonads are able to produce both male and female gametes (hermaphroditic gonads). The coelomic annelids develop gonads within the cavity wall. In these animals, the gametes first enter the coelom and then leave it via canaliculi communicating with the nephridia.

Gonads invertebrates. Invertebrates, the gonads appear as paired ridges residing laterally to the ventral mesentery. Cyclostomes feature hermaphroditic gonad in which the anterior portion functions as the ovary and the posterior – as the testis. Vast majority of other vertebrates possess fully differentiated ovaries or testes.

The genital ducts. Dual function of pronephros and mesonephros. In cyclostomes, the gonad neighbors the pronephros, which opens with several orifices into the coelom. Mature gametes enter the coelom and proceed via pronephric ducts to the common duct, which serves for urine voiding and gametes emission. In superior fishes, the genital ducts develop from mesonephric canaliculi. The mesonephric duct splits to form parallel para- mesonephric duct, which serves as the oviduct. In amphibians, mature oocytes also begin their way in the body cavity and pass via oviduct? (paramesonephric ducts) to rea. the cloaca. Testes in amphibians are closely associated with the mesonephros, which develops anterior genital and posterior excretory portions. The anterior portion is connected with testicular canaliculi and mesonephric duct serves for sperm transporting.

Thus, at early evolution stages both pronephros and mesonephros in vertebrates possess dual function – excretory and ejaculatory. In reptiles and birds, the genitalia separate from the excretory organs. Once the metanephros develops, the mesonephros fully differentiates into seminiferous ducts and the mesonephric ducts becomes the ejaculatory canal. Oviducts develop from the paramesonephric ducts and feature ability of coating the oocyte with leathery shell impregnated with calcium salts.

Genitals in the mammals. In mammals, the genitals descend to pelvic cavity; in most male species, the gonads leave the abdominal cavity and reside in the scrotum, where temperature is lower than in the abdominal cavity by 2–3 degrees (which is prerequisite for normal spermatogenesis). In rodents, insectivorous animals and some other mammals, the testes descend to the scrotum only for a mating season. Caudal ends of paramesonephric ducts in female mammals merge to form the uterus, which provides the place for embryo development. Merging variety results in variable shapes of uterus in different animals' species: a double uterus (in rodents), a septate uterus (in pigs) or a bicornuate uterus (carnivorous and hoofed animals). Finally, the monkeys and humans feature one unpaired uterus with two uterine tubes.

Transformation of the cloaca. In most of the vertebrates, the cloaca is the terminal segment of gut, where the excretory and ejaculatory ducts open. As evolution progresses, the urogenital and alimentary tracts part to form separate orifices. A short cloaca yet persists.in inferior mammals (duckbill and echidna). In superior mammals, the cloaca separates into anterior portion associated with the bladder and genital ducts (the urogenital sinus) and posterior portion – the rectum. In males, the urogenital sinus transforms into long urogenital canal, which serves for urination and ejaculation. In females, the sinus transforms into the vaginal vestibule, which contains openings of urinary and genital tracts.

Development of genitalia in humans is tightly associated with urinary system development and begins with indifferent stage. At this stage, embryo has no signs of developing sex (Fig. 53).

Indifferent stage of genitalia development. As mentioned previously, the urogenital folds form on the dorsal wall of embryonic body cavity laterally to developing vertebral column. Each fold splits into urinary (lateral) fold and gonadal (medial) ridge. Gonads primordias develop at 3–4 week of embryo development from mesodermal epithelium, which covers the gonadal ridge. The epithelium incorporates into the gonadal ridge mesenchyme to form primary sex cords. Primordial sex cells, which are likely to migrate from the yolk sac, appear in the sex cord. Sex cords in male embryo differentiates into seminiferous tubules, while in female embryo the cords separate into cell groups, which give rise to primordial follicles. The gonadal primordias gradually separate from the mesonephros to become individual organs. The gonads remain

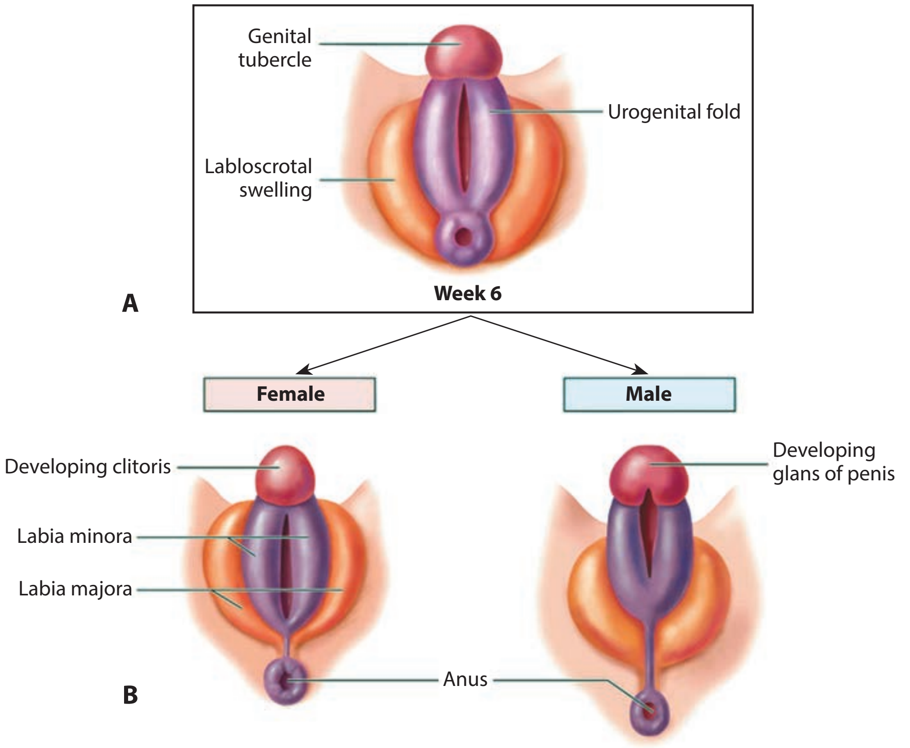


Fig. 53. Development of genitalia
A – Sexually indifferent stage. **B** – Urogenital folds begin to fuse

indifferent up to the 2nd month of development. Sex differentiation of the gonads starts at the 3rd month of development.

Development of mesonephric and paramesonephric ducts. Mesonephros with associated duct develops simultaneously with the gonads. Neighboring primordias of paramesonephric ducts form at the 6th week of development. They grow in caudal direction to fuse and open into nearby cloaca. Thus, by the end of the 2nd month of development each embryo regardless of sex develops: 1) paired indifferent gonadal primordias, 2) paired mesonephric ducts and 3) paired paramesonephric ducts (Fig. 54).

Development of male gonads. Former indifferent primordia develops seminiferous tubules, which connects to the mesonephros and its duct to form semen transporting pathways. The mesonephric duct eventually transforms into the ductus deferens while paramesonephric ducts disappear.

Development of female gonads. In this case, the primordia tissue differentiates into the cortex and medulla. The cortex contains dividing primordial cells, which transform into oogonia. Each ovary contains approximately 1 million of such cells. Each oogonium surrounded by a single layer of epithelial (follicular) cells forms a primary follicle.

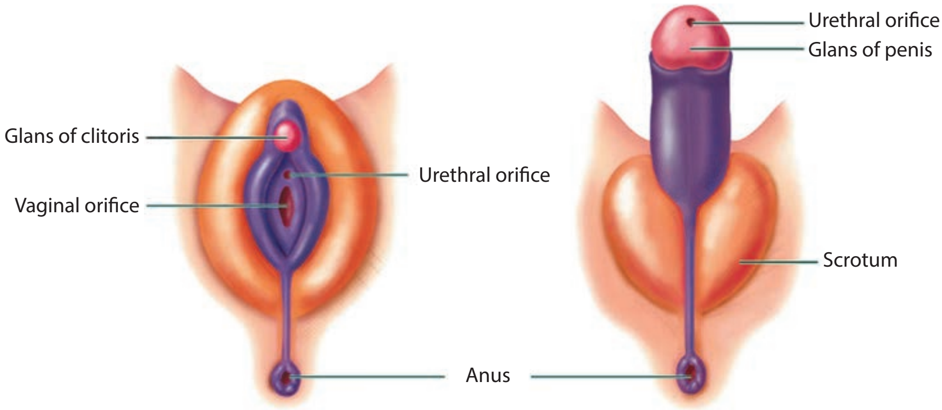


Fig. 54. External genitalia well differentiated

Descent of the gonads. The gonadal primordia appear at the level of L4–L5; however, neither ovaries nor testes remain at the place of origin but descend caudally. This process is called descent of the gonads (Fig. 55).

Descent of the testes. Key role in descent of the testes belong to the gubemaculum, gubemaculum testis – a ligament arising from the inferior pole of testis. The ligament runs caudally and penetrates the anterior abdominal wall to terminate in growing scrotum. As the result of rapid growth of trunk accompanied by reduction of the mesonephros and guberanculum, the testis descends caudally. By the 3rd month of development, the testis reaches the pelvic cavity and by the 7th month – the deep inguinal ring.

The processus vaginalis. During descent of the testes, the peritoneum forms the projection called the processus vaginalis, processus vaginalis peritonei. The processus also penetrates the anterior abdominal wall moving the muscles and fascia apart to form the inguinal canal. The processus enters the scrotum as well as the gubemaculum.

In the course of descent, the retroperitoneal testis appears posterior to the processus vaginalis by the 8th month of development. Upon completion of descent, the testis becomes enfolded into double layer of peritoneum.

The ductus deferens as it follows the testis becomes wrapped by the layers of anterior abdominal walls previously forced by the processus vaginalis. This process results in spermatic cord formation. After delivery, the upper portion of processus vaginalis occludes and two peritoneal cavities part.

Descent of the testis is of great biological significance because spermatogenesis requires appropriate temperature (approx 34 °C) maintained in the scrotum. In rodents, the inguinal canal remains open wide throughout the life and the testes descend to scrotum during mating season and remain protected by the abdominal wall the rest of the time.

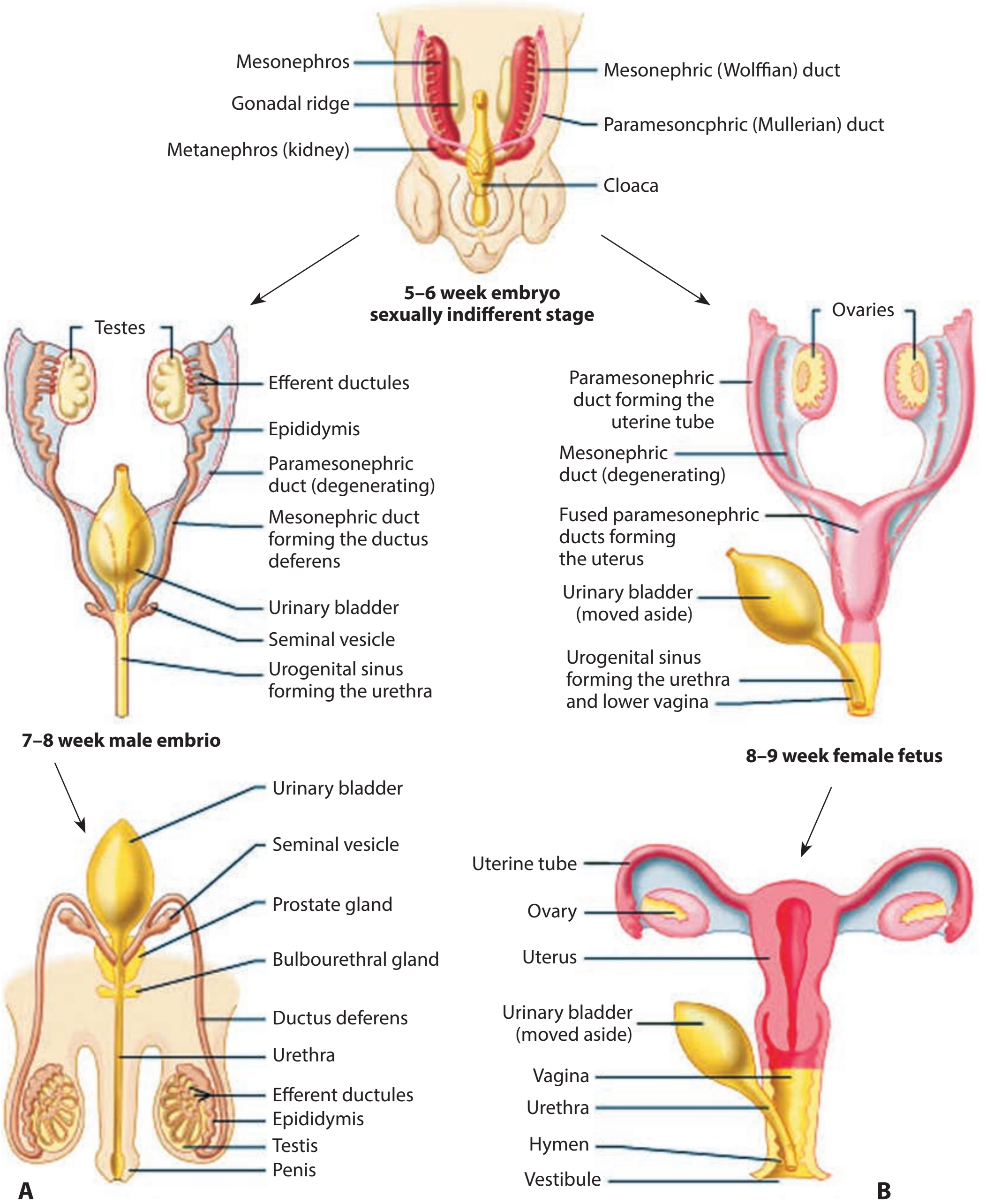


Fig. 55. Development of the genital system

If the processus vaginalis fails to occlude, the inguinal canal retains communication with serous cavity, which may result in hereditary inguinal hernias. In 50 % of cases, the processus vaginalis remains patent up to 1st month of life (Fig. 56).

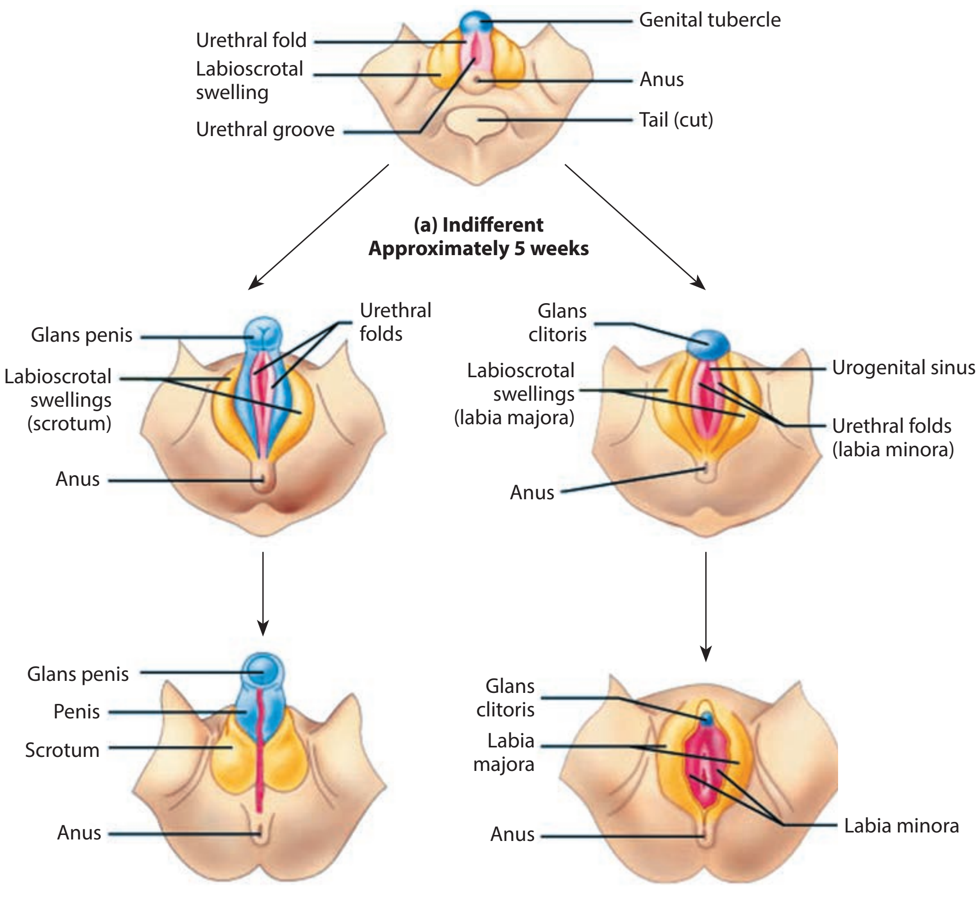


Fig. 56. Sexually indifferent stage

Anomalies of testis development

Underdevelopment of testes may result in monorchism (absence of one testis) or anorchism (absence of both testes). Deranged descent may result in uni- or bilateral retention of the testes in abdominal cavity. Such anomaly is called cryptorchidism. Surgical correction is required before the individual reaches 5 years of age otherwise malignancy or sterility become a concern.

Descent of the ovaries. Positioning and shape of ovaries also undergoes considerable changing: they enlarge and descend to pelvic cavity rotating around the sagittal axis. The ligament, which corresponds to the gubernaculum in males transforms into the ligament of ovary and round ligament of uterus. Ovarian serous coating reduces but mesovarium persists.

Developmental anomalies of the ovaries. Common anomalies are hypoplasia and aplasia (both unilateral and bilateral). Ovaries may completely descend through the inguinal canal and appear in the area of labia majores.

Development of the uterus, uterine tubes and vagina. Key role in development of internal genitalia in females belong to the paramesonephric ducts. They appear by the end of the 2nd month of development and reside laterally to the mesonephros, which disappears later. Paramesonephric ducts give rise to the uterine tubes, uterus and superior portion of vagina. As mentioned previously, the distal ends of paramesonephric ducts fuse to form the uterus and vagina. This portion exhibits intense growth especialW in myometrium. Unfused portions give rise to the uterine tubes. The cranial ends of tubes develop funnel-shaped opening and fimbriate trimming.

Developmental anomalies of the uterus. These anomalies result primarily from fusion disorders and constitute various degrees of duplication and abnormal positioning. Most common is fundus duplication. More severe disorders result in formation of bicornuate uterus with two cervices. In such cases, each horn has one uterine tube. Duplication may expand to the vagina to result in formation of double uterus with double vagina. Unicomuate uterus with one tube may form if unilateral underdevelopment of a paramesonephric duct occurs.

Apart from deformities described, underdevelopment of the uterine tubes, uterus and vagina may be observed. Vaginal atresia occurs as a part of severe general developmental disorders.

Development of the external genitalia. The external genitalia, as well as internal develop from indifferent primordias. At indifferent stage, all embryos regardless of sex feature the following primordias: 1) the genital tubercle 2) urethral folds, which enclose the urethral groove and 3) the paired labioscrotal swellings. Beginning from the 3rd month of development, the sex distinction signs become apparent.

Masculine-type transformations: 1) the genital tubercle grows to form the penis; 2) the urethral folds fuse to form the spongy urethra; 3) the labioscrotal swellings also fuse to form the scrotum. Fusion line appears as well distinguishable raphe of scrotum. The testes eventually descend into the scrotum.

Feminine-type transformations: 1) the genital tubercle grows slowly to form a small clitoris; 2) the urethral folds do not fuse and form the labia minores with vestibule between them; 3) the labioscrotal swellings also do not fuse and develop into the labia majores.

Hermaphroditism. The term generally refers to ambiguous sexual differentiation due to developmental disorders during embryonic period. There are two major types of hermaphroditism: true and false (pseudohermaphroditism). True hermaphroditism is a rare-type state featuring presence of both female and male gonads in an organism. The cases of true hermaphroditism are uncommon in humans; only single instances, when presence of seminiferous tubules and follicles was histologically confirmed in one organism have ever been reported. An individual in this case features underdeveloped intersexual genitalia.

Pseudohermaphroditism is more common; it can be divided into male and female types.

Male pseudohermaphroditism. The individual has 46XY chromo somal constitution and male gonads (usually underdeveloped) but genitalia are intersexual or resemble female. The penis is small and resembles the clitoris, the urethral folds and labioscrotal swellings remain unfused resembling thus the labia majores and minores.

Female pseudohermaphroditism. The individual has 46XX chromosomal constitution and underdeveloped (in most cases) ovaries. The external genitalia resemble those in males: the enlarged clitoris, fused labia majores and minores, looking like the scrotum. The ovaries (one or both) may descend to the labia majores area.

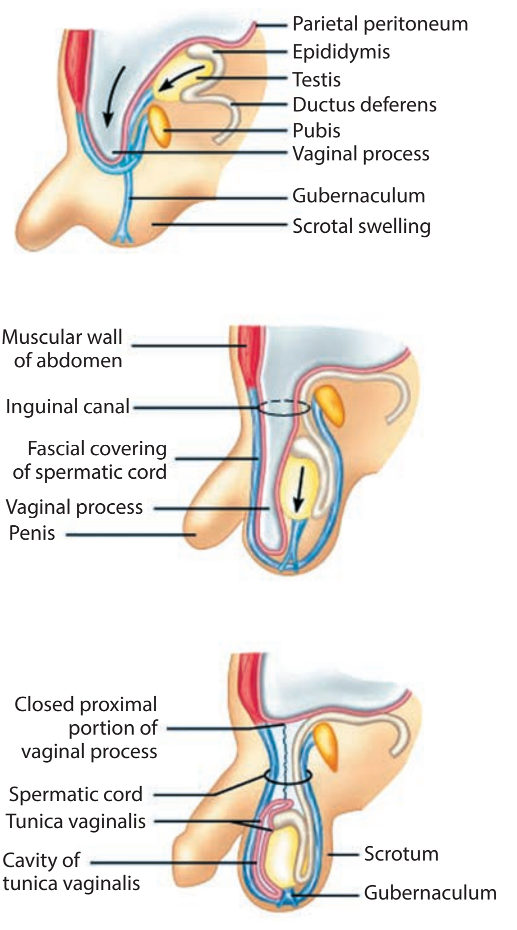


Fig. 57. The migration of the testis

The external genitalia in hermaphrodites are often poorly differentiated making it difficult to determine individuals' sex. In this case, a special histological study of the gonads is required (Fig. 57).

Clinical applications. Developmental disorders of external genitalia can be surgically corrected in order to bring the faulty genitalia into consistence with individuals' sex. Studying of hermaphroditism variety thus is of importance for applied medicine apart from basic studies.

THE MALE INTERNAL GENITALIA, ORGANA GENITALIA MASCULINA INTERNA

The testis, testis

Synonyms are Greek 'orchis' (which gives rise to 'orchitis' – inflammation of the testis and other terms) and 'didymis'. The testes are paired ovoid organs, suspended in the scrotum. Dimensions of testis average 2×3×5 cm and mass – 20–30 grams. The posterosuperior border neighbors to the epididymis (Lat. Id.). The long axis of the organ runs slantwise downwards and slightly medially; the left testis is suspended somewhat lower than the right.

Exterior of testis. The testis has the poles, surfaces and borders as follows:

- the upper pole, extremitas superior;
- the lower pole, extremitas inferior;
- the lateral surface, facies lateralis;
- the medial surface, facies medialis;
- the anterior border, margo anterior;
- the posterior border, margo posterior.

The epididymis consists of the head, body and tail:

- the head of epididymis, *caput epididymidis* is the superior expanded portion facing anteromedially;
- *the body of epididymis, corpus epididymidis* is the middle wedgeshaped portion neighboring the posterior border of testis;
- the *tail of epididymis, cauda epididymidis* is the narrower inferior portion, which passes into the ductus deferens.

Interior of the testis and epididymis. The testis is covered with tough *tunica albuginea* (Lat. Id.). On the posterior border, the tunica thickens and penetrates into depth of testis to form wedge-shaped *mediastinum of testis,* mediastinum testis. Outgrowths of mediastinum named the *septa testis,* septula testis run radially to separate the testicular parenchyma into the *lobules of testis,* lobuli testis (260–300 lobules). The lobules are pyramidal-shaped compartments with bases at the surface of testis and apices facing the mediastinum. These compartments enfold the *parenchyma of testis,* parenchyma testis, which consists of the *seminiferous tubules,* tubuli sem- iniferi contorti responsible for spermatogenesis. Each lobule contains 3–4 tubules 150–200 pm of diameter. The spermatozoids pass via the tubular system to the epididymis and further to the ductus deferens (Fig. 58–60).

Segments of tubular system in the testis and epididymis run in the following sequence:

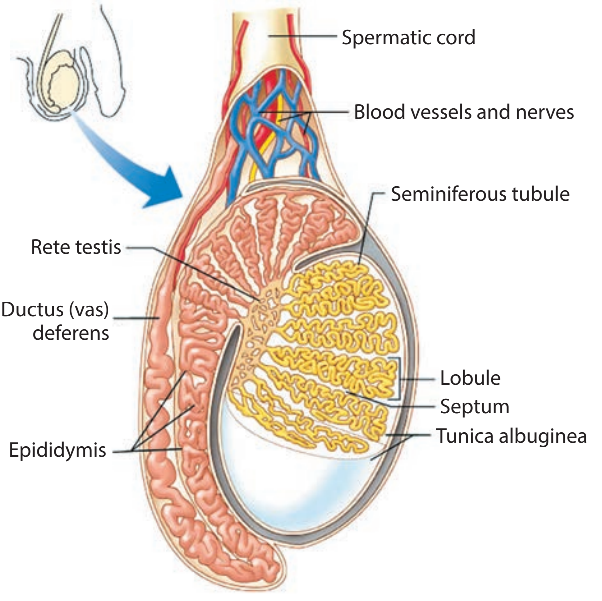


Fig. 58. The interior of testis and epidydimis

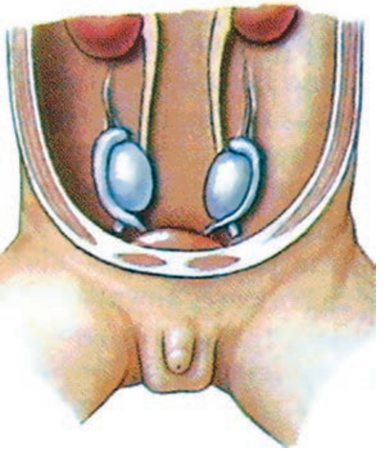


Fig. 59. 4 month fetus

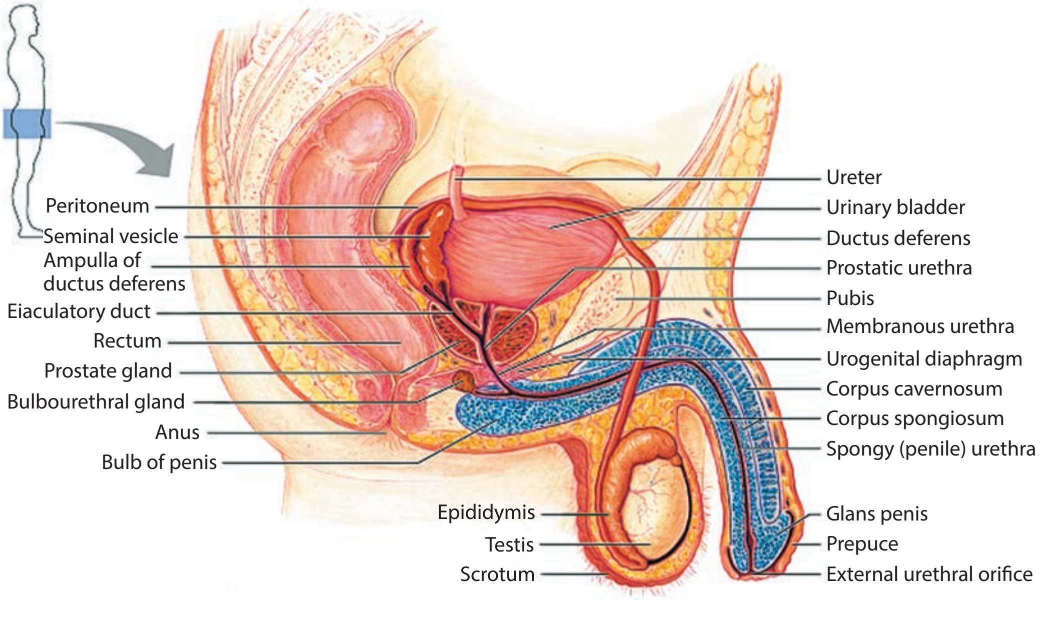


Fig. 60. Location of the testis and epidydimis

- the seminiferous tubules, tubuli seminiferi contorti, they occupy the most part of lobule; reaching the apex of lobule they merge to pass into the straight tubules;
- the straight tubules, tubuli seminiferi recti, short and thin (25pm) tubules, which radiate towards the mediastinum to become continuous with the rete testis;
- the rete testis (Lat. Id.) is the tubular network in the mediastinum continuous with the efferent ductiles;
- the efferent ductiles, ductuli efferentes testis (10–15 at all) run to the head of epididymis where form the lobules of epididymis;
- the lobules of epididymis, lobuli epididymidis, which consist of convoluted tubules merging to form the duct of epididymis;
- the duct of epididymis, ductus epididymidis, rather convoluted it descends to the tail where loops and passes into the ductus deferens.

The rudiments. The testis and epididymis sometimes hold small bodies called appendices (the appendix epididymidis, appendix epididymidis, the appendix of testis, appendix testis, the paradydimis, paradydimis), which consists of blind canals – the residua of embryonic genital ducts and mesonephros.

Formation of the testicular tunics. The testis forms in the extraperitoneal tissue where acquires its first – serous – tunic. At the end of fetus development, the tunic descends to the scrotum as the vaginal process, processus vaginalis.

Passing through the inguinal canal the process carries the layers of anterolateral abdominal wall. Upon descending to the scrotum, the testis becomes enfolded into the tunics formed of these layers:

- the external spermatic fascia, fascia spermatica externa, a thin projection of the superficial abdominal fascia;
- the cremasteric fascia, fascia cremasterica a very thin projection of the external oblique fascia;
- the cremaster, m. cremaster the muscular fibers that form an incomplete layer. The fibers are projections of the internal oblique and the transversus abdominis;
- the internal spermatic fascia, fascia spermatica interna well-developed, it derives from the transversal fascia;
- the tunica vaginalis, tunica vaginalis testis, the derivative of vaginal process. It is a serous coating (peritoneum), which consists of two plates – the visceral and parietal. The visceral plate fixes to the tunica albuginea, the parietal plate – to the internal spermatic fascia. The plates form a slitlike closed cavity The peritoneum covers almost entire surface of each testis; passing onto the epididymis, it forms the sinus of epididymis, sinus epididymidis open laterally.

  The parietal plate passes into visceral at the posterior border of testis.

Clinical applications

1. The testis arises at the level of the mesonephros at the level of L2/3 vertebrae and drags its vascular, lymphatic and nerve supply from this region. Pain from the

kidney is often referred to the scrotum and, conversely, testicular pain may radiate to the loin.

2. When searching for secondary lymphatic spread from a neoplasm of the testis, the upper abdomen must be palpated carefully for enlarged paraaortic nodes; because of cross-communications, these may be present on either side. Mediastinal and cervical nodes may also become involved. It is the beginner's mistake to feel for nodes in the groin; these are only involved if the tumour has ulcerated the scrotal skin and hence invaded scrotal lymphatics which drain to the inguinal nodes.

3. Rarely, a rapidly developing varicocele (dilatation of the pampiniform plexus of veins) is said to be a presenting sign of a tumour of the left kidney which, by invading the renal vein, blocks the drainage of the left testicular vein. Most examples of varicocele are idiopathic; why the vast majority are on the left side is unknown, but theories are that the left testicular vein is compressed by a loaded sigmoid colon, obstructed by angulation at its entry into the renal vein or even that it is put into spasm by adrenalin-rich blood entering the renal vein from the suprarenal vein!

4. The testis may fail to descend and may rest anywhere along its course – intra-abdominally, within the inguinal canal, at the external ring or high in the scrotum. Failure to descend must be carefully distinguished from retraction of the testis; it is common in children for contraction of the cremaster muscle to draw the testis up into the superficial inguinal pouch – a potential space deep to the superficial fascia over the external ring. Gentle pressure from above, or the relaxing effect of a hot bath, coaxes the testis back into the scrotum in such cases.

Occasionally the testis descends, but into an unusual (ectopic) position; most commonly the testis pass laterally after leaving the external ring to lie superficial to the inguinal ligament, but it may be found in front of the pubis, in the perineum or in the upper thigh. In these cases (unlike the undescended testis), the cord is long and replacement into the scrotum without tension presents no surgical difficulty.

5. Abnormalities of the obliteration of the processus vaginalis lead to a number of extremely common surgical conditions of which the *indirect inguinal hernia* is the most important.

This variety of hernia may be present at birth or develop in later life; in the latter circumstances it is probable that the processus vaginalis has persisted as a narrow empty sac and that development of the hernia results from some sudden strain due to a cough, straining at micturition or at stool, which forces abdominal contents into this peritoneal recess.

In infants, the sac frequently has the testis lying in its wall (congenital inguinal hernia) but this is unusual in older patients.

6. Accumulation of excess fluid in the serous cavity is called hydrocele. Hydrocele may occur as individual disease or become associated with other pathology. Treatment includes dissection of the tunics, eversion and fixation of the serous tunic. Inflammatory diseases of the testis (orchitis) and epididymis (epididymitis) are often associated with several infectious diseases (e.g. mumps).

The anatomical classification of hydroceles is into the following groups:

- Vaginal – confined to the scrotum and so called because it distends the tunica vaginalis.
- Congenital – communicating with the peritoneal cavity.
- Infantile – extending upwards to the internal ring.
- Hydrocele of the cord – confined to the cord.

Notice that, from the anatomical point of view, a hydrocele (apart from one of the cord) must surround the front and sides of the testis since the tunica vaginalis bears this relationship to it. A cyst of the epididymis, in contrast, arises from the efferent ducts of the epididymis and must therefore lie above and behind the testis. This point enables the differential diagnosis between these two common scrotal cysts to be made confidently (Fig. 61–62)).

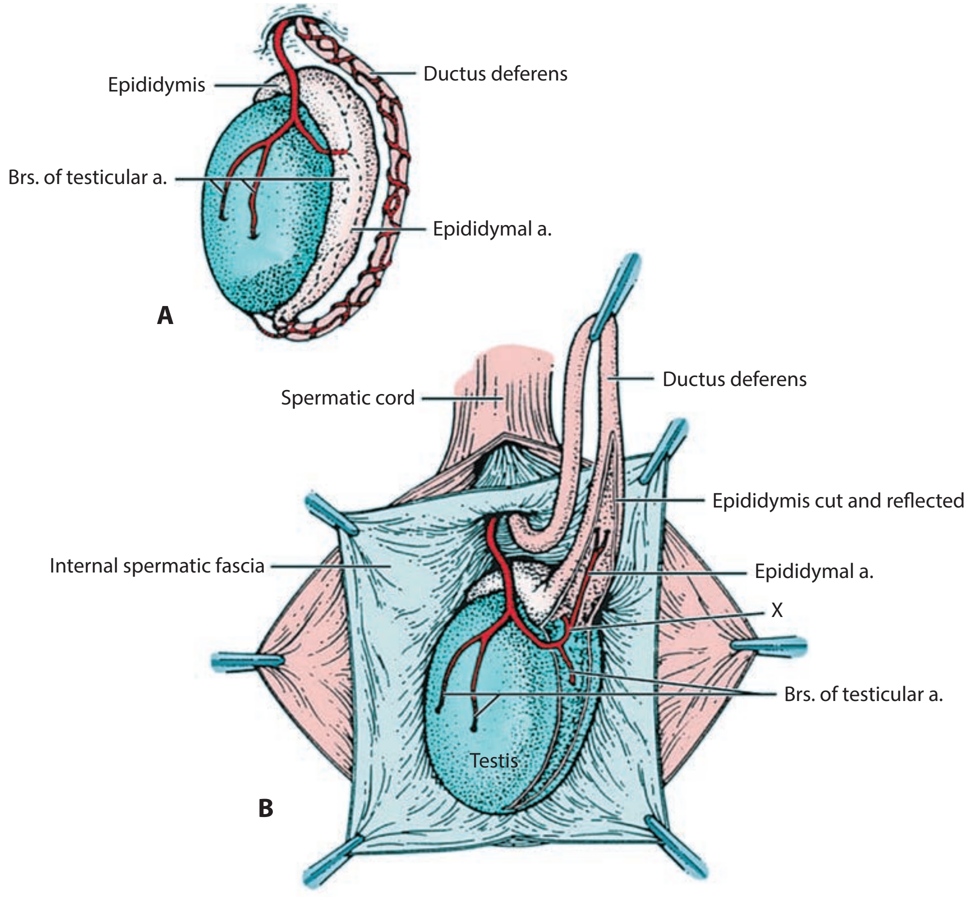


Fig. 61. Epididymectomy.

A – an epididymal branch of testicular artery supplies epididymis. **B** – epididymis dissected from below. Branch of testicular artery to testis must be preserved

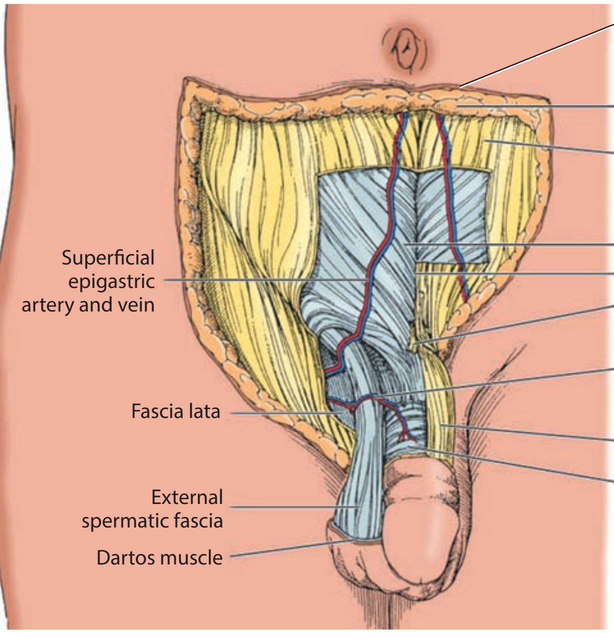


Fig. 62. Skin and fascia of inguinal area

The epithelial cells of the seminiferous tubules sometimes give rise to testicular cancer, one of the more common types of cancer occurring in young men. In most cases, the first sign of this condition is a painless enlargement of a testis or a scrotal mass that seems to be attached to a testis. When testicular cancer is suspected, a tissue sample is usually removed (biopsied) and examined microscopically. If cancer cells are present, the affected testis is surgically removed (orchiectomy). Depending upon the type of cancerous tissue present and the extent of the disease, a patient may be treated with radiation or with chemotherapy employing one or more drugs. As a result of such treatment, the cure rate for testicular cancer is high (Fig. 63).

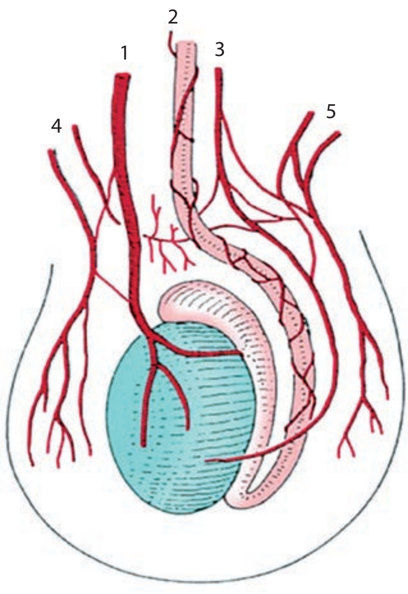


Fig. 63. Arterial supply of testis and epididymis: 1 – testicular artery; 2 – deferential artery; 3 – cremasteric artery; 4 – posterior scrotal artery; 5 – anterior scrotal artery

Formation of Sperm Cells

The epithelium of the seminiferous tubules consists of two types of cells: supporting cells (Sertoli's cells) and spermatogenic cells. The supporting cells are tall, columnar cells that extend the full thickness of the epithelium from its base to the lumen of the seminiferous tubule. Numerous thin processes project from these cells, filling the spaces between nearby spermatogenic cells. They support, nourish, and regulate the spermatogenic cells, which give rise to sperm cells (spermatozoa). In a young male, the spermatogenic cells are undifferentiated and are called spermatogonia. Each of these cells contains 46 chromosomes in its nucleus, which is the usual number for human cells (Fig. 64). During early adolescence, certain hormones stimulate the spermatogonia to become active. Some of them undergo mitosis, giving rise to new spermatogonia and providing a reserve supply of these undifferentiated cells. Others enlarge and become primary spermatocytes that then divide by a special type of cell division called meiosis. In the course of meiosis, the primary spermatocytes each divide to form two secondary spermatocytes. Each of these cells, in turn, divides to form two spermatids, which mature into sperm cells. Also during meiosis, one-half reduce the number of chromosomes in each cell. Consequently, for each primary spermatocyte that undergoes meiosis, four sperm cells with 23 chromosomes

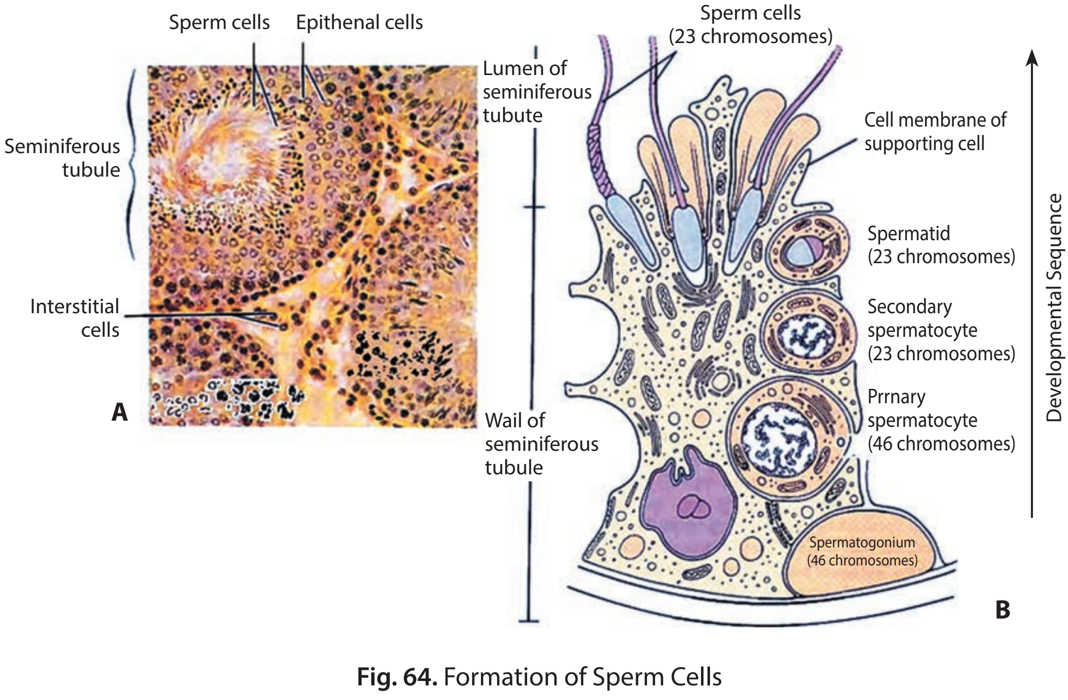


Fig. 64. Formation of Sperm Cells

A – light micrograph of seminiferous tubules (×200). **B** – spermatogonia give rise to primary spermatocytes by mitosis. The spermatocytes, in turn, give rise to sperm cells by meiosis in each of their nuclei are formed. This process by which sperm cells are produced is called spermatogenesis. The spermatogonia are located near the base of the germinal epithelium. As spermatogenesis occurs, cells in more advanced stages are pushed along the sides of supporting cells toward the lumen of the seminiferous tubule. Near the base of the epithelium, membranous processes from adjacent supporting cells are fused by specialized junctions (occluding junctions) into complexes that divide the tissue into two layers. The spermatogonia are on one side of this barrier, and the cells in more advanced stages are on the other side. This membranous complex seems to help maintain a favorable environment for the development of sperm cells by preventing certain large molecules from moving from the interstitial fluid of the basal epithelium into the region of the differentiating cells. Spermatogenesis occur continually throughout the reproductive life of a male. The resulting sperm cells collect in the lumen of each seminiferous tubule. Then they pass through the rete testis to the epididymis, where they remain for a time and mature (Fig. 65).

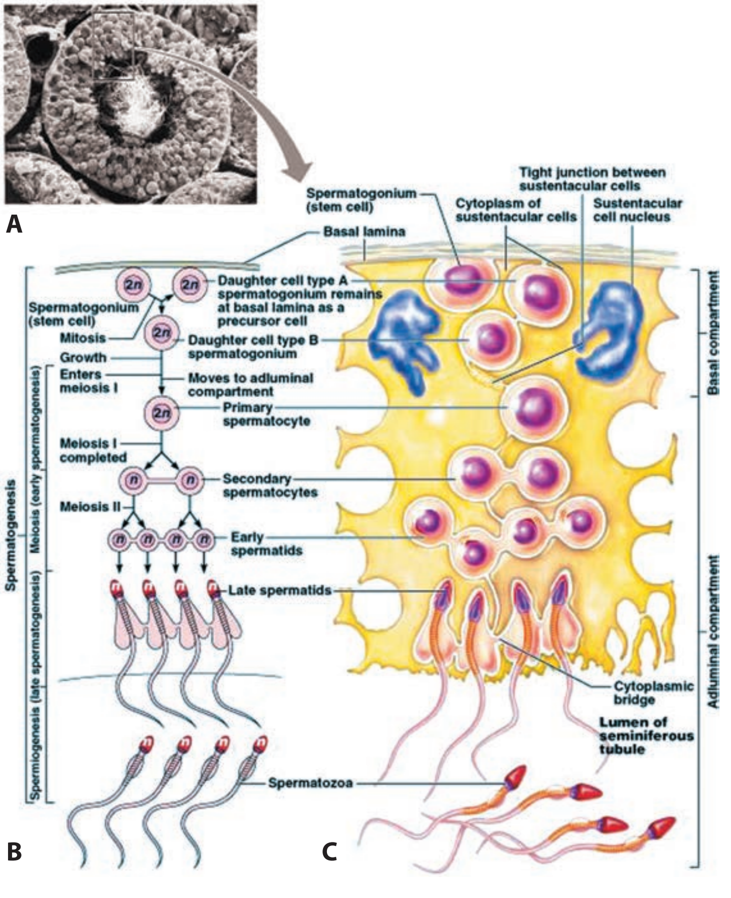


Fig. 65. Diagram of the spermatogenesis

Structure of a Sperm Cell

A mature sperm cell is a tiny, tadpole-shaped structure about 0.06 millimeters long. It consists of a flattened head, a cylindrical body, and an elongated tail. The head of a sperm cell, which is oval in outline, is composed primarily of a nucleus, and contains the chromatin of 23 chromosomes in highly compacted form. It has a small part at its anterior end called the acrosome, which contains lysosomal-like enzymes that aid the sperm cell in penetrating an egg cell at the time of fertilization. The body (midpiece) of the sperm cell contains a central, filamentous core and a large number of mitochondria arranged in a spiral. The tail (flagellum) consists of several longitudinal fibrils enclosed in an extension of the cell membrane.

Blood supply. The testis is supplied by the testicular arteries (aa. testiculares) which arise from abdominal aorta and partially by twigs of the artery to ductus deferens (a. ductus deferentis). Vein blood drains through the testicular veins (vv. testiculares), which take somewhat different routes: the right vein flows into inferior vena cava and the left-into the left renal vein.

Lymph drains to the lumbar lymph nodes.

Innervation is provided by branches of the coeliac, renal, abdominal aortic and inferior hypogastric plexuses (Fig. 66).

In cildren:

- fetal testes are located in the abdominal cavity. One of the first people who described the position of the testis in human fetus in the upper abdomen was Fabri-

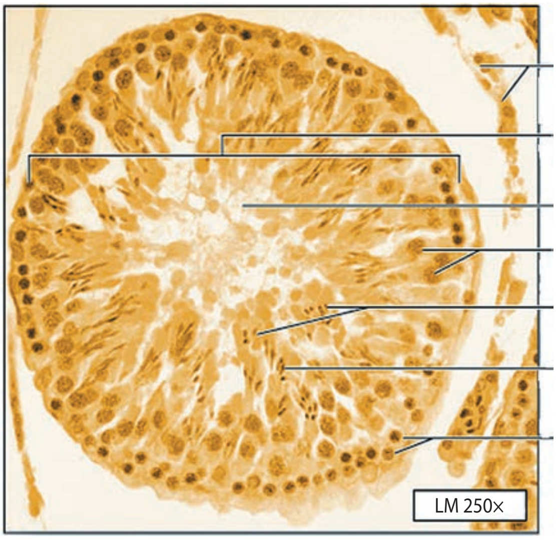


Fig. 66. Seminiferous tubule

cius in 1606. In newborn testis develops slowly up to the puberty (14 years). Then their growth is accelerating. The position of the testis in the scrotum is oblique. The length of the testis of the newborn is 10.5 mm long, at the age of five years old – 15 mm, at fourteen – 20 mm, at 18–40 mm, at 20–50 mm. The testis weight at the age of one year is 1g, at 14–2 g, at 15–16–8 g, at 19–20 g. The right testis is heavier than the left one, but the left testis is growing more rapidly, and later their weight is equalized. The epididymis in newborn is proportionally bigger than in adult. A superior ligament of epididymis (lig. epididymis superior) is missing. The body of the epididymis is located some distance away from the testicle. The epididymis length is 20 mm, the weight is 0.12 g. During the first 10 years the epididymis is growing slowly, and at puberty the growth accelerates. Convoluted seminiferous tubules (tubuli seminiferi contorti), direct seminal tubes (tubuli seminiferi recti) and the network of the testis have no clearance. At the age of 16, the diameter of seminiferous tubules increases, and in adults it is trippled. Tunica albuginea of the testis is thick, and a cubic surface epithelium becomes flat at the age of three.

Anomalies of the testes

Abnormalities of the number, structure and position of the testes are distinguished. The anomalies of the number include anorchism, cryptorchidism, monorchism, poliorchism. Anorchism is absence of both testes at birth. This anomaly is rare and is caused by disturbances in the early stages of embryonic development of the gonads after a short secretion of androgens. At the anorchism there are no prostate and seminal vesicles, underdeveloped genitals, eunuch like body structure, secondary sexual characteristics are weak or absent. Monorchism is congenital absence of one testis. The anomaly is due to violation of embryogenesis before placing the final kidneys and gonads. At the monorchisme, there is no epididymis and ejaculatory duct. Poliorchism is very rare. The additional testis is placed near the general, but there is no epididymis and ejaculatory duct. Sinorchism is congenital fusion of two testises that can not drop out of the abdominal cavity.

Anomaly structure. Uni-and bilateral testicular hypoplasia are distinguished. Testicular hypoplasia develops due to violations during early embryonic development. At unilateral hypoplasia underdeveloped testis needs to be removed, as it can serve as a source for the development of malignant tumors.

Anomaly position. Widespread abnormalities of gonads in men are cryptorchidism and testicular ectopia (Fig. 67). In 1786, John Gunther, was the first person who proposed the theory that explains the occurrence of cryptorchidism, according to which the cause disturbances of testicular descent lies in the organ itself.

Cryptorchidism is the delayed testicular descent. Cryptorchidism is a fairly common anomaly of the reproductive organs in childhood, creating multiple health and social problems. It is usually combined with other anomalies and chromosomal abnormalities, resulting in a large number of options of this disease. This requires the surgeon's profound knowledge of anatomy and surgical treatment options. The lack in the development of sexual organs at cryptorchidism is already observed in the neonatal period, while the secondary sexual characteristics are delayed for 2–3 years compared to healthy children.

Orchidopexy is the name of the surgical operation associated with the immobilization of the testis cryptorchidism.

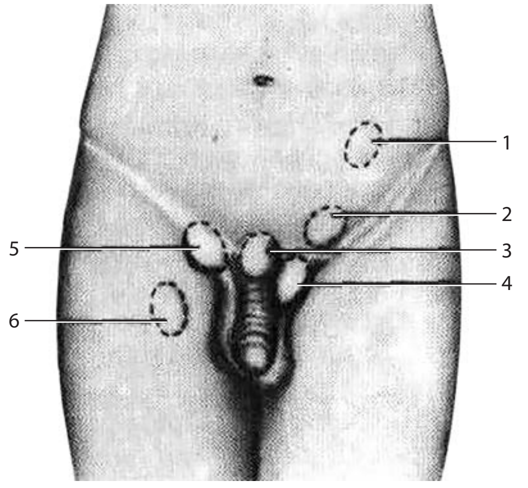


Fig. 67. Ectopic of the testis:
1 – abdominal; 2, 4, 5 – inguinal;
3 – pubic; 6 – femoral

Cryptorchidism can be inguinal (uni- or bilateral), intraperitoneal (uni- or bilateral). False and acquired cryptorchidism are distinguished. The most common classification of cryptorchidism according S. Schirren (1964):

- high physiological placing testes at birth (the testes descend itself by the end of 3–12 months old);
- wandering testis (false cryptorchidism);
- rolling testis (the normal value testis is above the superficial inguinal ring; it can descend into the scrotum, but it quickly returns to the same place);
- retention of the testes (due to mechanical obstruction normal testes retain to the inguinal canal or to the entrance of it);
- cryptorchidism uni-or bilateral (testises are undeveloped, highly placed and can not descend in the scrotum);
- ectopia (deviation from the norm during descending testes into the scrotum). Ectopic testis occurs when the testis does not descend into the scrotum through the inguinal canal, but through the femoral canal or turns to other parts of the inguinal canal. At the heart of this anomaly, there are different mechanical reasons that violate migration testis (connective tissue septum at the entrance to the scrotum, narrow inguinal canal, adhesions in the inguinal canal). The testis usually placed under the skin of the anterior abdominal wall in the inguinal area on the aponeurosis of the external oblique muscle, pubic region (ectopia pubopenialis). There are cases of testicular location near the penis, on the medial or anterior surface of the femur (ectopia femoralis), the perineum (ectopia perinealis). Less common transverse ectopia (ectopia transversum) happens when both testes are in the same half of the scrotum. Ectopic testis is 4 % of all anomalies. In children, testicular ectopia shows no signs of hormone deficiency and eunuhoidism.

The spermatic cord, funiculus spermaticus

The spermatic cord is a round strand approx. 20 cm long, which suspends the testis. The cord is a complex of structures enfolded into the same tunics as the testis is (but for the tunica vaginalis). The cord comprises the structures as follows:

- the ductus deferens;
- the testicular artery;
- the artery to ductus deferens;
- the pampiniform plexus continuous with the testicular vein;
- the lymphatic vessels;
- the nerves.

The cord runs upwards, enters the inguinal canal and reaches the deep inguinal ring where terminates because the constituents of the cord part.

The ductus deferens, ductus deferens

The ductus deferens arises directly from the duct of epididymis. It is 40–50 cm long, has thick wall and small lumen diameter (0.5 mm). The ductus is well palpable through skin. The wall consists of serosa, muscular tunic and adventitia. Best developed is the muscular tunic, which comprises three layers (Fig. 68).

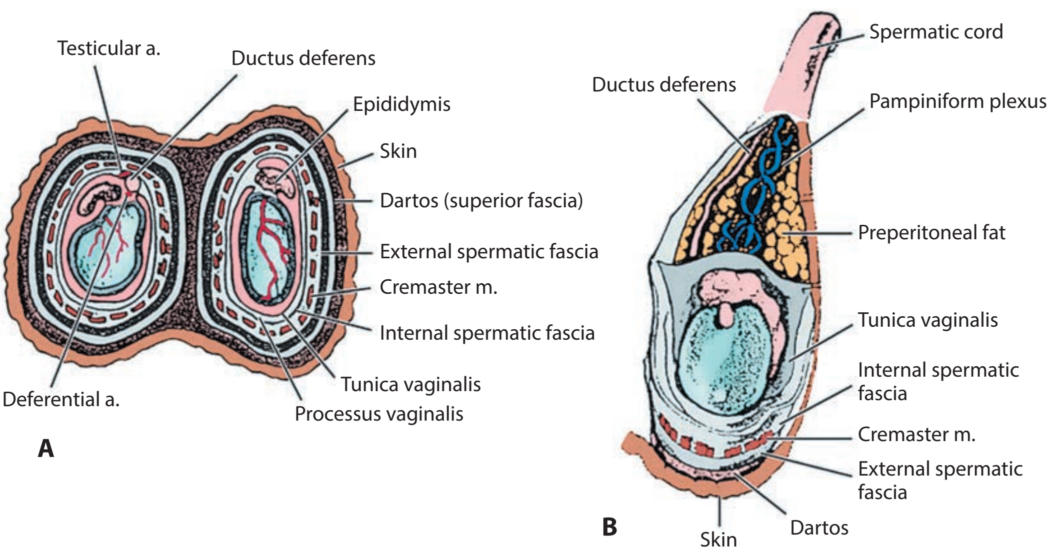


Fig. 68. The structure of scrotum and testis.
A – cross section of scrotum and testis. **B** – anterior view of left testis (the parietal layer of the tunica vaginalis and spermatic cord has been opened)

Relations. The ductus deferens leaves the scrotum and passes through the inguinal canal to reach the abdominal cavity. It has four segments – the scrotal part, the funicular part, the inguinal part and the pelvic part:

- the scrotal part, *pars scrotalis*, is the first shortest segment, which begins at the tail of epididymis and runs along the posterior border of testis medially to the epididymis;
- the funicular part, *pars funicularis*, it runs upwards within the spermatic cord lying posteromedially to neighboring vessels. This part constitutes almost a half of the entire ductus; it terminates at the superficial inguinal ring (Fig. 69);
- the inguinal part, *pars inguinalis* runs through the inguinal canal;
- the pelvic part, *pars pelvica* begins at the deep inguinal ring and enters the lesser pelvis. It descends along the lateral pelvic wall first laterally and then posterior to the urinary bladder. Running anteromedially to the ureter the part reaches the prostate where lies medially to the seminal glands. The terminal segment of the part becomes dilated to form the ampulla of ductus deferens, *ampulla ductus deferentis*. Inferior to the ampulla, the ductus narrows again and merges with the excretory duct (of the seminal gland) to form the ejaculatory duct, *ductus ejaculatorius*. The latter penetrates the parenchyma of prostate and opens into the prostatic urethra laterally to the seminal colliculus.

Arterial blood is supplied by the artery to ductus deferens *(a. ductus defemtis)* and branches of the middle rectal artery *(a. rectalis media)* and inferior vesical artery

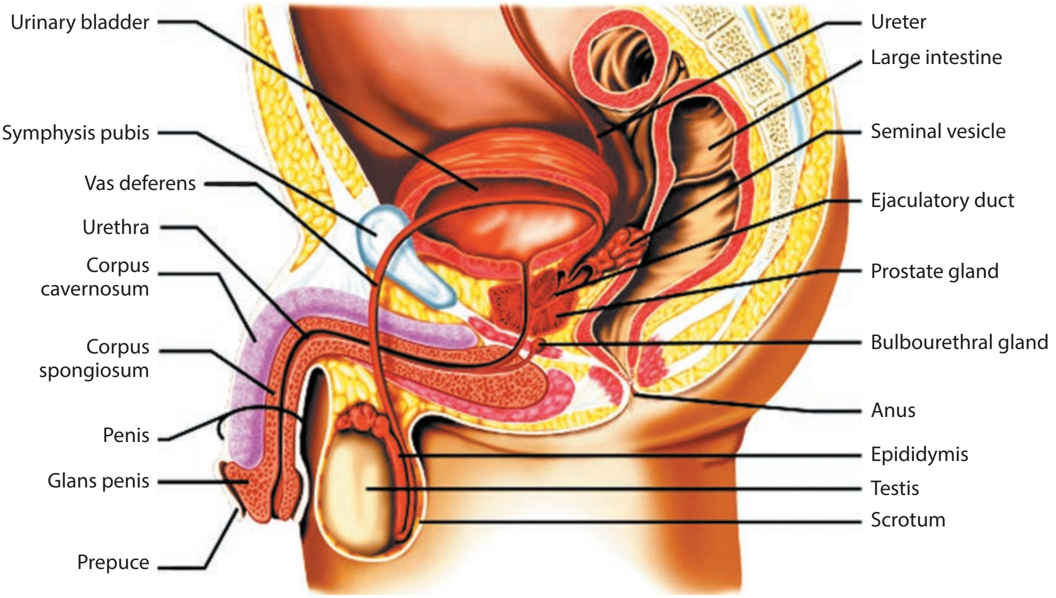


Fig. 69. Syntopy of the ductus deferens

(*a. vesicalis inferior*), which arise from internal iliac artery. Vein blood drains to the vesical venous plexus and further to the internal iliac artery.

Lymph drains to the internal iliac nodes.

Innervation is provided by the branches of inferior hypogastric plexus (Fig. 70).

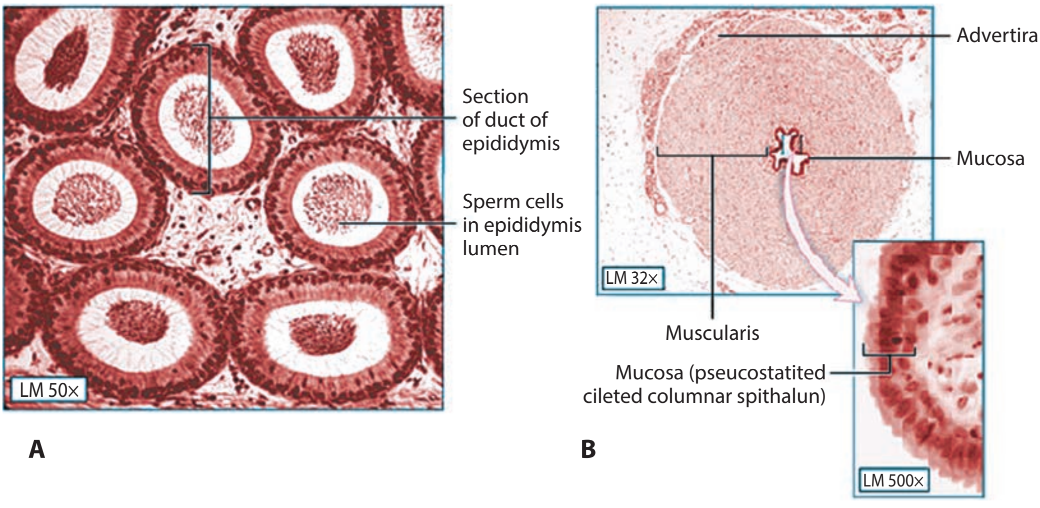


Fig. 70. The structure of the male internal genitalia.
A – the structure of the ductus deferens. **B** – the structure of the epididymis

The seminal gland, vesicula seminalis

The seminal gland is a paired elongated organ (5 cm long, 3 cm wide) with bumpy surface. Its superior portion is dilated and the narrower inferior portion is continuous with the excretory duct, *ductus excretorius*. Stretched gland appears as a tube 15 cm long. The gland is covered with the adventitia, which compacts the tube. The muscular layer and mucosa are well developed. The seminal glands lie posterior to the urinary bladder, laterally to the ampullae of ductus deferens and next to the base of prostate. The rectum lies posterior to the glands. The seminal gland is a special gland, which produces the sperm component.

Blood supply: arterial blood is supplied by the artery to ductus deferens (a. ductus deferentis). Vein blood drains to the vesical venous plexus and further to the internal iliac artery.

Lymph drains to the internal iliac nodes.

Innervation: branches of inferior hypogastric plexus (Fig. 71–72).

In cildren:

- in newborn seminal vesicles are located high in the abdominal cavity and well formed. The seminal vesicles of newborn weigh 0.05g. They are developed

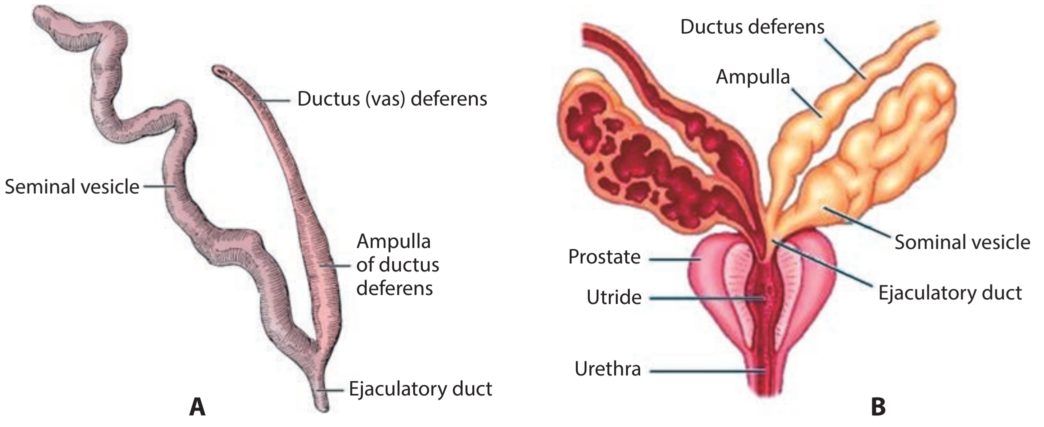


Fig. 71. Scheme of the formation of the ejaculatory duct

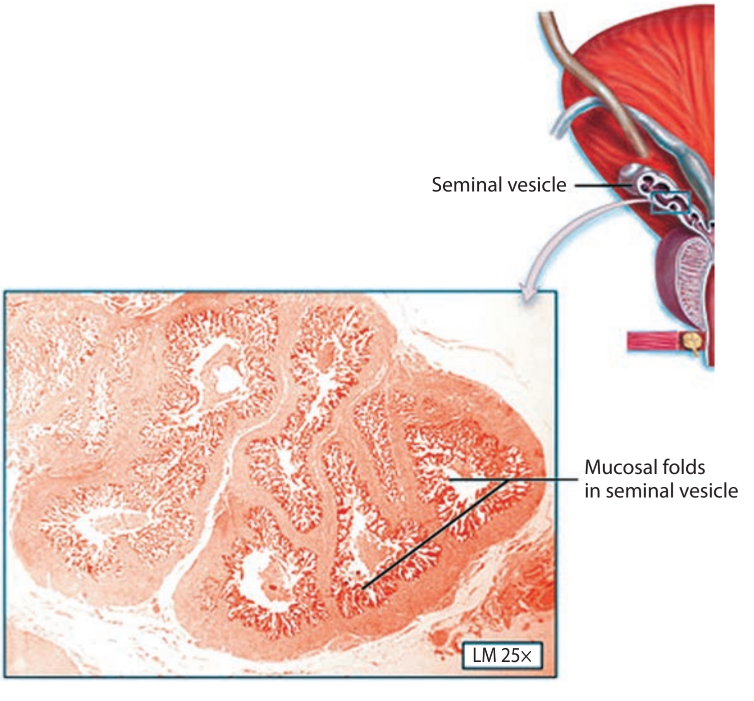


Fig. 72. The structure of the seminal vesicle

slightly before puberty, and during puberty there is a rapid increase of size and weight.

Clinical applications. The vesicles can be felt on rectal examination if enlarged; this occurs typically in tuberculous infection.

The prostate, prostata

The prostate is an unpaired organ, which resides in the lesser pelvis cavity inferior to the urinary bladder. It appears as a chestnutlike body sized 2×3×4 cm. The gland produces prostatic fluid. The prostate passes the urethra and ejacula-tory duct (Fig. 73).

Parts and surfaces. The prostate has parts and surfaces as follows:

- the base of prostate, *basis prostatae*, the superior part fixed to the fundus of bladder. Its posterior surface has a slit-like excavation which passes the ejaculatory ducts;
- the apex of prostate, *apex prostatae*, the part fixed to the perineal membrane;
- the anterior surface, *facies anterior*, a convex surface related to the pubic symphysis;

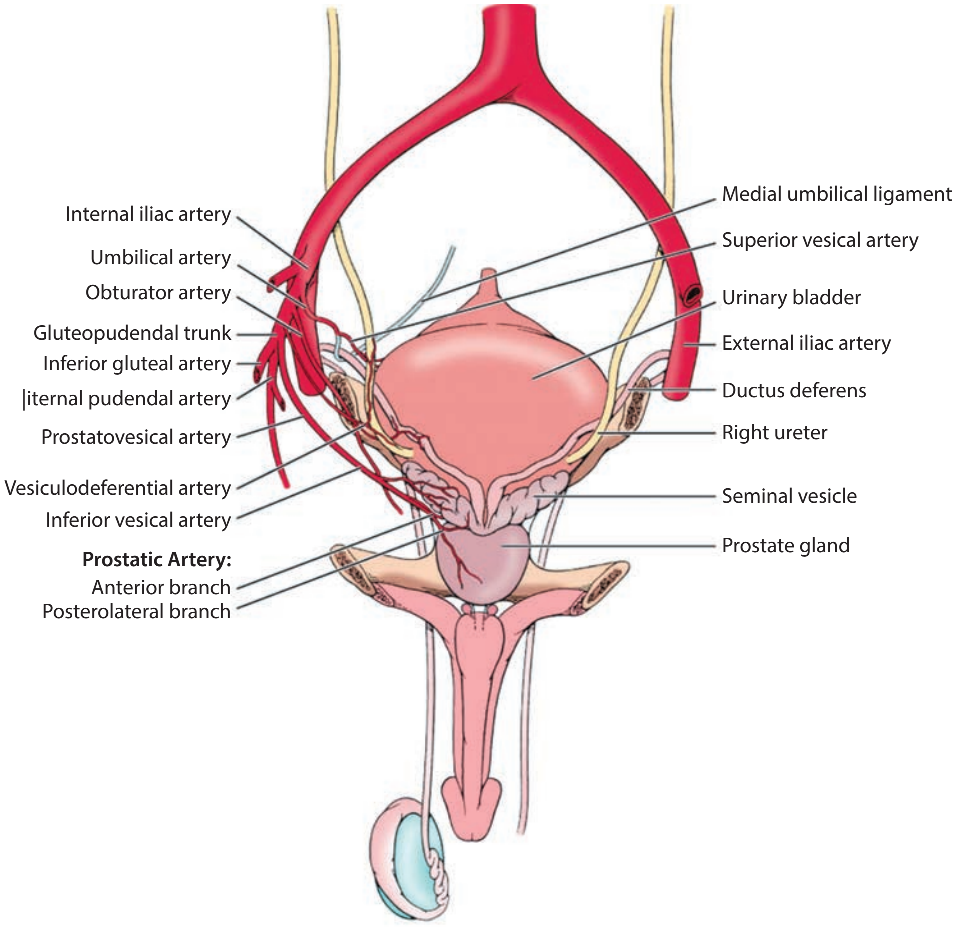


Fig. 73. Relations and vascularisation of the prostate, seminal vesicles, and ductus deferens

- the posterior surface, *facies posterior*, a flat surface related to the rectal ampulla;
- the inferolateral surface, *facies inferolateralis*, a rounded surface facing the venous plexus and the levator ani
- the right and left lobes ofprostate, *lobi prostatae dexter et sinister*, the lateral largest portions of the organ, which neighbor the levator ani;
- the isthmus of prostate, *isthmus prostatae*, which lies posterior to the urethra. The isthmus is confined between the ejacula- tory ducts; its superior portion fixes to the urinary bladder (in elderly individuals the isthmus often enlarges and protrudes into the bladder cavity causing thus urine retention).

Relations. The anterior surface fixes to the pubic symphysis with muscular fibers – the puboprostaticus, m. puboprostaticus.

The space between the pubic bones and prostate contains loose connective tissue and a large vesical venous plexus. The posterior surface has a scarcely noticeable groove, which delimits the lobes. This surface is related to the rectal ampulla so the prostate is easily palpable through the rectal wall. The prostate and rectum are separated by the rectovesical septum, septum rectovesicale.

Superiorly the prostate neighbors the bladder, the seminal glands and the ejaculatory ducts.

Interior of the prostate. The prostatic urethra passes through the entire gland from the base to the apex. The posterior wall of the urethra segment contains the seminal colliculus, colliculus seminalis (Fig. 74).

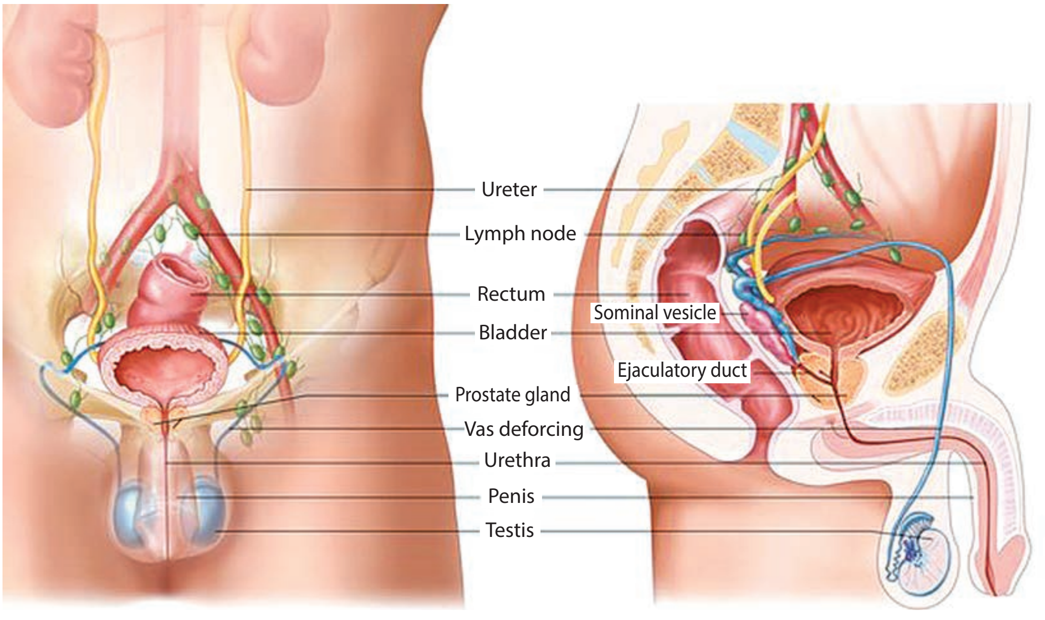


Fig. 74. Relations of pelvic viscera and perineum in male

On the apex of colliculus there is a small culdesac – the prostatic utricle, *utriculus prostaticus*, which opens into the urethra with a slit-like orifice. Laterallyto the utricle, there are the openings of ejaculatory ducts. The latter pass downwards, slantwise and medially through the prostate parenchyme to confine the isthmus. The prostate is enfolded into the capsule of prostate, capsula prostatica, which radiates into depth of prostate to form septa.

The prostatic matter comprises the parenchyma and muscular tissue:

- the parenchyma, (Lat. Id.) consists of 30–50 alveolar-tubular glands, which open with separate orifices on the urethral mucosa laterally to the seminal colliculus. The glands produce a prostatic secretion with characteristic smell. The glandular portion is concentrated mainly in the posterolateral portions of organ;
- the muscular tissue, substantia muscularis consists of smooth situated predominately in the anterior portion of the prostate. The muscular tissue is well developed so the prostate appears dense; around the urethra, the muscular fibers form a circular layer, which joins the fibers of bladder to form the internal urethral sphincter, m. sphincter urethrae intemus (Fig. 75).

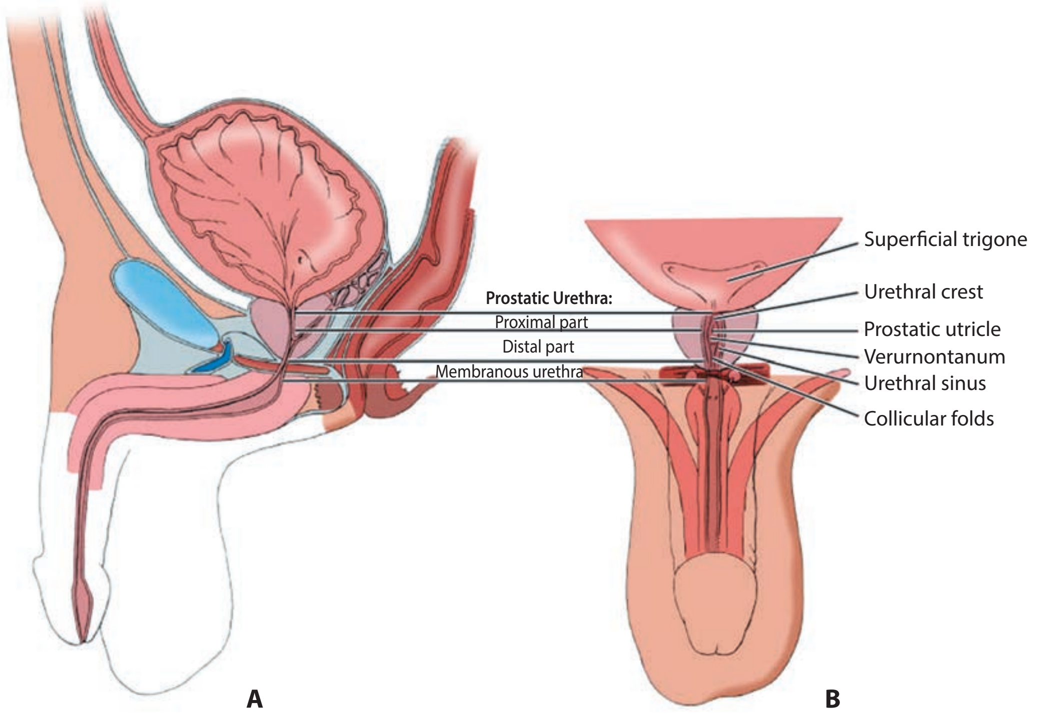


Fig. 75. Sagittal and anterior views of male reproductive organs

Clinical applications

1. Although the prostate gland is relatively small in male children, it begins to grow in early adolescence and reaches its adult size a few years later. As a rule, its size remains unchanged between the ages of twenty and fifty. In older males, however, the prostate gland commonly enlarges. As this happens, the gland may squeeze the urethra and interfere with urination.

2. The treatment of an abnormally enlarged prostate gland is usually surgical. If the obstruction created by the gland is slight, the procedure may be performed through the urethral canal and is called a transurethral prostatic resection.

3. The prostate gland is a common site of cancer in older males. Such cancers are usually stimulated to grow more rapidly by the male sex hormone, testosterone, and are inhibited by the female sex hormone, estrogen. Consequently, treatment for this type of cancer may involve removing the testes (the main source of testosterone), administering drugs that block the action of testosterone, or administering estrogen. Although such treatment usually does not stop the cancer, it may slow its development.

4. Prostatectomy for benign prostatic hypertrophy involves removal of the hypertrophic mass of glandular tissue from the surrounding normal prostate, which is compressed as a thin rim around it – a false capsule. This is usually performed transurethrally by means of an operating cystoscope armed with a cutting diathermy loop. During this procedure, the verumontanum, (colliculus seminalis), is an important landmark. The surgeon keeps his resection above this structure in order not to damage the urethral sphincter. If the prostate is very enlarged, open prostatectomy is indicated. The gland is approached retropubically, the capsule incised transversely and the hypertophied mass of gland enucleated.

5. After the age of 45 years some degree of prostatic hypertrophy is all but invariable; it is as much a sign of ageing as greying of the hair. Usually the lateral lobes are affected and such enlargement is readily detected on rectal examination. The median lobe may also be involved in this process or may be enlarged without the lateral lobes being affected. In such an instance, symptoms of prostatic obstruction may occur (because of the valve-like effect of this hypertrophied lobe lying over the internal urethral orifice) without prostatic enlargement being detectable on rectal examination.

Anterior to the urethra the prostate consists of a narrow fibromuscular isthmus containing little, if any, glandular tissue. Benign glandular hypertrophy of the prostate, therefore, never affects this part of the organ.

6. The fascia of Denonvilliers is important surgically; in excising the rectum it is the plane to be sought after in order to separate off the prostate and urethra without damaging these structures. A carcinoma of the prostate only rarely penetrates this fascial barrier so that ulceration into the rectum is very unusual.

Male infertility. In a male, infertility is the lack of the ability to induce fertilization of an egg cell. This condition can result from a variety of disorders. For example, if during development the testes fail to descend into the scrotum, the higher temperature of the abdominal cavity or inguinal canal prevents the formation of sperm cells by causing the cells in the seminiferous tubules to degenerate. Similarly, certain diseases, such as mumps, may cause an inflammation of the testes (orchitis) and produce infertility by destroying the cells of the seminiferous tubules. Other males are infertile because of a deficiency of sperm cells in their semen. Normally, a milliliter of this fluid contains about 120 million sperm cells, and although the estimates of the number of cells necessary for fertility vary, 20 million sperm cells per milliliter in a release of 3 to 5 milliliters is often cited as the minimum for fertility. Even though a single sperm cell is needed to fertilize an egg cell, many sperm must be present at the time. This is because each sperm cell can release enzymes that are stored in its acrosome. A certain concentration of these enzymes is apparently necessary to remove the layers of cells that normally surround an egg cell, thus exposing the egg cell for fertilization. Still other males seem to be infertile because of the quality of the sperm cells they produce. In such cases, the sperm cells may have poor motility, or they may have abnormal shapes related to the presence of defective genetic material.

The bulbo-urethral gland, glandula bulbourethralis is a paired small rounded gland, which lies in depth of perineal membrane. Each gland has a long (3–4 cm long) duct of bulbo-urethral gland, *ductus glandulae bulbourethralis*, which opens into the urethra in the segment related to the bulb of penis. The gland produces viscous secretion, which humidifies the urethra and prevents urethral mucosa from irritation.

Blood supply is provided by numerous branches of the inferior vesical arteries (aa. vesicales inferiores) and the middle rectal artery (aa. rectales media). Vein blood drains to the prostatic venous plexus (plexus venosus prostaticus) and to the branches of inferior vesical veins.

Lymph drains to deep iliac nodes.

Innervation: the branches of inferior hypogastric plexus (Fig. 76–79).

In children:

- in newborn prostate and seminal vesicles are large by size and are located in the pelvis higher than in adults. Prostate weight at birth is 0.82 g, it has a round shape. During puberty, the gland takes the shape of a chestnut and reaches its full development up to 21–25 years old.

Anomalies of the prostate

Aplasia is a missing prostate. This anomaly is very common and is a result of abnormal development. It can grow with genital atresia, bladder exstrophy and underdevelopment of the lower half of the body, the absence of testes, spermatic cord and seminal vesicles.

Hypoplasia is a congenital hypoplasia of the prostate. This anomaly is due to an abnormality of the external genitalia.

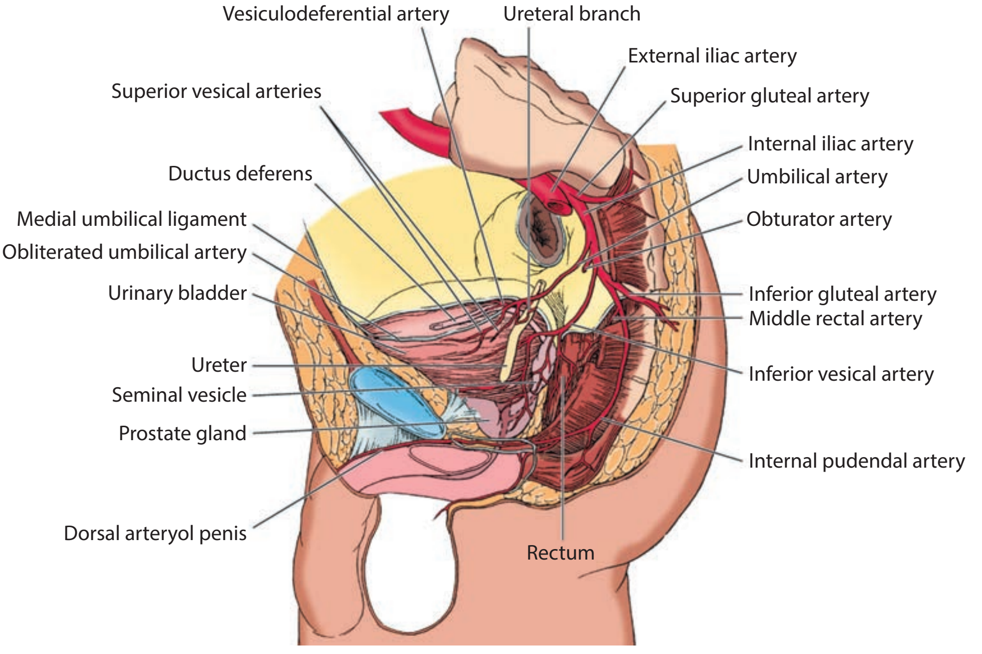


Fig. 76. Blood supply of the prostate

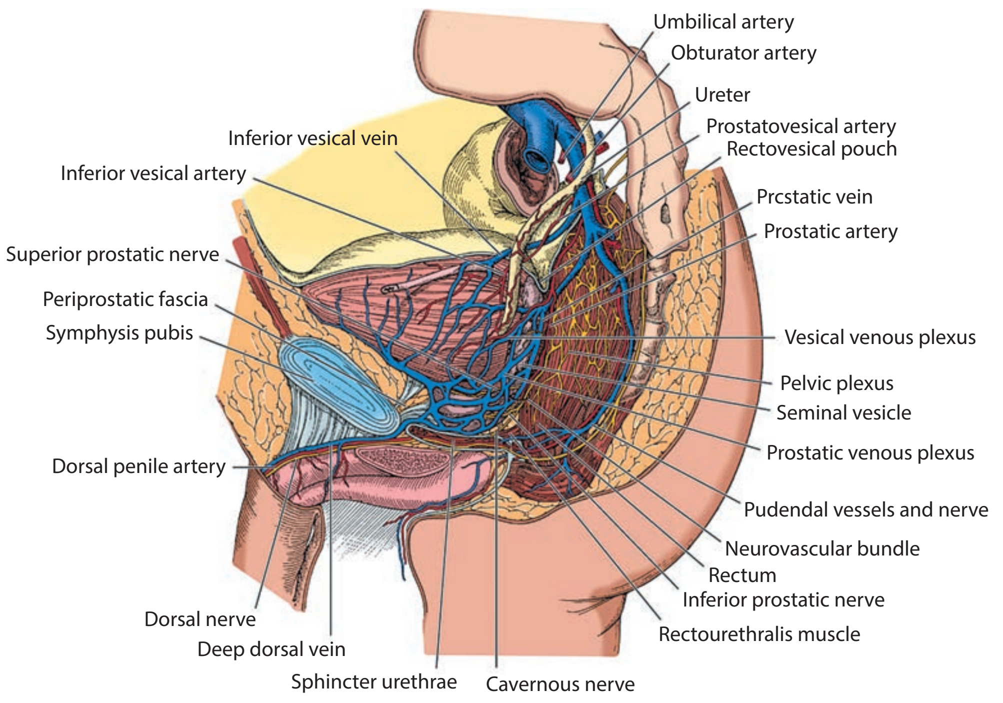


Fig. 77. Venous drainage of the prostate

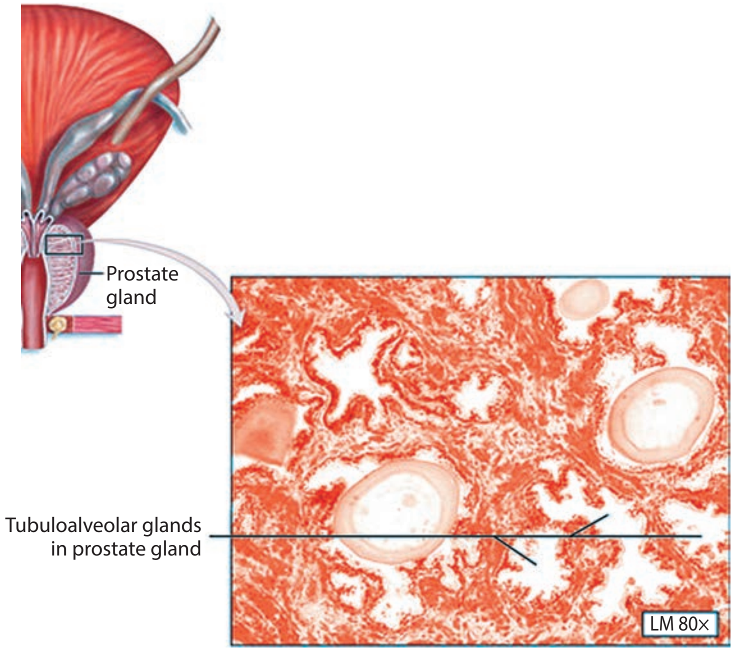


Fig. 78. The structure of the prostate

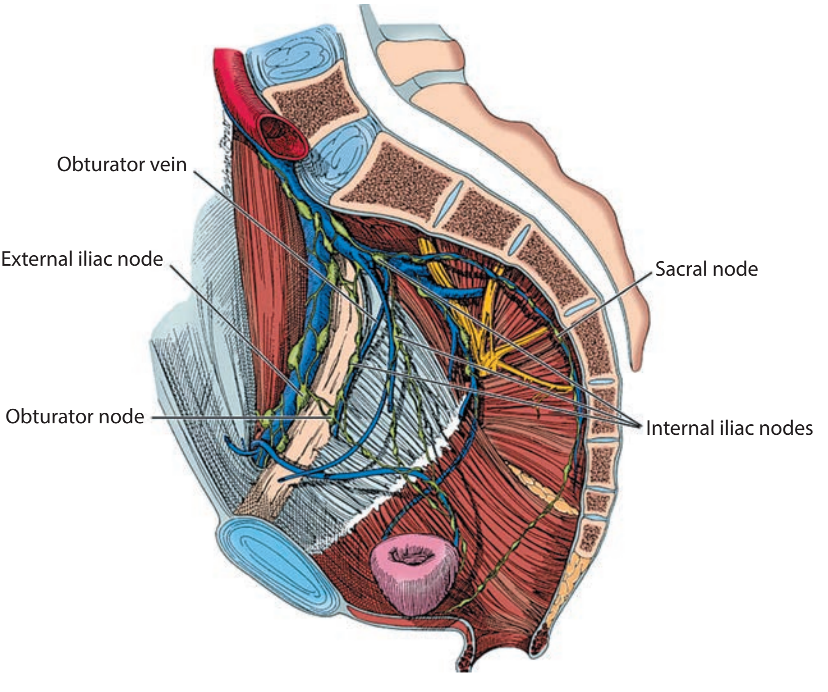


Fig. 79. The lymphatic drainage of the prostate

Atrophy is a congenital reduction of the prostate. This anomaly is associated with anomalies of the genital and urinary tract (bladder exstrophy, epispadias, polycystic kidney disease).

Ectopic prostate is very rare. At this anomaly, separate parts of the prostate gland can be in the neck of the bladder, in different parts of the urethra and penis, as well as between the seminal vesicles.

THE MALE EXTERNAL GENITALIA, ORGANA GENITALIA MASCULINA EXTERNA

The penis, penis

Synonym 'phallus' (Greek) gives birth to phalloplasty and other medical terms. The penis is a copulatory organ; it features cylindrical shape and consists of two paired corpora cavernosa and single corpus spongiosum. In the exterior of penis the dorsum of penis, *dorsum penis* and the *urethral surface*, facies urethralis are distinguishable.

Parts. The penis has parts as follows:

- the root of penis, *radix penis* the posterior portion fixed to the pubic bones;
- the body of penis, *corpus penis* the larger middle portion of the organ;
- the glans penis (Lat. Id.) the anterior expanded cone-shaped portion with prominent posterior ridge – the corona of glans, corona glandis. Posterior to the corona, there is a narrower portion called the neck of glans, collum glandis. On the tip of glans there is an opening of urethra (Fig. 80);

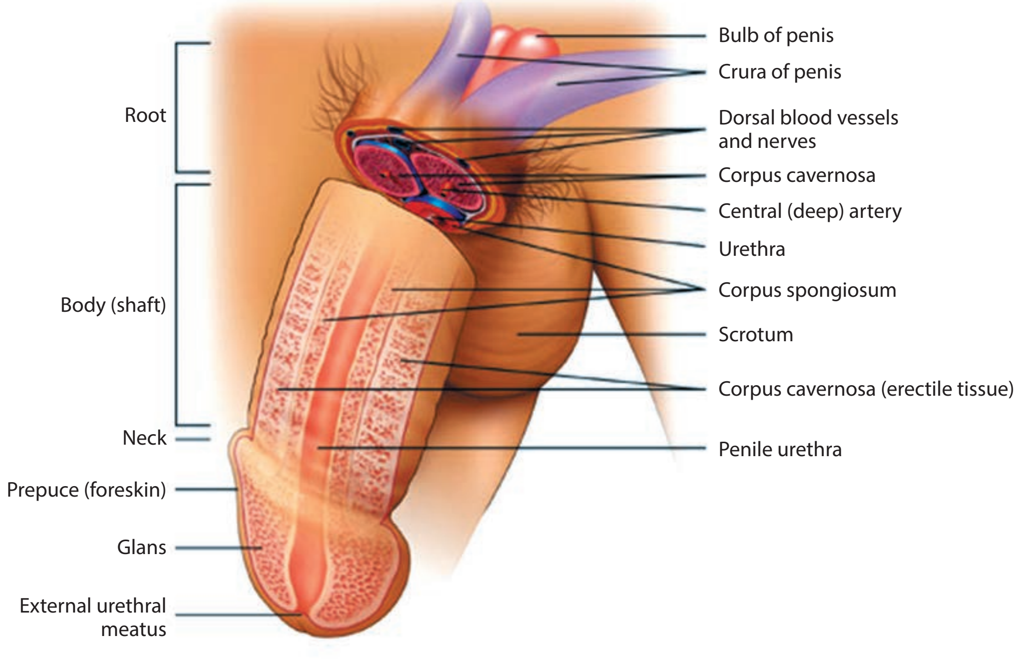


Fig. 80. The structure of the penis

- the prepuce, *preputium penis* a fold formed of skin duplication, which enfolds the glans (on the urethral surface there is a frenulum, frenulum preputii, which runs to the urethral orifice).

The corpora cavernosa penis (Lat. Id.). The posterior portions called the crura of penis, *crura penis* fix to the inferior pubic rami and the rami of ischium. The anterior portions are pointed and fix to the glans. The corpora form a firm junction; the fibrous tissue filling the junction is called the septum penis.

The corpus spongiosum penis (Lat. Id). The corpus spongiosum lies in deep median groove between the corpora cavernosa on the urethral surface of penis. Its anterior portion forms the glans, glans penis, resembling a mushroom cap. Pointed tips of the corpora cavernosa, fit the excavation on the posterior surface of glans. The posterior expanded portion of corpus spongiosum is called the bulb of penis, *bulbus penis*.

The bulb of penis adheres to the perineal membrane. The corpus spongiosum passes the urethra.

Interior of the corpora cavernosa. The corpora cavernosa are covered with dense tunica albuginea of corpora cavernosa, *tunica albuginea corporum cavenosorum* (approx. 2 mm thick), which gives the trabeculae of corpora cavernosa, *trabeculae corporum cavenosorum* in depth of the corpora. The trabeculae form numerous endothelium-lined cells, which contain blood. The cells communicate with the veins and arteries. The latter are much convoluted (the helicine arteries, *aa. helicinae*) and have

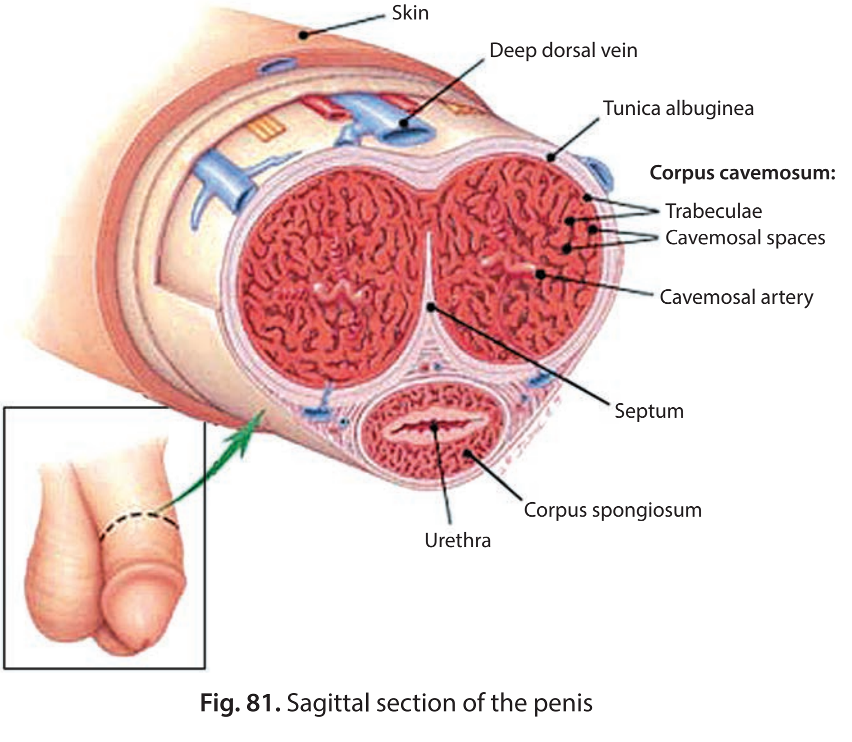


Fig. 81. Sagittal section of the penis

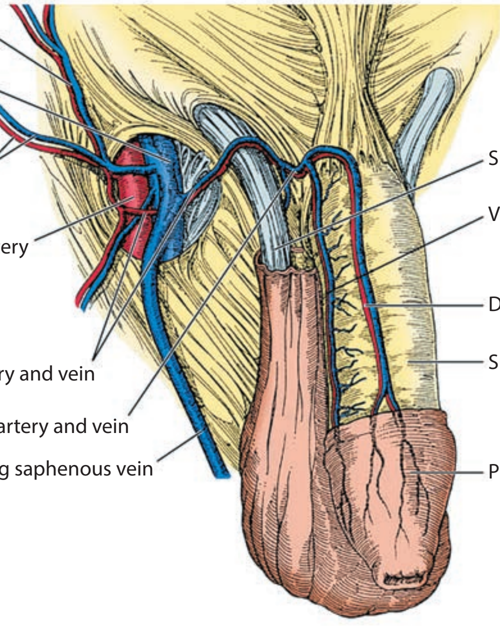


Fig. 82. Superficial arterial system

cushion-like projections, which regulate blood influx. Sexual excitement eventually leads to blood influx into the cells and the penis enlarges and becomes turgid (penile erection) (Fig. 81–82).

The corpus spongiosum has the similar structure but its tunica albuginea is much thinner and the cells are smaller.

Fascia and ligaments. Both corpora cavernosa and the corpus spongiosum are covered with deep and superficial fascia of penis, fascia penis profunda et superficialis; the deep fascia is much better developed. At the pubic symphysis, the fascia pass onto the abdominal wall to form the following ligaments:

- the *fundiform ligament of penis*, ligamentum funduforme penis running from the inferior portion of the pubic symphysis; it enfolds the penis from two sides and interlaces into the tunica albuginea of corpora cavernosa;
- the *suspensory ligament of penis*, ligamentum suspensorium penis running sagittaly; it appears as a strong triangular plate, which arises from the superficial abdominal fascia at the linea alba and interlaces into the superficial fascia of penis.

The skin covering the penis is thin and movable; at the glans, where it eventually attaches it becomes thinner and devoid of subcutaneous layer. Internal surface of the prepuce contains the openings of preputial glands, *glandulae preputiales*. These glands produce the preputial smegma, *smegma preputii*. On the urethral surface of prepuce, there is the raphe of penis, *raphe penis*, which runs midline (Fig. 83–84).

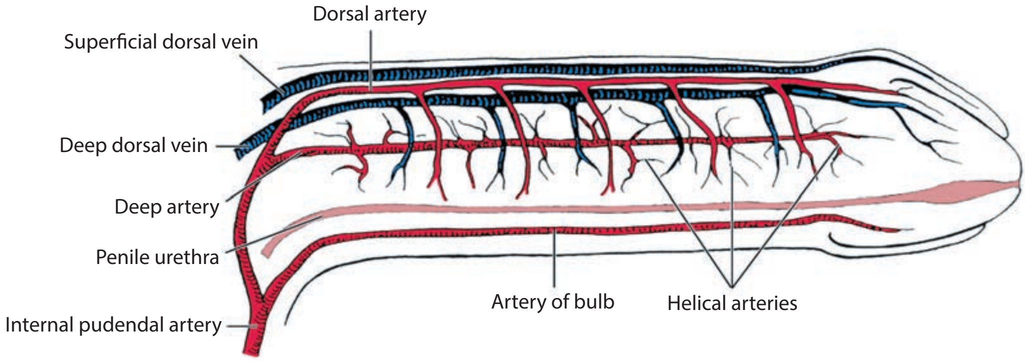


Fig. 83. Blood supply and venous drainage of the penis

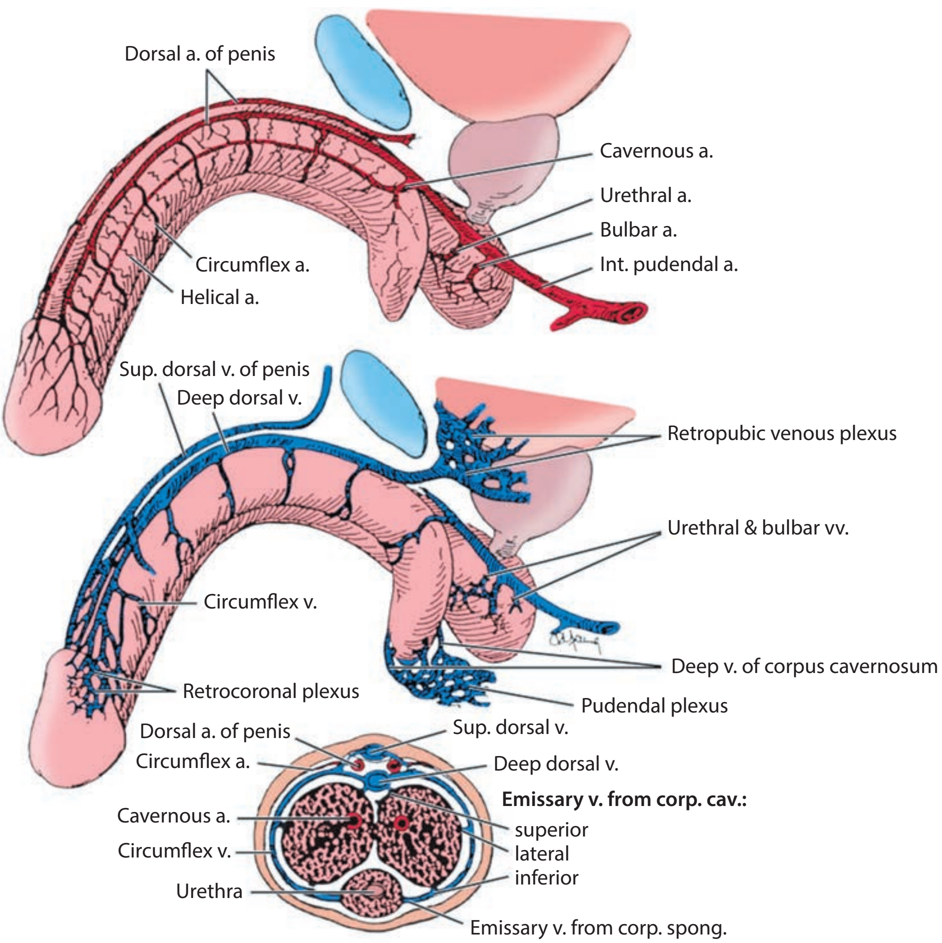


Fig. 84. Vascularization of penis

Blood supply. Skin and tunics of the penis receive arterial blood via the anterior scrotal branches (rr. scrotales anteriores) arising from deep external pudendal artery and via the dorsal artery of penis (a. dorsalis penis) arising from the internal pudendal artery. The corpora cavernosa and corpus spongiosum receive blood via the deep artery of penis (a. profunda penis) and dorsal artery of penis (a. dorsalis penis) arising from the internal pudendal artery. The bulb of penis is supplied by the artery of bulb of penis (a. bulbi penis), the corpus spongiosus receive supplementary urethral arteries (aa. uretrales), which both also arise from the internal pudendal artery. Vein blood drains via the deep dorsal vein of penis (v. dorsalis penis profunda) and via the vein of bulb of penis (v. bulbi penis) to the vesical venous plexus. Vein blood takes supplementary route via deep veins of penis (w. profundae penis) to the internal pudendal vein (v. pudenda interna).

Lymphatic vessels run to the internal iliac and superficial inguinal nodes.

Innervation: sensory nerve is the dorsal nerve of penis (n. dorsalis penis), which arises from the pudendal nerve. Sympathetic fibers arise from the inferior hypogastric plexus (plexus hypogastricus inferior) and parasympathetic – from the pelvic splanchnic nerves (nn. splanchnici pelvini).

The scrotum, scrotum

The scrotum is a sac-like outgrowth of the anterior abdominal wall, which supports and protects the testes and testicular tunics. The thin skin is heavily pigmented, wrinkled and contains numerous sebaceous and sweat glands. The scrotal cavity is subdivided into two compartments by the septum of scrotum, *septum scroti* appearing on skin surface as the raphe of scrotum, *raphe scroti*. Subcutaneous layer contains well-developed smooth muscle fibers, which form the dartos muscle, *m. dartos*.

Blood supply and venous drainage. The scrotal walls contain the anterior scrotal branches (rr. scrotales anteriores), which arise from the external pudendal artery and the posterior scrotal arteries (rr. scrotales posteriores) which arise from the perineal artery. The cre- master is supplied by the cremasteric artery (a. cremasterica) arising from the inferior epigastric artery. The anterior scrotal veins (w. scrotales anteriores) flow into the femoral vein and the posterior scrotal veins (w. scrotales posteriores) – into the internal pudendal veins (Fig. 85).

Lymphatic vessels flow into superficial inguinal nodes.

Innervation is provided by the anterior scrotal nerves (nn. scrotales anteriores) arising from the genitofemoral nerve and the posterior scrotal nerves (nn. scrotales posteriores) arising from the pudendal nerve. Non-striated muscles are supplied by the inferior hypogastric plexus (plexus hypogastricus inferior) (Fig. 86).

Clinical applications. The scrotal subcutaneous tissue is continuous with the fasciae of the abdominal wall and perineum and therefore extravasations of urine or blood deep to this plane will gravitate into the scrotum. The scrotum is divided by a septum into right and left compartments but this septum is incomplete superiorly so extravasations of fluid into this sac are always bilateral.

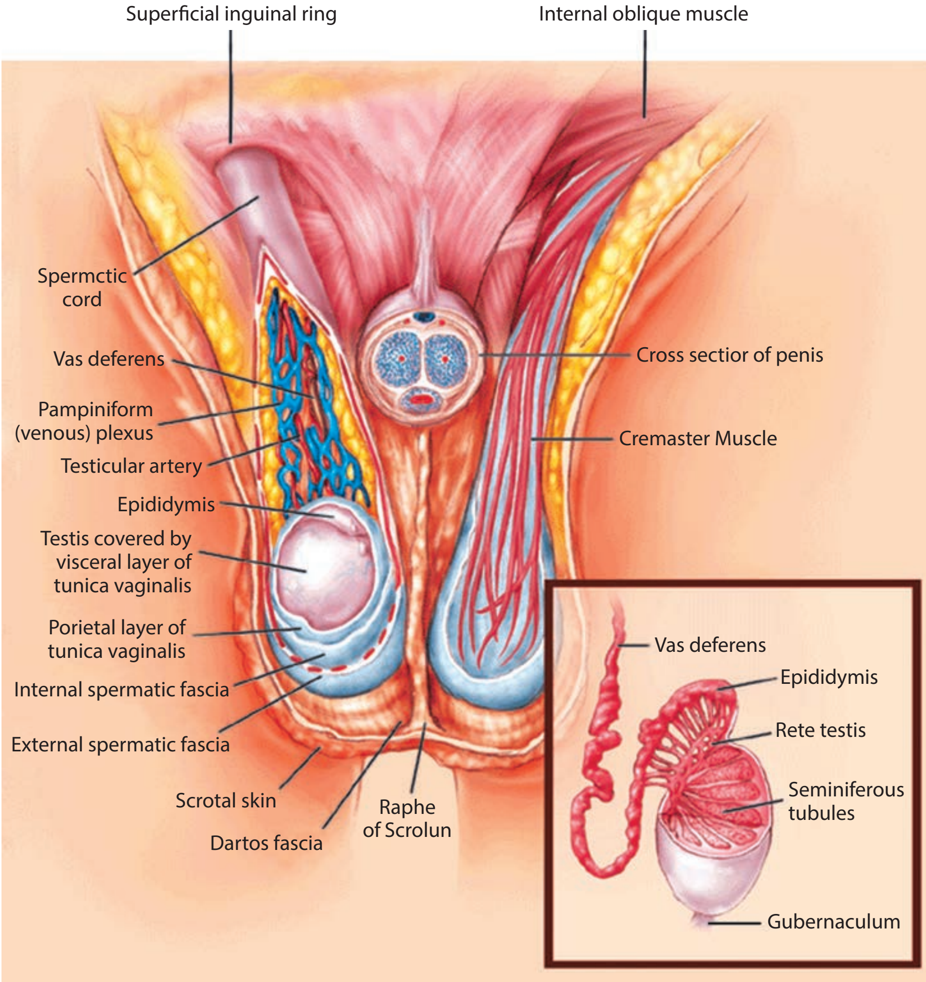


Fig. 85. Anterior surface of the scrotum

The lax tissues of the scrotum and its dependent position cause it to fill readily with oedema fluid in cardiac or renal failure. Such a condition must be carefully differentiated from extravasation or from a scrotal swelling due to a hernia or hydrocele.

The male urethra, urethra masculina

The male urethra is responsible for urine and sperm withdrawal. It is 18–20 cm long and 5–8 mm wide. The urethra begins with the internal urethral orifice, *ostium uretrae internum* within the bladder, passes through the prostate, the perineal mem-

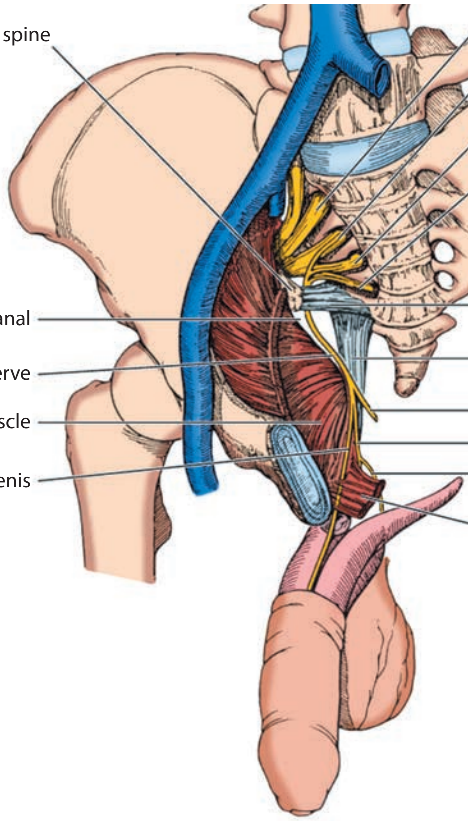


Fig. 86. Somatic innervation of the penis

brane, the corpus spongiosum of penis and opens with the external urethral orifice, *ostium urethrae externum* on the tip of glans of penis. In the male urethra three parts are distinguished:

1) the prostatic part;
2) the intermediate part;
3) spongy.

The prostatic part, *pars prostatica* is 2–3 cm long. It runs vertically through the prostate. The middle portion is dilated and contains the urethral crest, *crista urethralis* with associated seminal colliculus, *colliculus seminalis* (1.5–2 cm long, 3–4 mm high). The seminal colliculus contains the prostatic utricle; laterally to the colliculus, the ejaculatory ducts open. Numerous prostatic glandules open into the space between the seminal colliculus and urethral wall (the prostatic sinus, *sinus prostaticus*).

The intermediate part, *pars intermedia* 1–1.5 cm long, the narrowest of three parts runs slantwise, anteroposteriorly to penetrate the perineal membrane. The striated muscle fibers encircle the intermediate part to form the external urethral sphincter, m. sphincter urethrae externus.

The spongy urethra, *pars spongiosa* is the longest (15–16 cm long) one; it passes through the corpus spongiosus. The dilated posterior portion contains orifices of the bulbo-urethral glands. The anterior also dilated portion of the segment is called the navicular fossa, *fossa navicularis* (approx. 1 cm long). The urethral mucosa contains the urethral glands, *gll. urethrales* and blind excavations called the urethral lacunae, *lacunae urethrales*; the latter are of practical significance because infectious agents are most likely to retain in the lacunae. The lacunae open mostly in the navicular fossa (Fig. 87).

Urethral flexures. S-shaped urethra has two distinguishable flexures:

- a flexure inferior to the pubic symphysis; it arches posteroinferiorly. It runs from the apex of prostate to the suspensory ligament. This is the fixed part of the urethra (Fig. 88);
- a flexure anterior to the pubic symphysis arching superoanteriorly. During catheterization it's possible to straighten this free part of urethra elevating the penis.

Dilations and constrictions of the urethra. Narrowed segments of the urethra are:

- the external urethral orifice, which appears as a vertical slit;
- the intermediate part, which is the narrowest one (4 mm of diameter). This part is the most difficult for catheter to pass;
- the internal urethral orifice.
- dilated segments of the urethra are:
- the navicular fossa (9–10 mm of diameter);
- the bulb-related part (10–12 mm of diameter);
- the middle segment of prostatic part (up to 12 mm).

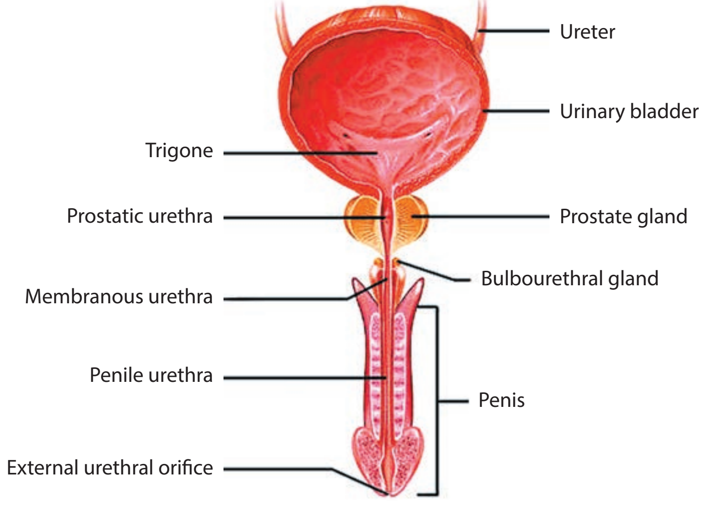


Fig. 87. The male urethra

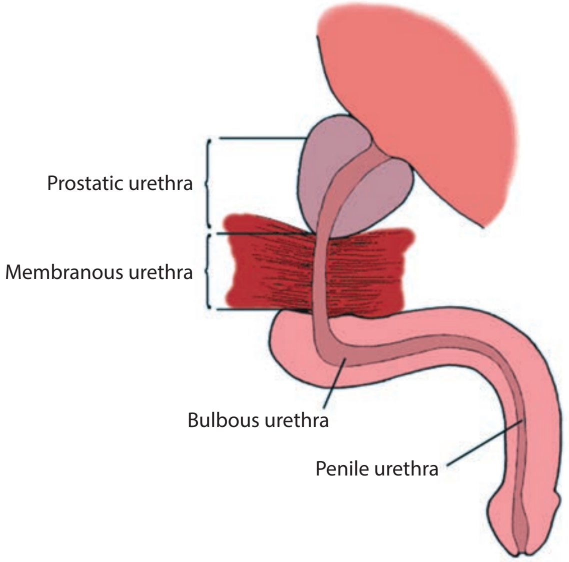


Fig. 88. Urethral flexures

Clinical applications

1. Most common pathologies of the urethra are inflammatory diseases (especially gonorrhea), which result in strictures formation. During treatment it is necessary to keep in mind the lacunae and urethral glands, which may retain the infectious agent.

2. Where the urethra passes beneath the pubis is a common site for it to be ruptured by a fall astride a sharp object, which crushes it against the edge of the symphysis.

3. The external orifice is the narrowest part of the urethra and a calculus may lodge there. Immediately within the meatus, the urethra dilates into a terminal fossa whose roof bears a mucosal fold (the lacuna magna) which may catch the tip of a catheter. Instruments should always be introduced into the urethra beak downwards for this reason.

In children:

- in male newborns urethra has a large curvature 5–6 cm long. The prostate and membranous part of the urethra is 2 cm long, and the spongy part is 3–4 cm long. The internal urethral orifice is at the level upper third of the symphysis. The position, the contractions and the expansions of the urethra are the same as in adults. In female newborns urethra is wide,arcuately curved, the length is 1–3 cm. It has a poorly developed folds and glands and muscular tunic of the urethra and the external sphincter is formed by 13 years old.

Anomalies of the penis

Congenital absence of the penis. This anomaly is very rare and is combined with anomalies which are incompatible with life.

Congenital absence of the head of the penis is more common, along with anomalies of the other organs.

Hidden penis. At this anomaly scrotum is formed normally, but the penis is missing.

Ectopia of the penis is the rarest anomaly. At this anomaly testes are normally developed, the small penis is placed behind the scrotum.

Doubling of the penis is very rare. The doubling can be full (two of the penis with two normally developed urethra) and incomplete (two penises with penile urinary groove on the medial surface of each of them).

The membranous penis happens very often. At this anomaly scrotal skin leaves the skin of the penis not near the root, but from the middle, sometimes from the head.

Congenital phimosis is characterized by narrowing of the opening of the foreskin. Physiological phimosis is observed in most boys during the period of the development of the fetus and early years of life. In most cases, phimosis is an acquired defect that develops in early childhood. Phimosis is detected in 3–4 % of men. The complication of phimosis is paraphimosis, so that infringement of the glans penis, with the tapered end of the front skin shifted back.

Short frenulum of the penis is characterized by the shortening of the vertical folds of the foreskin, which is connected with the head of the penis on the surface of the urethra.

Anomalies of the urethra

Congenital urethral valves. There are septums, which are covered with mucous membrane on both sides. There are three types of valves:

1) valves, which are located below the seminal tubercle;

2) funnel-shaped valves that go from seminal tubercle to the neck of the bladder;

3) valves, which are located above or below the seminal tubercle as a transverse diaphragma.

Congenital hypertrophy of the seminal tubercle. It is characterized by increasing seminal tubercle, which can block the urethral orifice and appear in the cavity of the bladder.

Congenital obliteration of the urethra is combined with other anomalies incompatible with life. Boys have segmental obliteration more often. It is detected at the area of the bulb of the penis or in the the navicular fossa of the urethra, the external orifice of the urethra.

Congenital narrowing of the urethra can be in any area, but more often they are located in the distal part. They cover a small area, and have annularly-cylindrical shape and can be in the form of diaphragm septum. The narrowing of the external orifice of the urethra is combined with phimosis and splice of the embryonic layers in the pudendal area.

The doubling of the urethra happens together with doubling of the penis. There are different degrees of doubling the urethra:

1) doubling of the urethra with a doubling of the penis (diphallia);
2) doubling of the urethra in one penis;
3) paraurethral ducts.

Congenital urethral diverticulum is sacciform extension of the posterior wall the urethra, which communicates with it through a narrow way. Diverticulum has the same layers as the urethra and lined with a mucous membrane. Congenital diverticula are more often localized in the anterior wall and very rare – in the posterior wall of the urethra.

Hypospadias is characterized by the absence of posterior wall of the urethra. The classification of hypospadias is based on the dystopia degree of the external orifice of the urethra. The classification of hypospadias according to Savchenko N. E. (Fig. 89–92):

1. Hypospadias of the penis:
- coronary hypospadias;
- capitate and paracoronal hypospadias:
  a) with the curvature of the head of the penis;
  b) without bending of the head of the penis;
  c) with narrowing of the external orifice of the urethra.
- hypospadias of the distal third of the penis;
- hypospadias of the middle third of the penis;
- hypospadias of the proximal third of the penis;
- the penoscrotal hypospadias.

2. Scrotal hypospadias:

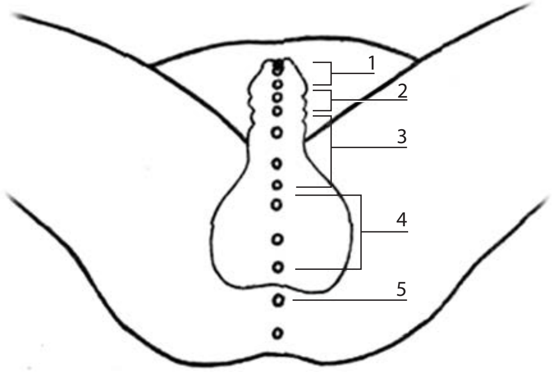


Fig. 89. Classification of hypospadias according to Savchenko N. E.:
1 – "hypospadias without hypospadias"; 2 – coronary, paracoronary; 3 – penile; 4 – scrotal; 5 – perineal

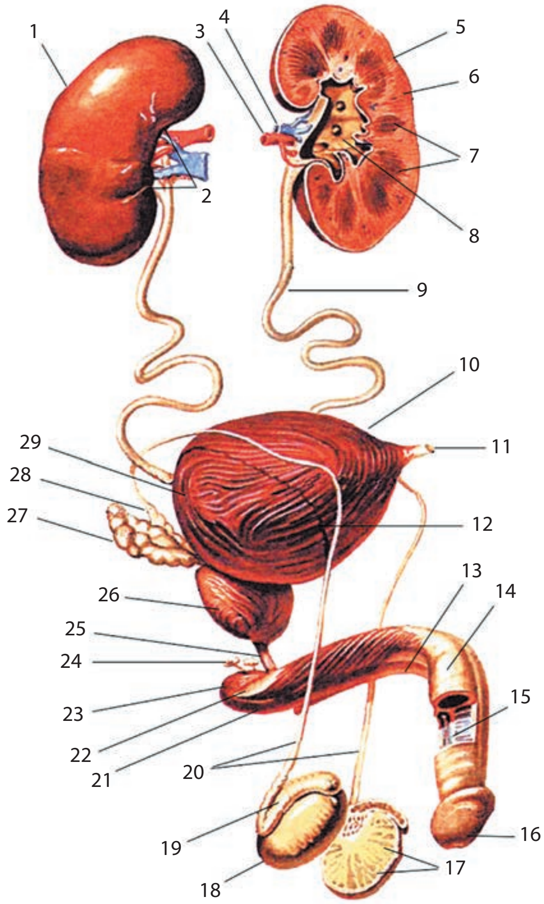


Fig. 90. Male genital organs, isolated (review):
1 – right kidney; 2 – hilum of kidney; 3 – renal artery; 4 – renal vein; 5 – left kidney; 6 – renal cortex; 7 – renal pyramids; 8 – renal pelvis; 9 – ureter; 10 – apex of bladder; 11 – median umbilical ligament (urachus); 12 – body of bladder; 13 – corpus spongiosum penis; 14 – corpus cavernosum penis; 15 – spongy urethra; 16 – glans penis; 17 – lobules of testis; 18 – testis; 19 – epididymis; 20 – ductus deferens; 21 – ischiocavernosus muscle; 22 – root of penis; 23 – bulbospongiosus muscle; 24 – bulbo-urethral or cowper's gland; 25 – membranous urethra; 26 – prostate; 27 – seminal gland; 28 – ampulla of ductus deferens; 29 – fundus of bladder

- hypospadias of the distal third of the scrotum;
- hypospadias of the middle third of the scrotum;
- with the ex[pression of the free part of the penis on the ventral surface;
- with a sharp hypoplasia or complete absence of the penis.

3. Scrotal-perineal hypospadias.
4. Perineal hypospadias.
5. “Hypospadias without hypospadias”.

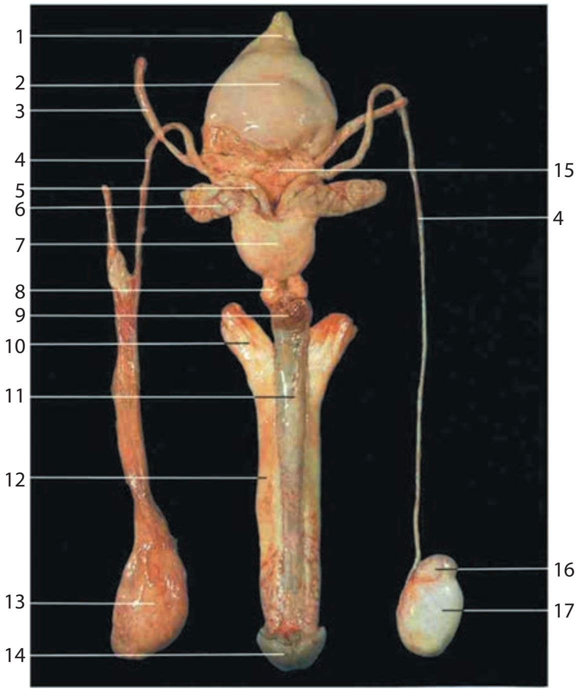


Fig. 91. Male genital organs, isolated (posterior aspect):

1 – apex of urinary bladder with urachus; 2 – urinary bladder; 3 – ureter; 4 – ductus deferens; 5 – ampulla of ductus deferens; 6 – seminal vesicle; 7 – prostate; 8 – bulbo-urethral or cowper's gland; 9 – bulb of penis; 10 – crus penis; 11 – corpus spongiosum of penis; 12 – corpus cavernosum of penis; 13 – testis and epididymis with coverings; 14 – glans penis; 15 – fundus of bladder; 16 – head of epididymis; 17 – testis; 18 – mucous membrane

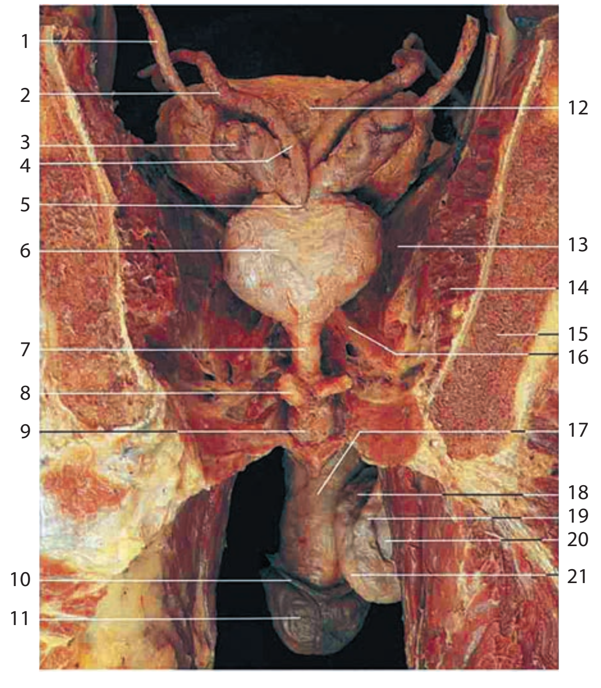


Fig. 92. Accessory glands of male genital organs in situ. Coronal section through the pelvic cavity. Posterior aspect of urinary bladder, prostate, and seminal vesicles:

1 – ureter; 2 – ductus deferens; 3 – seminal vesicle; 4 – ampulla of ductus deferens; 5 – ejaculatory duct (proximal portion); 6 – prostate; 7 – membranous urethra; 8 – bulbo-urethral or cowper's gland; 9 – bulb of penis; 10 – penis; 11 – glans penis; 12 – urinary bladder; 13 – levator ani muscle; 14 – obturator internus muscle; 15 – pelvic bone (cut edge); 16 – puboprostatic ligament; 17 – corpus spongiosum of penis; 18 – head of epididymis; 19 – beginning of ductus deferens; 20 – testis; 21 – tail of epididymis

THE FEMALE GENITAL SYSTEM, SYSTEMA GENITALE FEMININUM

The female internal genitalia, *organa genitalia feminina interna* comprise the ovaries, the uterine tubes and the vagina. The female external genitalia, *organa genitalia feminina externa* comprise the structures associated with the pudendal cleft.

The female internal genitalia, Organa genitalia feminina interna

The ovary, ovarium

Synonym is Greek 'oophoron'. The ovary is the principal gland of female genital system, which produces the oocytes. Apart from this, the ovary has the endocrine function producing the hormones, which regulate functioning of the female sexual sphere and the entire organism. It is a paired flattened ovoid organ sized 1×2×3 cm and 5–8 g of weight.

Exterior of the ovary. Each ovary has the following surfaces, borders and extremities (Fig. 93):

- the lateral surface, *facies lateralis*, which lies adjacent to the lateral pelvic wall in shallow ovarian fossa, fossa ovarica;
- the medial surface, *facies medialis*, facing the uterus and uterine tube;

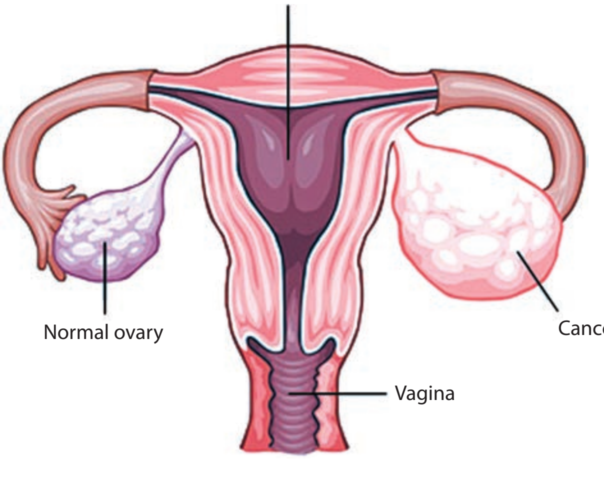


Fig. 93. Organa genitalia feminina interna

- the free border, *margo liber*;
- the mesovarian border, *margo mesovaricus*. The mesovarium continuous with the broad ligament of uterus attaches to this border. The mesovarian border also contains the longitudinal groove called the hilum of ovary, *hilum ovarii*, which passes the vessels and nerves;
- the tubal extremity, *extremitas tubaria*, rounded, directed superiorly it is enfolded by the infundibulum (of the uterine tube);
- the uterine extremity, *extremitas uterina*, pointed, directed inferiorly. Between the extremity and the uterus, the ligament of ovary, ligamentum ovarii proprium expands. This ligament is tough and consists of elastic and muscle fibers.

Relations. The ovary lies at the lateral wall of lesser pelvis posterior to the broad ligament of uterus. It is positioned almost vertically in the related ovarian fossa (Fig. 94, 95).

The ovarian fossa, *fossa ovarica* is bounded by the external and internal iliac arteries and veins. Within the fossa, the ovary lies adjacent to the parietal peritoneum, which invests the fossa. Deeper layers are the fascia and obturator internus.

Syntopy. The movable ovary neighbors the uterine tube, uterus, intestines. The tubal extremity normally does not ascend over the pelvic inlet.

Why the peritoneum-devoid ovary still has mesentery? During embryonic period, the ovary is fully covered with peritoneum and thus has a mesentery.

With the development progress, the serous coating undergoes involution with subsequent substitution with a thin layer of germinal epithelium. The mesovarium,

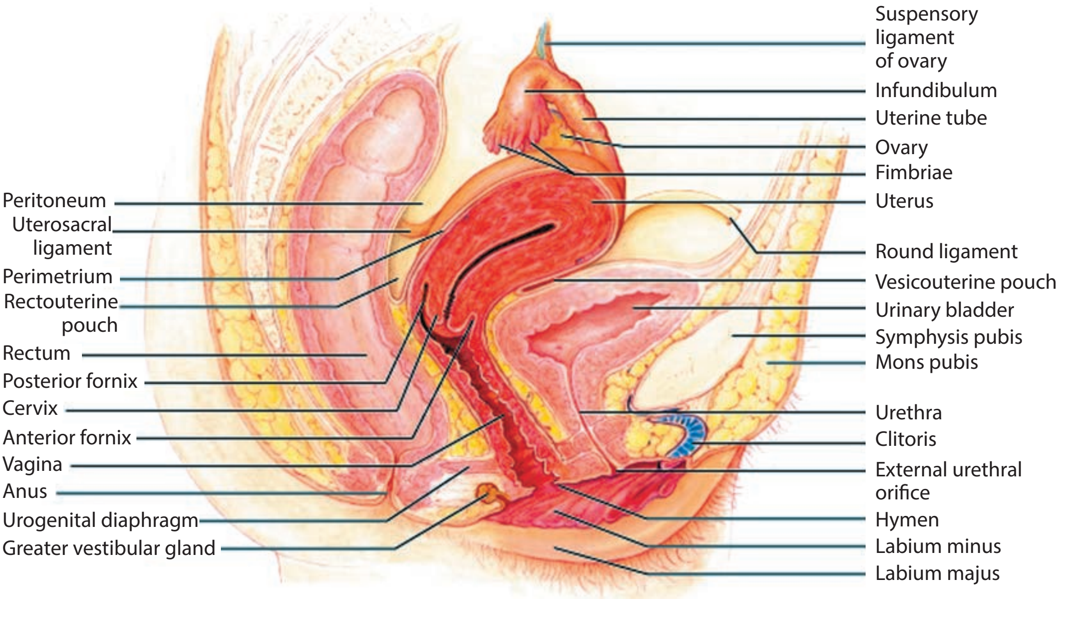


Fig. 94. Relations of viscera in female lesser pelvis

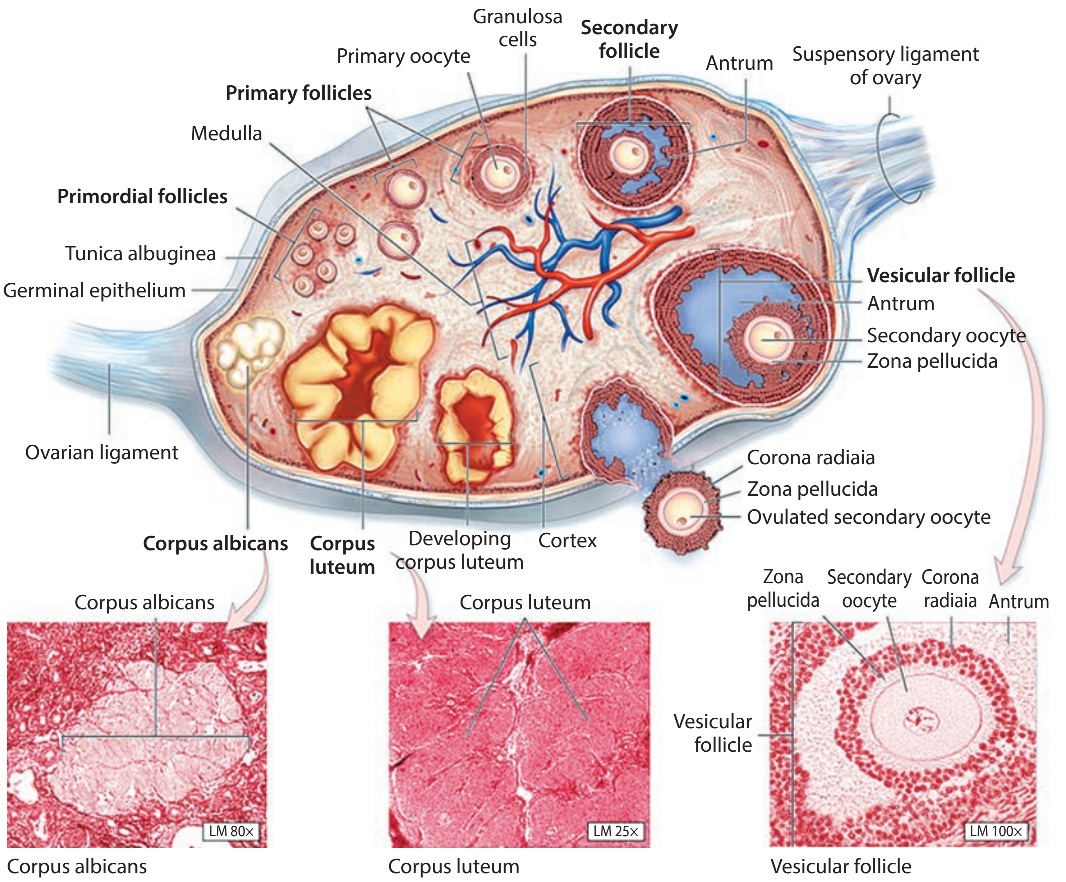


Fig. 95. Microscopic structures of the ovary

however remains for the lifetime and serves for attaching the ovary to the broad ligament of uterus. Site of mesovarium termination is well visible on the related border as a whitish line.

The suspensory ligament of ovary, *ligamentum suspensorium ovarii* is a peritoneal fold, which runs from the linea terminalis to the tubal (upper) extremity.

Clinical applications

It is noteworthy that the suspensory ligament of ovary contains the ovarian vessels and nerves that is a concern during ovariectomy.

Interior of the ovary. The ovary is liner with the germinal epithelium adherent to thin tunica albuginea, which consists of connective tissue. At the hilum, the tunica albuginea penetrates the organ to form its stroma (the ovarian stroma, stroma ovarii). The principal substance of ovary is divided into the ovarian cortex and ovarian medulla:

- the ovarian medulla, *medulla ovarii* is the central portion of the organ. It consists of loose connective tissue and contains blood and lymphatic vessels and nerves;
- the ovarian cortex, *cortex ovarii* is the outer denser portion, which contains the follicles – the parenchyme of organ.

Ovarian follicles. The ovarian follicles are subdivided into the primary and secondary. The primary follicles, folliculi ovarici primarii are fine rounded bodies, which contain primordial gametes. The primary follicles develop into the vesicular ovarian follicles. Number of primary follicles in newborn girl constitutes approximately one million in each ovary, yet vast majority of the follicles degenerate and approximately 40000 remain when she reaches puberty. Only 400–500 follicles are ovulated during woman's reproductive lifetime (Fig. 96).

The vesicular ovarian follicles, *folliculi ovarici vesiculosi* are developing primary follicles, which appear during puberty. In development process, the primary follicles enlarge and develop cavity filled with follicular fluid. The follicular epithelium forms a mound supporting the developing oocyte – the cumulus oophorus protruding into the follicular cavity. Mature follicle is rather large (4–10 mm of diameter) and well visible with naked eye in sectioned ovary.

Ovulation. Mature vesicular follicle dislodges in direction of the ovary surface to form a translucent bulge. The fluid pressure grows and the follicle eventually ruptures.

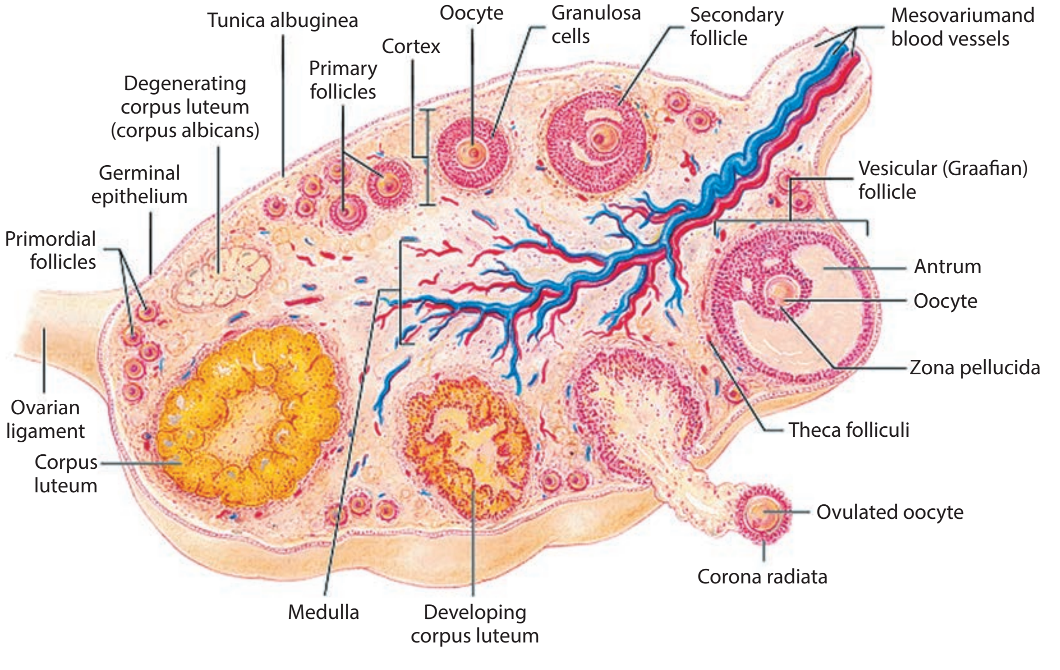


Fig. 96. The internal structure of the ovary

Follicular fluid and oocyte extrudes into the peritoneal cavity. The whole process is called ovulation.

Why the multiparous pregnancy occurs. Usually more than one follicle reach ovulation, however only one ruptures, while the rest involutes so single pregnancy is characteristic of humans. However, several follicles may occasionally rupture and oocytes released may be fertilized to result in multiparous pregnancy.

The corpus luteum. Epithelium of emptied follicle transforms into the corpus luteum, larger in pregnant (1–2 cm). It persists throughout the pregnancy period and functions as endocrine gland, which produces hormones prerequisite for normal pregnancy course. After delivery, the corpus luteum involutes. Connective tissue substitutes reduced secretory epithelium to form cicatrix-like persistent corpus albicans.

If no fertilization occurs, the corpus luteum is smaller and called the cyclic menstrual corpus luteum, corpus luteum ciclicum menst- ruationis. In 10–12 days, it also regresses to leave the corpus albicans, which eventually resolves.

Rudiments. The broad ligament of uterus contains underdeveloped blind canaliculi called epoophoron and paroophoron. They are the residua of mesonephros, which correspond to epididymis and paradydimis in males.

In children.

- In a newborn girl ovaries and fallopian tubes are above the entrance to the pelvis. Ovaries are cylindrical and can be shifted forward to the deep inguinal ring, or back to the promontorium. Body weighs 0.2 g, and at the age of one year old – 0.5 g, at 5 years old – 1 g, at 12 years old – 2 g. During the period of puberty ovarian weight increases to 5 g, and by 20 years old it reaches its final value. At birth, ovarian cortex contains 100–200 thousand primary follicles. By the perior of sexual maturity there are about 10 thousand follicles.

Anomalies of the ovary

The wrong position of the ovary (ectopia ovariorum) is an anomaly which means that one or two ovaries are located at the deep inguinal ring or protrude under the skin of the labia majora. In the last case, a uni- or bilateral ovarian hernia (hernia ovarica) is formed. About 2–4 % of the women can have additional (ovarii accessorii) ovaries which are located next to the normal ovary.

Blood supply of the ovaries is provided by the ovarian artery (a. ovarica), which arises from the abdominal aorta and the ovarian branches (rr. ovarici) of the uterine artery. Vein blood drains via accompanying veins.

Lymphatic vessels run to the lumbar lymphatic nodes.

Innervation of the ovaries is provided by the abdominal aortic and inferior hypogastric plexuses.

Fallopian tube, Tuba uterina
(oviductus – lat. oviduct, salpinx – gr., Fallopian tube)

Openings of the tube. The uterine tube has the openings as follows:

- the uterine ostium, *ostium uterinum tubae uterinae*, which opens into the uterine cavity:
- the abdominal ostium, *ostium abdominal tubae uterinae*, which opens into the abdominal cavity. The parts of uterine tube are (Fig. 97);
- the uterine part, *pars uterina* is the narrowest potion, which passes through the uterine wall. It opens into the uterine cavity with 1mm uterine ostium;
- the *isthmus, isthmus tubae* uterinae, a bit wider portion adjacent to the uterus. It is 3–5 cm long and 3–5 mm in diameter;
- the ampulla, *ampulla tubae uterinae*, the more dilated portion next to the isthmus. It is 5–8 cm long and 6–8 in diameter. Fertilization commonly occurs in this potion of tube;
- the infundibulum, *infundibulum tubae uterinae*, the terminal most dilated portion ending with abdominal ostium. The infundibulum neighbors the tubal extremity and free border of the ovary. The abdominal opening is trimmed with the fimbriae (Lat. Id.), the longest of which – the ovarian fimbria, fimbria ovarica – usually fixes

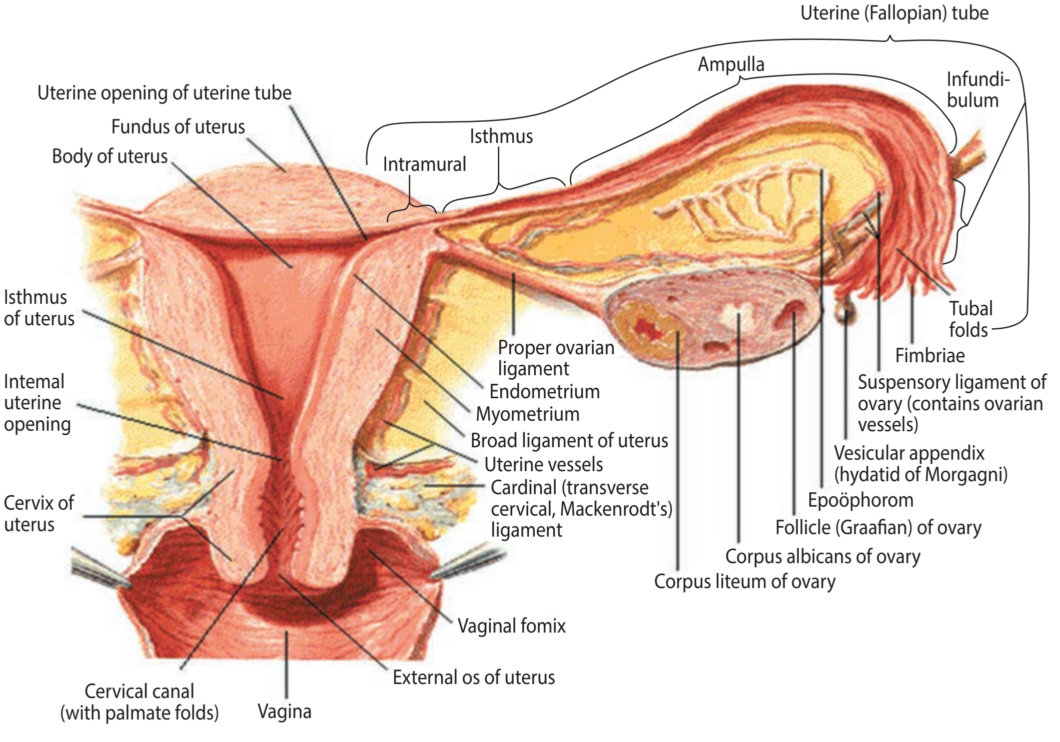


Fig. 97. Anterior view of the female internal reproductive organs

to the ovary. Tubal routing. The uterus related portion runs horizontally, forms flexure and runs almost vertically along the mesovarian border of ovary. The terminal portion arches superiorly directing the infundibulum downwards to adhere to the free border and medial surface of ovary.

Wall layers of the tube

The tubal wall consists of the layers as follows:

- the mucosa with submucosa;
- the muscular layer;
- the serosa.

The mucosa is lined with ciliated epithelium, which undulates in direction of the uterus assisting thus oocyte motion. The mucosa forms numerous folds of uterine tube, plicae tubariae, which transform the tube lumen into groove labyrinth. The submucosa is well developed.

The muscular layer consists of two layers of non-striated muscles: the external longitudinal and internal circular. Peristaltic contractionsof the muscles during ovulation form serous fluid flow directed to the uterus. Contractions are most intense at fimbria. The serous fluid carries the oocyte into the tube. Peristaltic waves and epithelium undulations move the oocyte into the uterus.

The serosa. Peritoneum completely covers the tube (it is an intraperitoneal organ). The tube lies in the upper portion of broad ligament of uterus. The portion of latter related to the tube is called the mesosalpinx (Lat. Id.).

Oocyte route and fate after ovulation. Upon follicle rupture, the oocyte appears in the peritoneal cavity, enters the tube via the abdominal ostium and moves along the tube. If no fertilization occurs, the oocyte leaves the uterus during menstruation. Fertilization normally occurs in the ampulla. The embryo takes 3–4 days to reach the uterine cavity. Here it implants to remain for the entire development term.

Ectopic pregnancy. The most common cause of ectopic pregnancy is inflammation of the tube (salpingitis), which results in total or partial tube obstruction. Total obstruction of both tubes causes sterility even if both ovaries function properly. Partially occluded tube passes the sperm (3–4 pm) and allows fertilization. The fertilized oocyte (150 pm in diameter) experiences cleavage and thus enlarges. The embryo as it is unable to pass through the narrowed segment lodges in the tube and implants into the mucosa. The condition may result in tube rupture or embryo extrusion into the abdominal cavity. This in turn causes life-threatening bleeding. The condition requires urgent operation, which constitutes blood vessels ligaturing and tube removal.

Ectopic pregnancy may also develop in the ovary if the oocyte retention occurs or in the abdominal cavity if the oocyte fails to enter the tube. These two types of ectopic pregnancy are uncommon.

Unaltered oocyte capturing process works perfectly, which is evident in surgical cases of ovariectomy with removal of contralateral tube. Ovulated oocyte is able to enter the opposite tube so normal pregnancy is possible in this case.

Blood supply is provided by two sources: the tubal branch (r. tubarius) of the uterine artery and twigs of the ovarian artery (a. ovarica). The latter supplies the infundibulum. Vein blood drains via accompanying veins to the uterine venous plexus.

Lymphatic vessels run to the lumbar nodes.

Innervation is provided by the ovarian and uterovaginal plexuses.

In children.

- In the newborn girl oviduct has more bends and forms 3–4 loops. It is short and wide, it can be 3 cm long, and the ampoule can be 5 mm wide. The position of the fallopian tubes depends on the position of the uterus. When tilting the entire uterus forward, tubes are located on the bladder.

Developmental abnormalities of the fallopian tube

1. *Atresia of the fallopian tube* can be uni- or bilateral, local or total. It is the result of congenital obliteration of tubes.
2. *The* doubling of the fallopian tube can be uni- or bilateral.
3. *The increase of the fallopian tube* can be accompanied by excessing and twisting of tubes.
4. *The decrease of the fallopian tube* is the result of its hypoplasia. When the abdominal opening of the fallopian tube reaches the ovary, the sperm cells can not go to the tube.

The uterus, uterus

Synonyms 'metra' (Greek) and 'hysteros' (Greek) give rise to 'hysteropathy', 'hysterectomy', 'endometritis' and other terms.

The uterus is an unpaired organ with thick muscular wall. It provides a space for embryo development and takes the most important part in delivery.

Shape, sizes and surfaces. The pear-shaped uterus resides in the midmost portion of lesser pelvis. In adult woman who never experienced pregnancy and delivery, the uterus sizes 7 cm long, 4 cm wide and 2 cm thick. Weight of uterus averages 40–50 grams. In women, who experienced at least one pregnancy followed by delivery sizes and weight of the organ are larger.

The uterus has two surfaces delimited by borders:

- the vesical surface, *facies vesicalis* directed inferomedially towards the urinary bladder (Fig. 98);
- the intestinal surface, *facies intestinalis* directed superoposteriorly; it neighbors the rectum;
- the border of uterus (left and right), *margo uteri*, which delimits the surfaces at the respective side;

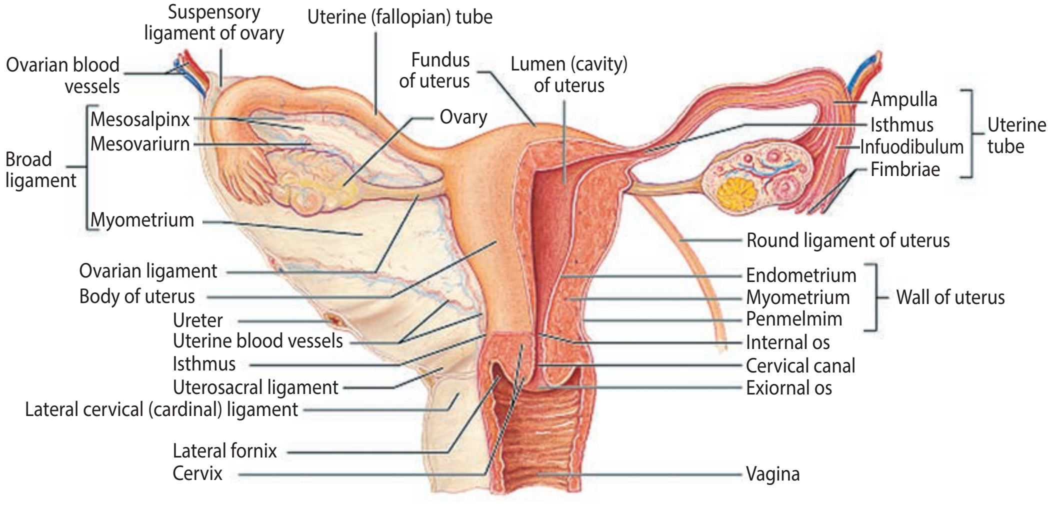


Fig. 98. Female internal genitalia

Parts of the uterus. The uterus has parts as follows:

- the fundus of uterus, *fundus uteri* is the uppermost dome-shaped portion superior to the entrance of the uterine tubes. It is directed anterosuperiorly;
- the body of uterus, *corpus uteri* is the widest middle portion up to 4 cm long;
- the cervix of uterus, *cervix uteri* is the narrowest portion about 3 cm long. The cervix of uterus in turn is subdivided into the supravaginal and vaginal parts:
- the vaginal part, *portio vaginalis cervicis* is the inferior one third of cervix open into the vagina. The tip of the part contains the external os of uterus, ostium uteri;
- the supravaginal part, *portio supravaginalis cervicis* the superior portion constituting two thirds of total cervix length. This portion joins the body of uterus. A small narrowed portion between the body of uterus and cervix is called the isthmus of uterus, isthmus uteri.

The uterine cavity, cavitas uteri

The uterine cavity appears as slit-like triangular cavity. Its wider superior portion communicates with the uterine tubes and inferior portion passes into the cervical canal. At the junction of uterine cavity and cervical canal there is a narrower segment (4 mm in diameter) related to the cervix of uterus. This is the internal os of uterus, *ostium uteri internum*. The cervical canal, *canalis cervicis uteri*. The canal is approximately 3 cm long and runs from the uterine cavity to open into the vagina with oval or round external os of uterus, *ostium uteri*. The latter resides in the center of cervix and is bounded by thick anterior and posterior lips, *labiorum anterius et posterius*. The posterior lip is thin-ner and longer because the related posterior wall of vagina fixes higher than anterior (Fig. 99, 100).

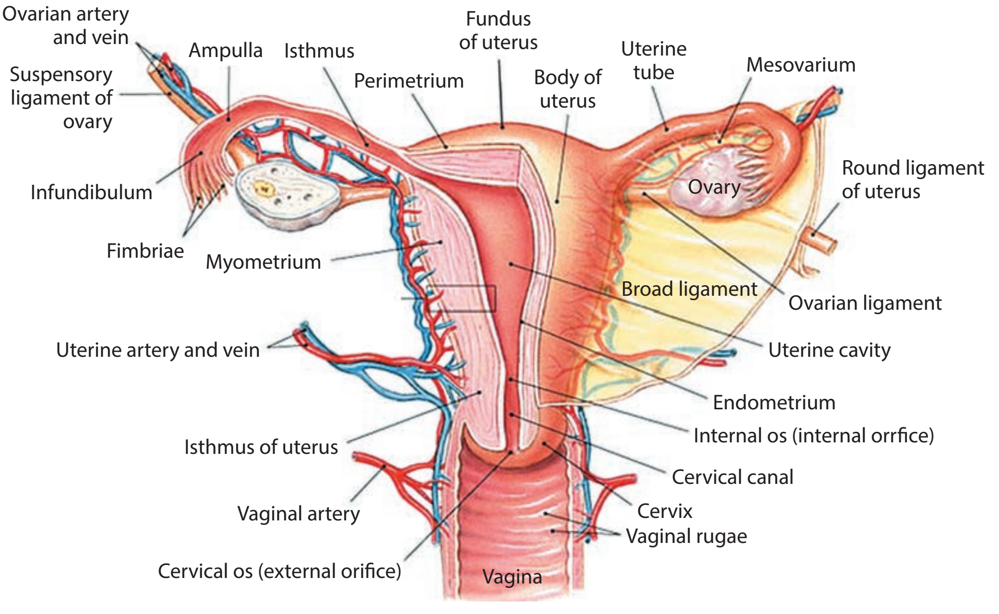


Fig. 99. Female internal genitalia, posterior view

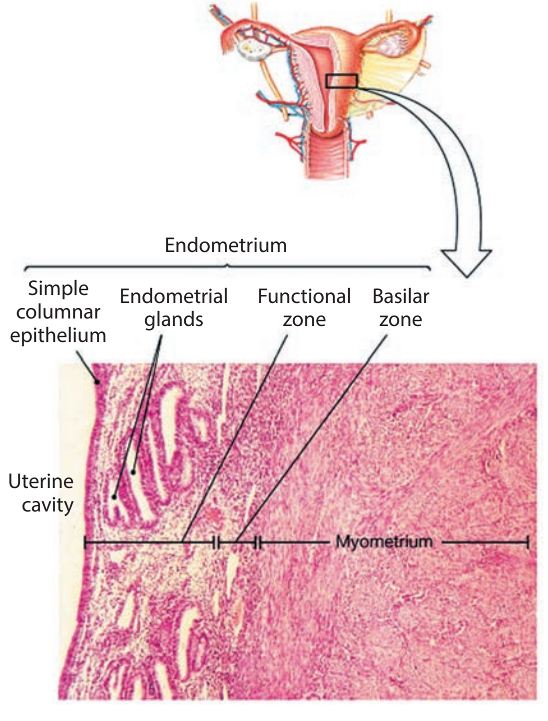


Fig. 100. The microscopic structure of the uterine wall

Clinical applications

In order to enter the uterine cavity safely (e.g. in abortion) the cervical canal requires appropriate dilation. For this purpose the special metal dilators (Hegar dilators) increasing in diameter are used. Dilated so, canal passes necessary instruments and allows required manipulations.

Cancer developing within the tissues of the uterine cervix can usually be detected by means of a relatively simple and painless procedure called the Pap (Papanicolaou) smear test. This technique involves scraping off a tiny sample of cervical tissue, smearing the sample on a glass slide, staining it, and examining it for the presence of abnormal cells. Because this test can reveal certain types of cervical cancers in the early stages of development, when they may be cured completely, the American Cancer Society recommends that women between ages twenty and sixty-five have a Pap test every three years.

Relations. The uterus resides in the lesser pelvis cavity between the urinary bladder and rectum. Position of the uterus varies depending on these organs' filling especially bladder filling. Normally the uterus forms a flexure at an angle of 90–100 degrees. In this position, the fundus of uterus is directed anteriorly. Obstetricians call such flexure anteflexio (anterior flexure). Under pathological conditions, the uterus may develop marked posterior flexure called retroflexio. The longitudinal axis of uterus runs slantwise posteroinferiorly to cross the vaginal axis at a direct angle open anteriorly. In this case, the entire uterus tilts anteriorly (relative to vagina) – anteversio. The urinary bladder being filled, the uterus exhibits posterior tilting (retroversio) accompanied by insignificant straightening of cervical-uterine flexure.

Factors significant for uterus support. The factors are like the following:

- junction with firmly fixed vagina;
- fixation of the cervix to the bladder;
- the pelvic fascia, which fixes the uterus to the pelvic walls;
- the peritoneum, which forms folds and ligaments enfolding muscles.

Peritoneal relations. Most part of the uterus is covered by the peritoneum except for the vaginal part of cervix and anterior portion of the supravaginal part attached to the bladder. From the bladder, the peritoneum passes onto the uterus to form the vesico-uterine pouch, excavatio vesicouterina; its floor neighbors the cervix. Posteriorly, the peritoneum covers both intestinal surface and supravaginal part of cervix reaching the posterior surface of vagina. Passing onto the rectum the peritoneum forms the recto-uterine pouch, excavatio rectouterina.

The peritoneal cavity can be accessed through the puncture of the posterior peritoneum-covered part of vagina (namely the posterior part of the fornix). This technique is of great significance for diagnostics of such severe conditions as tube or corpus luteum rupture. The port may also be used as medication route (Fig. 101, 102).

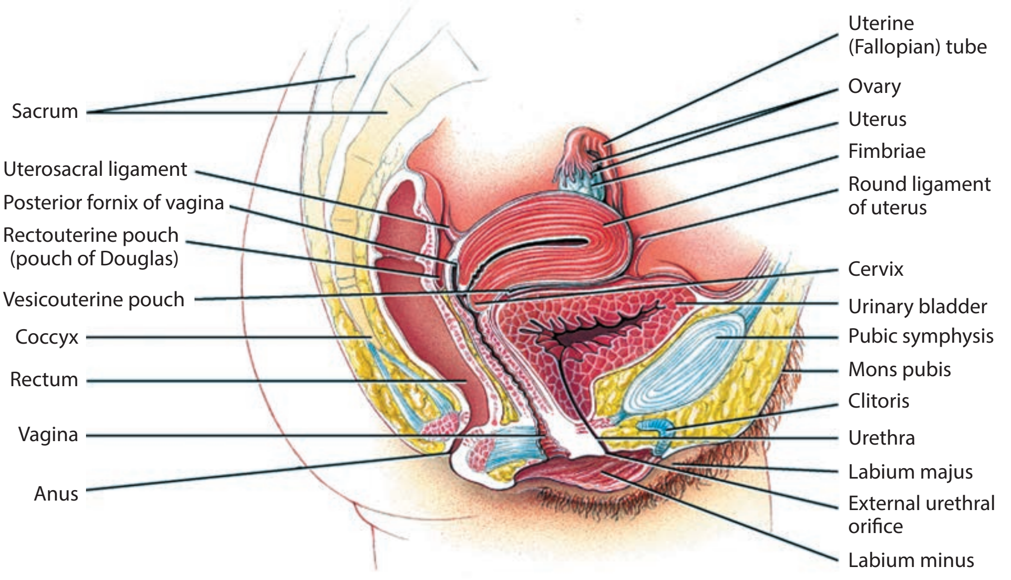


Fig. 101. The syntopy of the uterus

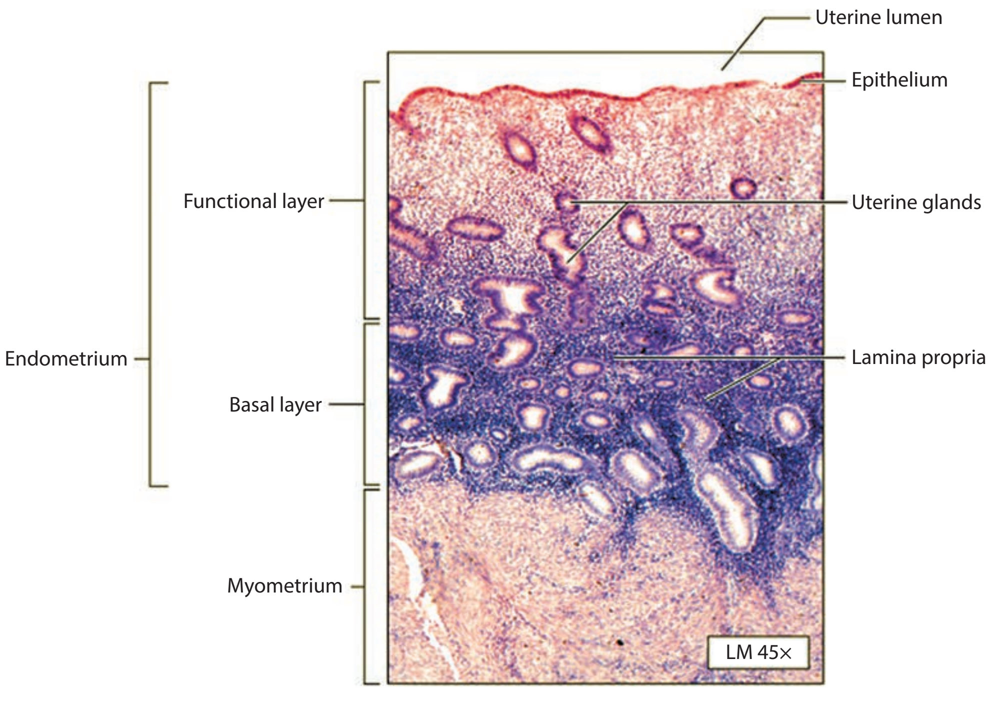


Fig. 102. The microscopic structure of the uterine wall

Peritoneal folds and ligaments.

Passing onto the neighboring organs, the peritoneum forms several ligaments the most important of which is the broad ligament of uterus, ligamentum latum uteri. It is a peritoneum duplication, which lies almost frontally and expands between the uterine borders and lateral pelvic walls. Its superior part contains the uterine tube and posterior part is related to mesovarium. The broad ligament of uterus serves as mesometrium (Lat. Id.) and mesosalpinx (Lat. Id.). The third related structure – the mesovarium demarcates these two parts.

The broad ligament of uterus contains a paired connective tissue strand – the round ligament of uterus, *ligamentum teres uteri*, which arises from the vesical surface of uterus inferior to the uterine tube and runs anteriorly along the lateral pelvic wall. The ligament leaves the pelvis via the inguinal canal to terminate in the subcutaneous fat of the mons pubis and labia majores. Pain in the uterus thus may irradiate to the labia majores. Within the base of broad ligament, there are fibrous bands, which expand from the cervix and vagina and attach to the pelvic walls – the cardinal ligaments, ligamenta cardinalia. Inferiorly they fix to the fascia investing the perineal membrane preventing thus lateral displacements of uterus.

The space between the peritoneal plates of the broad ligament mostly in its inferior portion is filled with fat called the parametrium (Lat. Id.). The fat around the cervix is called the paracervix (Lat. Id.). Inflammation of the fiat – parametritis – is common in clinical practice.

The recto-uterine fold, plica rectouterina expands from the cervix of uterus to the rectum. The fold bounds the recto-uterine pouch laterally. In depth of fold, there are abundant elastic and muscular fibers, which form the rectouterinus, m. rectouterinus.

The uterine wall. The uterine wall consists of three layers: the serosa (perimetrium), the muscular layer (myometrium) and the mucosa (endometrium).

The perimetrium (Lat. Id.) is the serous coating (peritoneum) which fixes to the muscular layer (Fig. 103–105).

The myometrium (Lat. Id.) is the thickest layer (2–3 cm thick), which consists of interlaced muscular fibers separated by connective tissue and elastic fibers. The muscular fibers form three distinct layers:

1) the outer longitudinal layer,

2) the middle circular well-developed layer, which includes spiral and loop-like fibers. This layer contains numerous blood vessels,

3) the inner thin longitudinal layer.

During pregnancy, the muscular fibers exhibit striking hypertrophy. They grow longer and thicker (tenfold) than in non-pregnant state. This results in considerable enlargement of the uterus. After delivery, the large fibers experience fatty degeneration and are replaced with newer small fibers.

Endometrium (Lat. Id.) is the mucous membrane, which lacks subserosa and directly attaches to the myometrium. The endometrium contains the uterine glands, *glandulae uterinae* (in the uterine cavity) and the cervical glands, *glandulae cervicales*

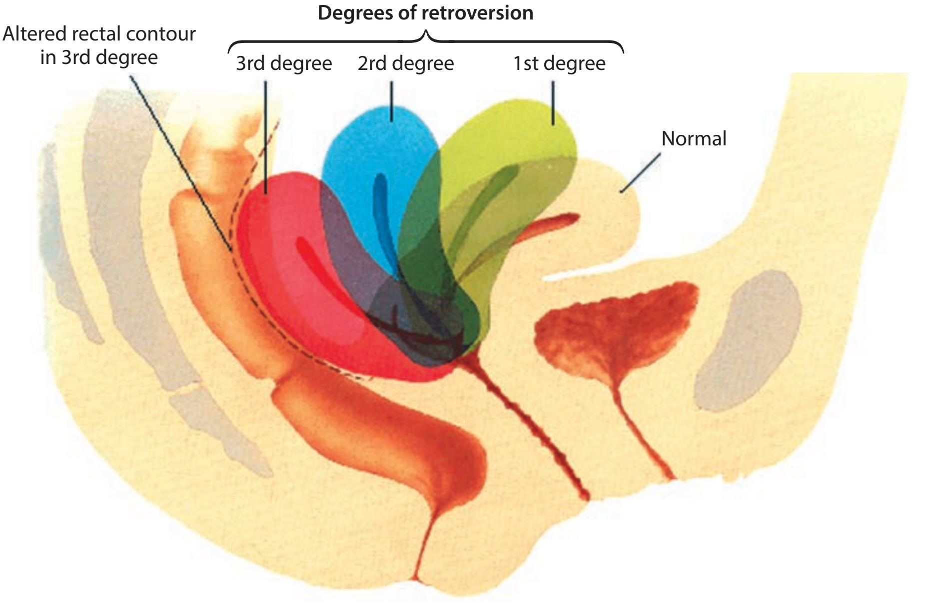


Fig. 103. Variations of the positions of the uterus

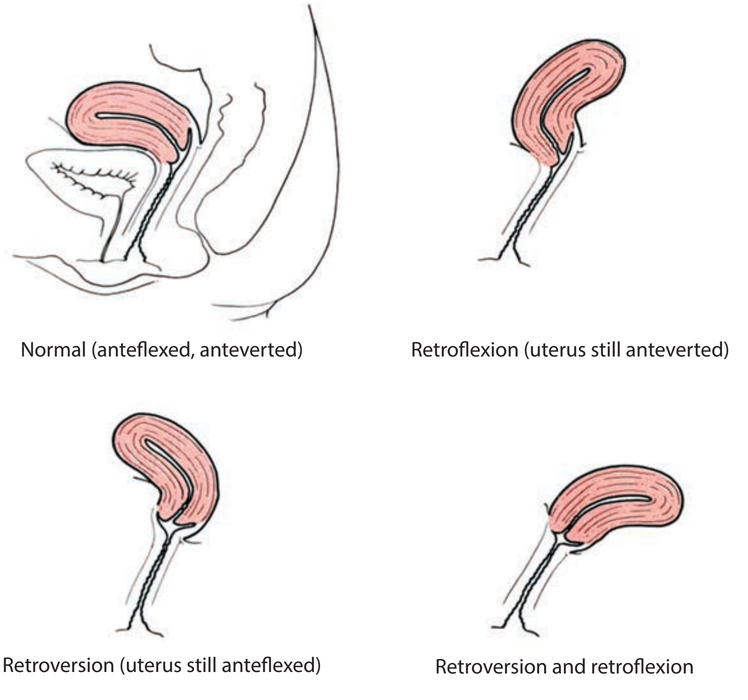


Fig. 104. Variations in uterine position and their terminology

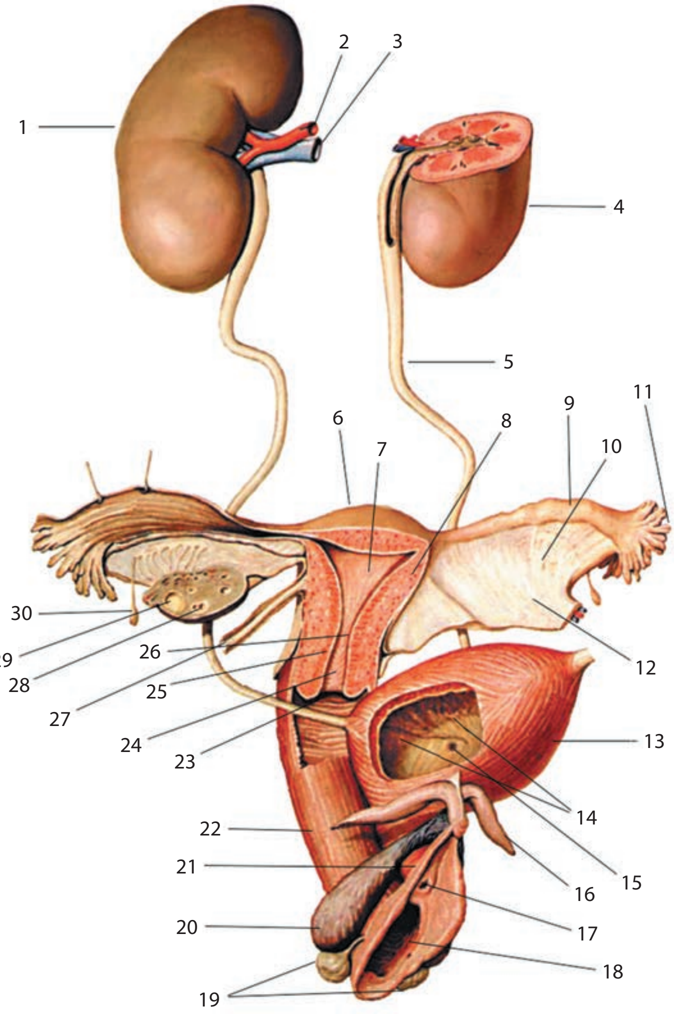


Fig. 105. Female genital organs, isolated (anterior aspect). The anterior wall of the vagina has been opened to display the vaginal portion of the cervix:

1 – right kidney; 2 – renal artery; 3 – renal vein; 4 – left kidney; 5 – ureter; 6 – fundus of uterus; 7 – body of uterus; 8 – myometrium; 9 – ampulla of uterine tube; 10 – mesosalpinx; 11 – fimbriae; 12 – mesometrium; 13 – urinary bladder; 14 – vesical rugae; 15 – ureteric orifice; 16 – crus of clitoris; 17 – external urethral orifice; 18 – vaginal os; 19 – greater vestibular glands; 20 – bulb of vestibule; 21 – female urethra; 22 – vagina; 23 – external os of uterus; 24 – cervical canal; 25 –cervix of uterus; 26 – isthmus of uterus; 27 – round ligament of uterus; 28 – corpus luteum of ovary; 29 – follicle (Graafian) of ovary; 30 – vesicular appendix

(in the cervical canal). The mucosa of cervical canal forms branched palmate folds, *plicae palmatae*, which prevent the vaginal contents from entering the uterine cavity. Other endometrium areas do not feature such folds.

The endometrium is a unique mucous membrane subject to cyclic changes associated with the ovarian cycle. The endometrium consists of two layers – the functional (desquamating part, eliminated from the uterine cavity during menstruation) and basal (germinal), which gives birth to new functional layer.

Upon ovulation, the endometrium proliferates, thickens and becomes swollen. It contains specific spiral arterioles responsible for rich blood supply. In this state, the endometrium is ready for implantation of the developing embryo. If no fertilization occurs, the functional layer is withdrawn from the uterine cavity. The withdrawal process is called menstruation. Mucosa withdrawal occurs under effect of hormones, which cause the spasms and twisting of arterioles. Lacking blood supply, the functional layer undergoes necrosis and desquamation with further withdrawal accompanied by hemorrhage. Menstruation lasts 3–4 days. After that the basal layer gives birth to new functional layer. Cyclic changes of endometrium with periodical desquamation are characteristic of the uterus.

Assisted reproduction technology. The topical problem of modern obstetrics and gynecology is treatment of female infertility, which commonly results from tubal occlusion. In this case, if at least one ovary retains normal functionality in vitro fertilization (IVF) may help. To do so, the oocyte obtained surgically is fertilized by appropriate semen in vitro. After several days of in vitro development, a zygote is introduced into the uterine cavity for implantation and further development. Such operations commonly result in normal delivery. The main problem lies in creation of complex media suitable for fertilization and initial development of the embryo.

Blood supply is provided by the paired uterine artery *(a. uterina)*, which arises from the internal iliac artery. Each uterine artery runs along the respective border of uterus between the plates of broad ligament of uterus giving branches to anterior and posterior surfaces of the organ. Upon reaching the fundus of uterus, the artery branches off to supply the uterine tube and ovaries. Vein blood drains to the left and right uterine plexuses (plexus venosus uteri), which in turn give rise to the uterine vein and veins that flow into the ovarian and internal iliac veins and to the rectal venous plexuses.

Lymphatic vessels collecting lymph from the, fundus reach the lumbar lymph nodes, while the vessels that drain the body and cervix run to the internal iliac nodes and to the sacral and inguinal nodes (following the round ligament of uterus).

Innervation is provided by the inferior hypogastric plexus via the pelvic splanchnic nerves.

In children

In a newborn uterus has a cylindrical shape, its length is 27–36 mm, its weight is 2g. The fances of the uterus is located higher than the lower edge of the pubic symphysis. Until ten years old uterus grows slowly. At 15 years old, the growth of the uterus accelerates, and the body grows faster than the cervix. The weight of the uterus is 6–7 g at 11–15 years old, at 16–20 years old it is 20 g.

Anomalies of the uterus

1. *Agenesis of the uterus* is the absence of the uterus and happens rarely.

2. *Aplasia of the uterus*. Happens when the uterus has a form of one or two rudimentary muscle ridges. The frequency varies from 1:4000–5000 to 1:5000–20000 in newborn girls. This anomaly is often combined with aplasia of the vagina, as well as anomalies of other organs: the spine (18.3 %), heart (4.6 %), teeth (9.0 %), gastrointestinal (4.6 %), urinary organs (33.4 %).

The variants of aplasia:

a) the rudimentary uterus, can be defined in the form of cylindric, located in the center of the pelvis, left or right, and has the size of 2.5–3.0 × 2.0–1.5 cm;
b) the rudimentary uterus, has the form of two muscular ridges, located at the wall of the pelvis, measuring 2.5 × 1.5 × 2.5 cm;
c) muscle ridges (no vestiges of the uterus) can be detected

3. *Hypoplasia of the uterus* (uterine infantilism). Happens when the uterus is reduced in size, has a large bend forward and conic cervix. There are 3 degrees of hypoplasia:

a) rudimentary uterus is underdeveloped uterus (up to 3 cm long), which is not divided into the neck and body, and has no cavity;
b) an infantile uterus is a small uterus (3–5.5 cm long) with a long neck and conic cervix;
c) teen uterus is 5.5–7 cm long.

4. *The doubling of uterus* occurs during embryogenesis as a result of isolated development paramezonefric ducts, when the uterus and vagina develop as paired organ. There are several variants of doubling:

a) the doubling uterus (uterus didelphys) means the existence of two separate unihorned uteruses (Fig. 106). Each of them is connected to a corresponding portion of the bifurcated vagina. This is due to non mearging paramezonefric ducts along their entire length. Two sexual apparatus are divided by a transverse fold of peritoneum. On each side there is one ovary and one fallopian tube;
b) the split of the uterus (uterus duplex) occurs when in the specific area uterus and vagina are combined by the fibromuscular layer; while the cervix and two vaginas are fused. Some variants can be possible: one of the vaginas is closed, one of the uterus has no connection with the vagina or one of the uterus is small by size with a reduced functional activity.

5. *Bicornuate uterus* (uterus bicornus) is the division of the body of the uterus in 2 parts with the presence of one cervix, without separating of the vagina (Fig. 107). The division into parts starts high, but in the lower part of the uterus they always merge.

The division into 2 horns begins within the body of the uterus so that the two horns diverge in opposite directions at high or low angles. At the distinguished splitting of the uterine body in two parts bicornuate uterus are formed. Often, two horns, which are not merged, have no cavities. These processes take place during the 10–14th week of fetal development due to incomplete or too low fusion of paramezonefric ducts. There are three forms:

a) complete form which is a rare variant, the division into two uterine horns begins practically at the level of the sacro-uterine ligaments. At hysteroscopy it is detected that from the start of the internal fornix two separate hemicavities are formed, each of them has only one orifice of the uterine tube;
b) incomplete form is divided into two horns and observed only in the upper third of the body of the uterus. In this case, the size and shape of the uterine horns are usually different. At hysteroscopy one cervix is defined, and closer to the bottom of the uterus there are two hemicavities. In every part of the body of the uterus there is one orifice of the fallopian tube;
c) saddle shape (uterus arcuatus) is division of the body of the uterus into two horns only in the bottom to form a small indentation on the outer surface in the form of the seat (bottom of the uterus is not usually rounded and concave inside). Hysteroscopy shows both the orifices of the fallopian tubes, while the bottom appears in the uterine cavity in the form of the ridge (Fig. 108).

6. Unihorned uterus (uterus unicornus) is a form of uterus with a partial reduction of one half (Fig. 109). This is a result of atrophy of one paramezonefric duct. The difference of unihorned uterus is the absence its bottom in the anatomical sense. In 31.7 % of cases, it is combined with anomalies of the urinary organs. It occurs in 1–2 % of cases of animalies of the uterus and vagina.

7. *The divided uterus* (bifid uterus, intrauterine septum) is observed in the presence of septum in the cavity of the uterus, which makes it bichambered (Fig. 110, 111). Its frequency is 46 % of the total number of anomalies of the uterus. Intrauterine septum can be thin, thick, or broad-based (in a shape of a triangle):

a) uterus septus is a fully formed, completely divided uterus (Fig. 112).
b) uterus subseptus is an incomplete form, partly divided uterus 4.1 cm long.

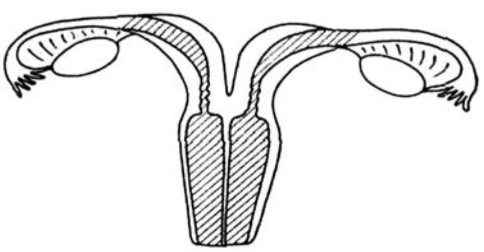


Fig. 106. Uterus et vagina duplex is the doubling of the uterus and vagina, which occurs when nonunion paramesonephric ducts

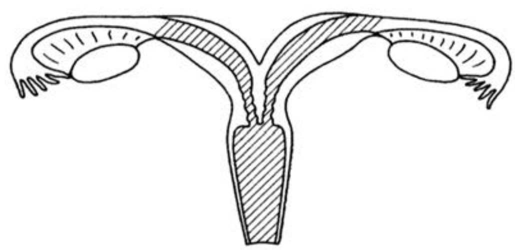


Fig. 107. Uterus duplex is the doubling uterus with a vagina. It is the result of nonunion middle portion paramesonephric ducts

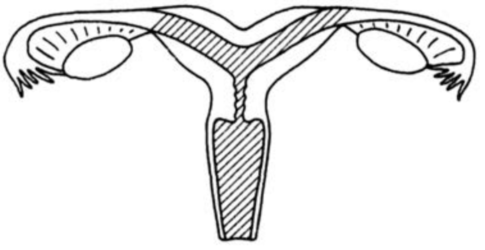


Fig. 108. Uterus bicornus is bicornuate uterus with a vagina

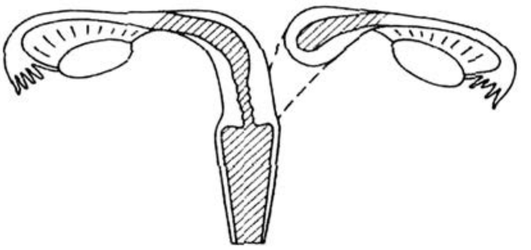


Fig. 109. Uterus assimetricus seu unicornus is asymmetric or unihorned uterus which occurs at the one-side delay of paramezonefric duct

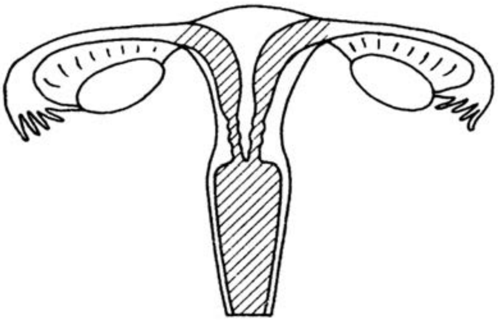


Fig. 110. Uterus septus is a uterus divided by a septum

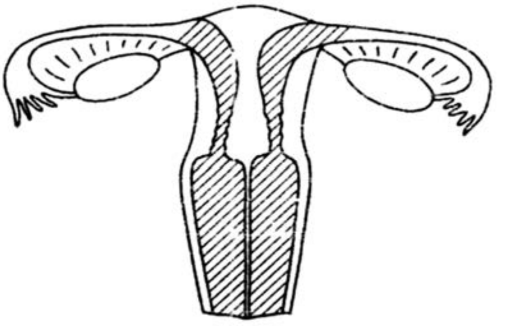


Fig. 111. Uterus septus et vagina septa happens when uterus and vagina are separated by a septum

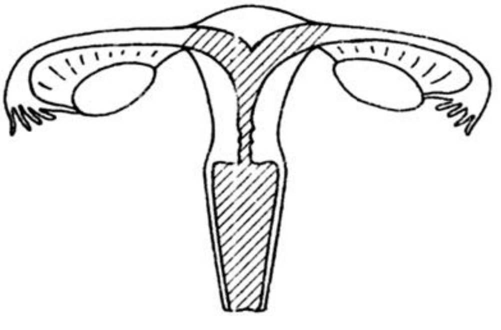


Fig. 112. Uterus subseptus is a uterus with an incomplete septum

The vagina, vagina

Synonym is Greek 'colpos', which gives rise to 'colpitis', 'colposcopy' and other medical terms (Fig. 113).

The vagina is a well-stretchable tube 8–10 cm long, which runs from the cervix of uterus through the perineal membrane and reaches the pudendal organs to open with the vaginal orifice, ostium vaginae (Fig. 114).

The walls of vagina. The vagina has the anterior and posterior walls:

- the anterior wall, paries anterior the shorter one, which attaches to the anterior lip of cervix of uterus. The anterior wall is firmly fixed to the urinary bladder and urethra;
- the posterior wall, paries posterior, somewhat longer than the anterior, which fixes to the posterior lip of the cervix of uterus. The uppermost part (1–2) cm of the wall is covered with peritoneum, while the rest fixes to the rectum separating from the intestine with rectovaginal septum, septum rectovaginale.

The vaginal fornix, *fornix vaginae* is a slit-like space between the vaginal portion of cervix and vaginal walls. The vaginal fornix is divided into the anterior, posterior and lateral parts. The posterior part is the most important part determined in applied gynecology as the posterior fornix, fornix posterior As far as the posterior wall attaches to the cervix of uterus higher than the anterior the posterior part is much deeper than the anterior. The posterior par thus is a convenient place for puncturing the abdominal cavity (namely the recto-uterine pouch).

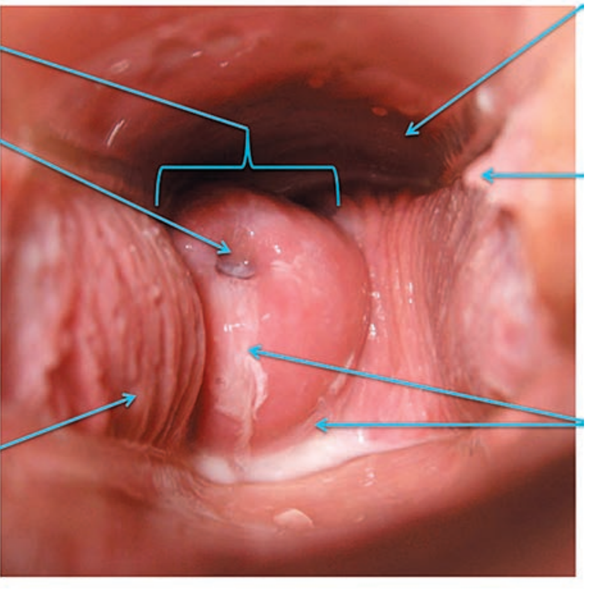


Fig. 113. Appearance of the vagina

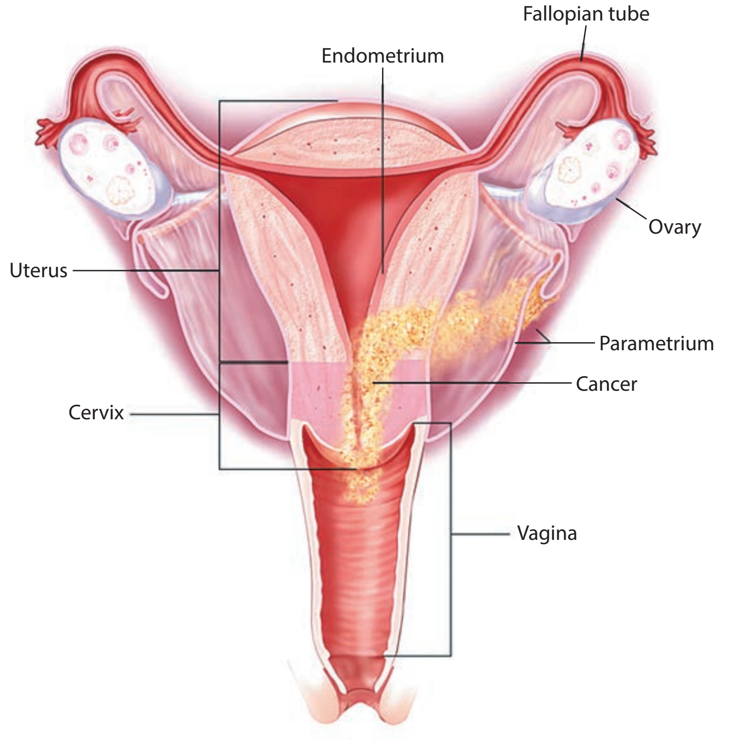


Fig. 114. Anterior view of the internal reproductive organs of the woman

The hymen (Fig. 115) is a thin annular or crescent-shaped fold of mucous membrane, which closes the vaginal orifice. Residua of ruptured hymen are called the hymenal caruncles, carunculi hymenales.

The shape of hymen is rather variable, which is important for forensic medicine. Solid hymen causes menstrual blood retention and requires surgical opening.

The vaginal wall. *The vaginal wall consists of three layers*: 1) the external layer represented with fibrous connective tissue, which fixes to neighboring organs 2) the mid-

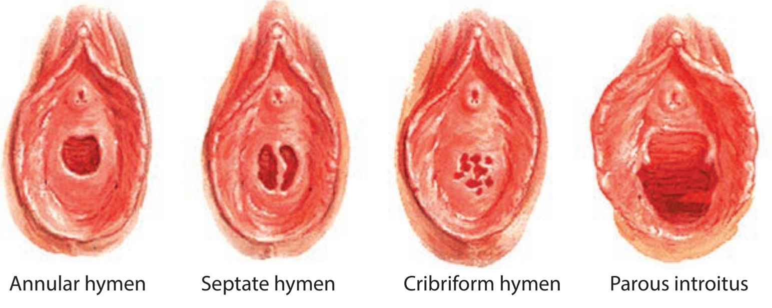


Fig. 115. Forms hymen membrane

dle muscular layer consisting of non-striated muscular fibers, which form crossing longitudinal (external) and circular (internal) layers 3) the internal mucous layer (mucous membrane) lined with stratified squamous epithelium without glands. The mucosa forms transverse vaginal rugae, *rugae vaginales*, which lie in the middle of both walls and appear as anterior and posterior vaginal columns, columnae rugarum anterior et posterior.

The anterior vaginal column expands to the external urethral orifice to form the urethral carina of vagina, carina urethralis vaginae. The vaginal mucosa generally lacks the submucosa.

Blood supply is provided by the vaginal arteries, *(aa. vaginales)* the branches of internal iliac artery and the vaginal branches *(rr. vaginales)*, which arise from the uterine artery, the middle rectal artery and internal pudendal artery. Vein blood drains via vaginal venous plexus into the internal iliac veins.

Lymphatic vessels that drain vaginal wall run to internal iliac nodes (upper portion related vessels) and to inguinal lymph nodes (loser portion related vessels).

Innervation is provided by the inferior hypogastric plexus and branches of the pudendal nerve (n. pudendus).

In children

In the newborn girl's hymen is thick, and consist of dense tissue. The opening of the hymen is growing rapidly at the age of 16–18 years old.

Clinical application

The vaginal fornices are clinically important because they are relatively thin-walled and allow the internal abdominal organs to be palpated during a physical examination. Also, the posterior fornix, which is somewhat longer than the others, provides a surgical access to the peritoneal cavity through the vagina.

Female Infertility. It is estimated that about 60 % of infertile marriages are the result of female disorders. One of the more common of these disorders is hvposccrction of gonadotropic hormones from the anterior pituitary gland, followed by failure of the female to ovulate (anovulation). This type of anovulatory cycle can sometimes be detected by testing the female's urine for the presence of pregnandiol, a product of progesterone metabolism. Since the concentration of progesterone normally rises following ovulation, no increase in pregnanediol in the urine during the latter part of the menstrual cycle suggests a lack of ovulation. The treatment of such a disorder may include the administration of the hormone HCG, which is obtained from human placentas. As mentioned, this substance has effects similar to those of LH and can stimulate ovulation. Another ovulatory substance, HMG (human menopausal gonadotropin), which can be obtained from the urine of postmenopausal women, contains a mixture of LH and FSH. HMG also may be used to treat females with gonadotropin deficiencies. However, either HCG or HMG may overstimulate the ovaries and cause many follicles to release egg cells simultaneously, resulting in multiple births later. Another cause of female infertility is endometriosis, in which tissue resembling the inner lining of the uterus (endometrium) is present abnormally in the abdominal cavity. Some researchers believe that small pieces of the endometrium may move up through the uterine tubes during menses and become implanted in the abdominal cavity. In any case, once this tissue is present in the cavity, it undergoes changes similar to those that take placc in the uterine lining during the menstrual cycle. However, when the tissue begins to break down at the end of the cycle, it cannot be expelled to the outside. Instead, its products remain in the abdominal cavity where they may irritate its lining (peritoneum) and cause considerable abdominal pain. These products also tend to stimulate the formation of fibrous tissue (fibrosis), which, in turn, may encase the ovary, preventing ovulation mechanically, or may obstruct the uterine tubes. Still other women become infertile as a result of infections, such as gonorrhea, which may cause the uterine tubes to bccomc inflamed and obstructed, or may stimulate the production of viscous mucus that can plug the cervix and prevent the entrance of sperm cells.

Abnormal development of the vagina

1. *Agenesis of the vagina* means no vagina and happens rarely.

2. *Aplasia of the vagina* develops during the 17th-week of fetal development as a result of the central cell lysis of paramezonefric ducts. It can be complete or partial at functional normal or functional rudimentary uterus:

a) complete vaginal aplasia is often combined with aplasia of the uterus or a rudimentary uterus, and in 43.6 % of cases – with abnormalities of the urinary system;
b) partial aplasia of the vagina is combined with the uterus, which is functioning normally. In 19.3 % of cases it occurs with abnormalities of the urinary system. Maybe middle or lower third can be aplasiared.

3. *Atresia of vagina* (Müllerian duct aplasia) occurs when the lower part of the vagina is replaced by fibrous tissue. Superior parts, cervix, body of the uterus, fallopian tubes, ovaries and external genitalia are formed correctly. At puberty, secondary sexual characteristics appear, but without menstruation, and hydrometrocolposy is possible. There are several forms: hymenal; retrohymenal, vaginal, cervical.

4. *Vaginal septum* (the division of the vagina) can be complete or partial, has underdeveloped epithelial and muscular layers.

5. *The doubling of the vagina* (vagina duplex) is the septum between the two organs which is represented by all the layers of the wall. It is usually associated with the doubling of the vagina.

THE FEMALE EXTERNAL GENITALIA, ORGANA GENITALIA FEMININA EXTERNA

The pudendum, pudendum femininum

Synonym 'vulva' (Lat.) gives birth to 'vulvitis' – inflammation of external genitals. The pudendum comprises the organs related to the pudendal cleft, rima pudendi.

The mons pubis (Lat. Id.) is a skin eminence corresponding to underlying adipose tissue pad, which covers the pubic symphysis. At puberty, the mons pubis becomes covered with coarse pubic hair.

The labia majora, *labia majora* pudendi are paired thickened skin folds covered with hair. The labia enclose the pudendal cleft and protect deeper pudendal organs. The labia merge to form the anterior and posterior commissures, *commissura labiorum anterior et posterior*. The skin of labia is heavily pigmented and contains numerous sebaceous and sweat glands.

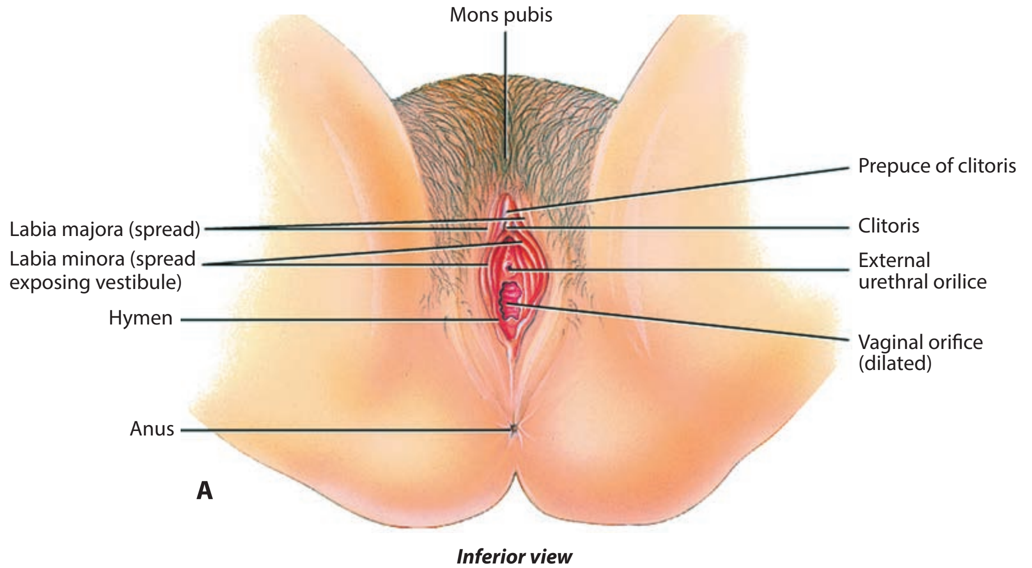
The labia minora, *labia minora* pudendi are thinner skin folds, residing medially to the labia majora. The labia minora are narrower and shorter than the latter. The labia minora enclose the vestibule, vestibulum vaginae. Posterior ends of labia merge to form the frenulum of labia minora, frenulum labiorum pudendi. Anterior to the frenulum, there is the vestibular fossa, fossa vestibuli vaginae. Anterior end of each labium splits into two crura – the medial and lateral. The lateral crura enfold the glans of clitoris to form the prepuce of clitoris, preputium clitoridis. The medial crura reach the clitoris inferiorly and merge to form the frenulum of clitoris, frenulum clitoridis.

The clitoris comprises two corpora cavernosa of clitoris, corpora cavernosa clitoridis similar to male corpora cavernosa yet much smaller. The clitoris has two crura of clitoris, crura clitoridis, fixed to the pubic bones and the glans of clitoris, glans clitoridis. The glans is enfolded into the prepuce and frenulum of clitoris.

The bulb of vestibule, *bulbus vestibuli* appears as cavernous venous plexus 3 cm long and 1.5 cm wide. It resides in the base of each labium majus laterally to the vaginal orifice. The bulb is enfolded by the connective tissue and smooth muscle fibers. The lateral thickened parts of bulb merge to form the commissure, which lies between the external urethral orifice and clitoris. The bulb thus appears as unpaired horseshoe-like body similar to the corpus spongiosum in males.

The vestibule, *vestibulum vaginae* is the space between the labia minora, which contains the clitoris and external urethral orifice. Apart from the structures listed, the vestibule contains numerous orifices of the ducts of lesser vestibular glands, gll. vestibuläres minores.

The greater vestibular glands, *glandulae vestibulares majores* (Bartholin's glands) are paired rounded organs in size with pea (about 1 cm wide). They reside under the perineal membrane posterior to the bulb of vestibule. The ducts of glands open into the vestibule. The greater vestibular glands are similar to the bulbo-urethral glands in males. They produce secretion, which moistens the vaginal inlet. Inflammation of the glands is common in clinical practice.



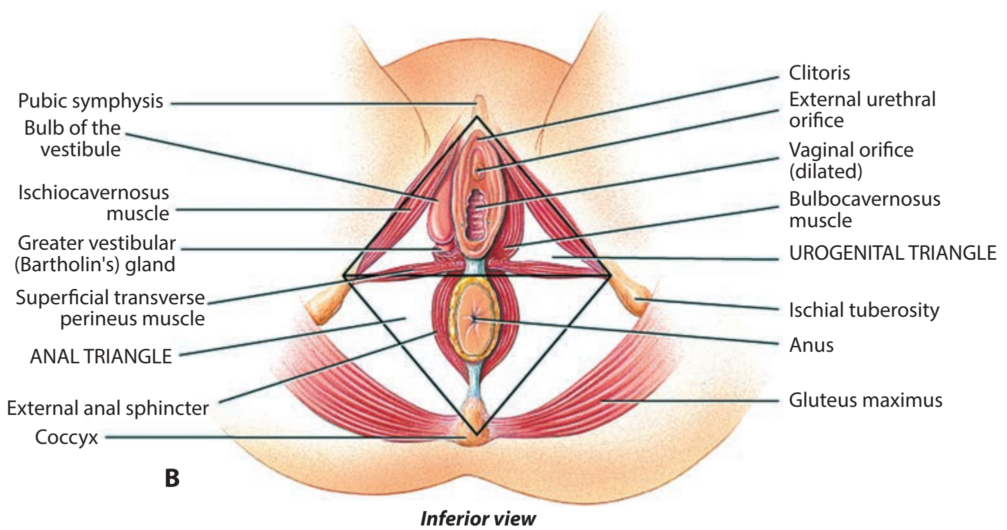


Fig. 116.

A – the female external genitalia. **B** – the internal muscles of the perineum

The female urethra, *urethra feminina* belongs to the urinary organs and serves for urine voiding. However, it is closely related to the genital organs so it's quite reasonable to consider it in this section.

Sizes. The female urethra is a short (3–4 cm long) tube with orifice diameter of 7–8 mm (see Fig. 116).

Ostiums, routing and sphincter of female urethra

The female urethra begins at the urinary bladder with the internal urethral orifice, *ostium urethrae internum* and runs anteroinferiorly. Having reached the pubic symphysis the urethra forms a slight arch and penetrates the perineal membrane. Striated muscular fibers encircle the passing urethra to form the external urethral sphincter, *m. sphincter urethrae extenus*. The urethra opens into the vestibule with the external urethral orifice, ostium urethrae extemus – the narrowest portion of urethra (5–6 mm in diameter).

Wall layers. The urethral mucosa contains the urethral glands, *gll. urethrales* and urethral lacunae, *lacunae urethrales*. The submucosa contains spongiose-type venous plexuses, which form the spongy layer, *tunica spongiosa*.

Muscular layer consists of longitudinal and circular fibers. The related adventitia fixes to the vagina.

Clinical applications

Shorter female urethra allows easier catheterization than that in males. Lacunae and glands may retain infection much likely to proceed to the bladder and cause cystitis. Cystitis is a common chronic disease in females unlike males.

Blood supply. Both labia majores and minores are supplied by the anterior labial branches (rr. labiales anteriores), which arise from the deep external pudendal artery (a branch of the femoral artery) and by the posterior labial branches (rr. labiales posteriores) that arise from the perineal arteries (the branches of pudendal arteries). **Vein blood** from both labia flows via accompanying veins to the internal iliac veins (vv. iliacae internae).

Lymphatic vessels that drain the labia run to the superficial inguinal nodes.

Innervation of the labia is provided by the anterior labial branches (rr. labiales anteriores) of the ilioinguinal nerve, the posterior labial branches (rr. labiales posteriores) of the pudendal nerve and the genital branches (rr. genitales) of genitofemoral nerve.

The clitoris and bulb of vestibule are supplied by the deep artery of clitoris (a. profunda clitoris), the dorsal artery of clitoris (a. dorsalis clitoris) and the artery of bulb of vestibule (a. bulbi vestibuli vaginae), which arise from the internal pudendal artery.

Vein blood collected from the clitoris flows via the deep dorsal vein of clitoris (v. dorsalis profunda clitoris) to the vesicular venous plexus and via the deep veins of clitoris (v. profundae clitoris) to the internal pudendal vein. The vein of bulb of vestibule (v. bulbi vestibuli) joins the internal pudendal vein and the inferior rectal veins.

Lymphatic vessels draining the clitoris and bulb of vestibule run to the superficial inguinal nodes.

Innervation of clitoris is provided by the branches of dorsal nerve of clitoris (n. dorsalis clitoris), a branch of the pudendal nerve and by the cavernous nerves of clitoris (nn. cavemosi clitoridis) arising from the inferior hypogastric plexus.

In children:

- in newborn girls labia majors are developed better in their posterior side and they do not cover completely labia minores that protrude from the pudendal orifice. After birth, body fat in labia majors increases, and they close pudendal orifice tightly;
- in the newborn girl clitoris is relatively long, his foreskin and frenulum all well developed;
- in the newborn girl the urethra is 29 mm long, and also wide, curved and obliquely directed. As a child grows the muscle layer develops, and by school age sphincter is completely developed. The urethra is completely formed by 13 years old.

At childbirth the introitus may be enlarged by making an incision in the perineum *(episiotomy)*. This starts at the fourchette and extends mediolaterally on the right side for 1.5 in (3 cm). The skin, vaginal epithelium, subcutaneous fat, perineal body and superficial transverse perineal muscle are incised. After delivery the episiotomy is carefully sutured in layers.

THE STRUCTURE OF THE PELVIS

The pelvis is made up of the hip bones, the sacrum and the coccyx, bound to each other by dense ligaments.

The hip bone

The *ilium* with its *iliac crest* running between the *anterior* and *posterior superior iliac spines*; below each of these are the corresponding *inferior spines* (Fig. 117, 118).

Well-defined ridges on its lateral surface are the strong muscle markings of the glutei. Its inner aspect bears the large *auricular surface* which articulates with the

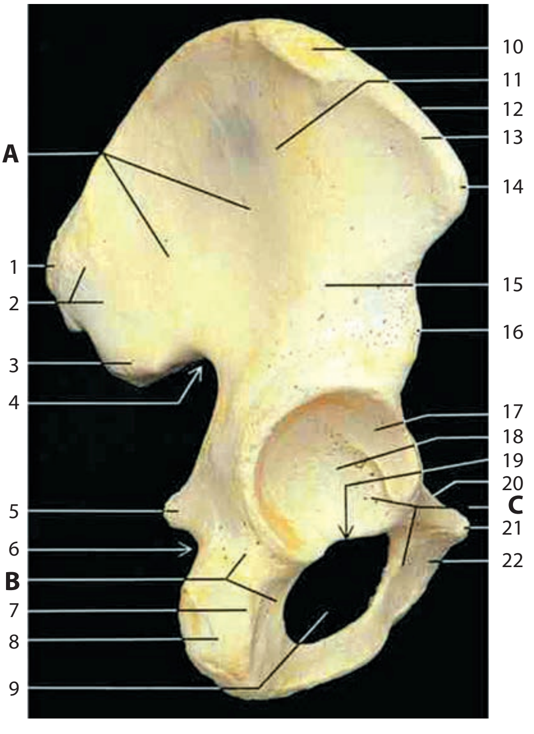


Fig. 117. Right hip bone (lateral aspect).

A – ilium. **B** – ischium. **C** – pubis. 1 – posterior superior iliac spine; 2 – posterior gluteal line; 3 – posterior inferior iliac spine; 4 – greater sciatic notch; 5 – ischial spine; 6 – lesser sciatic notch; 7 – body of ischium; 8 – ischial tuberosity; 9 – obturator foramen; 10 – iliac crest; 11 – anterior gluteal line; 12 – internal lip of iliac crest; 13 – external lip of iliac crest; 14 – anterior superior iliac spine; 15 – inferior gluteal line; 16 – anterior inferior iliac spine; 17 – lunate surface of acetabulum; 18 – acetabular fossa; 19 – acetabular notch; 20 – pecten pubis; 21 – pubic tubercle; 22 – body of pubis

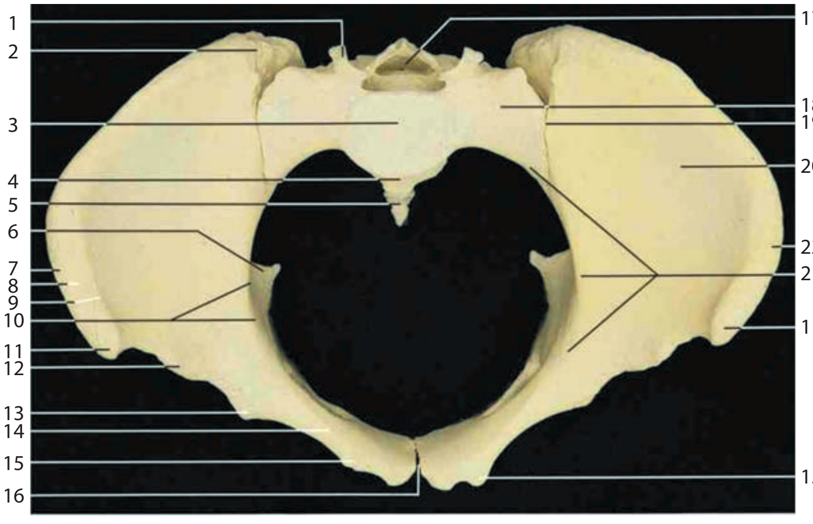


Fig. 118. Female pelvis (superior aspect):
1 – superior articular process of sacrum; 2 – posterior superior iliac spine; 3 – base of sacrum; 4 – sacral promontory; 5 – coccyx; 6 – ischial spine; 7 – external lip; 8 – intermediate line of iliac; 9 – internal lip; 10 – arcuate line; 11 – anterior superior iliac spine; 12 – anterior inferior iliac spine; 13 – iliopubic eminence; 14 – pecten pubis; 15 – pubic tubercle; 16 – pubic symphysis; 17 – sacral canal; 18 – ala of sacrum; 19 – position of sacro-iliac joint; 20 – iliac fossa; 21 – linea terminalis; 22 – iliac crest

sacrum. The *iliopectineal line* runs forward from the apex of the auricular surface and demarcates the *true* from the *false pelvis*.

The *pubis* comprises the *body* and the *superior* and *inferior pubic rami*.

The ischium has a vertically disposed body, bearing the ischial spine on its.

posterior border which demarcates an upper (greater) and lower (lesser), sciatic notch. The inferior pole of the body bears the ischial tuberosity then projects forwards almost at right angles into the ischial ramus to meet the inferior pubic ramus.

The obturator foramen lies bounded by the body and rami of the pubis and the body and ramus of the ischium. All three bones fuse at the acetabulum which forms the socket for the femoral head, for which it bears a wide crescentic articular surface.

The pelvis is tilted in the erect position so that the plane of its inlet is at an angle 60° to the horizontal. (To place a pelvis into this position, hold it against a wall so that the anterior superior spine and the top of the pubic symphysis both touch it).

The sacrum

The sacrum is made up of five fused vertebrae and is roughly triangular.

The anterior border of its upper part is termed the *sacral promontory* and is readily felt at laparotomy.

Its anterior aspect presents a *central mass*, a row of four *anterior sacral foramina* on each side (transmitting the upper four sacral anterior primary rami), and, lateral to these, the *lateral masses* of the sacrum. The superior aspect of the lateral mass on each side forms a fan-shaped surface termed the *ala*.

Note that the central mass is roughly rectangular – the triangular shape of the sacrum is due to the rapid shrinkage in size of the lateral masses of the sacrum from above down.

Posteriorly lies the *sacral canal*, continuing the vertebral canal, bounded by short pedicles, strong laminae and diminutive spinous processes. Perforating through from the sacral canal is a row of four *posterior sacral foramina* on each side. Inferiorly, the canal terminates in the *sacral hiatus*, which transmits the 5th sacral nerve. On either side of the lower extremity of the hiatus lie the *sacral cornua*. These can easily be palpated by the finger immediately above the natal cleft.

On its lateral aspect, the sacrum presents an *auricular facet* for articulation with the corresponding surface of the ilium.

The 5th lumbar vertebra may occasionally fuse with the sacrum in whole or in part; alternatively, the 1st sacral segment may be partially or completely separated from the rest of the sacrum. The posterior arch of the sacrum is occasionally bifid.

Note that the dural sheath terminates distally at the second piece of the sacrum. Beyond this the sacral canal is filled with the fatty tissue of the extradural space, the cauda equina and the filum terminale.

The coccyx

This is made up of three to five fused vertebrae articulating with the sacrum; occasionally the first segment remains separate. It represents, of course, the tail of more primitive animals (Fig. 119).

The functions of the pelvis

1. It protects the pelvic viscera.

2. It supports the weight of the body which is transmitted through the vertebrae, thence through the sacrum, across the sacroiliac joints to the innominate bones and then to the femora in the standing position or to the ischial tuberosities when sitting. (The sacroiliac joint is reinforced for this task as will be described below.)

3. During walking the pelvis swings from side to side by a rotatory movement at the lumbosacral articulation which occurs together with similar movements of the lumbar intervertebral joints. Even if the hip joints are fixed, this swing of the pelvis enables the patient to walk reasonably well.

4. As with all but a few small bones in the hand and foot, the pelvis provides attachments for muscles.

5. In the female it provides bony support for the birth canal.

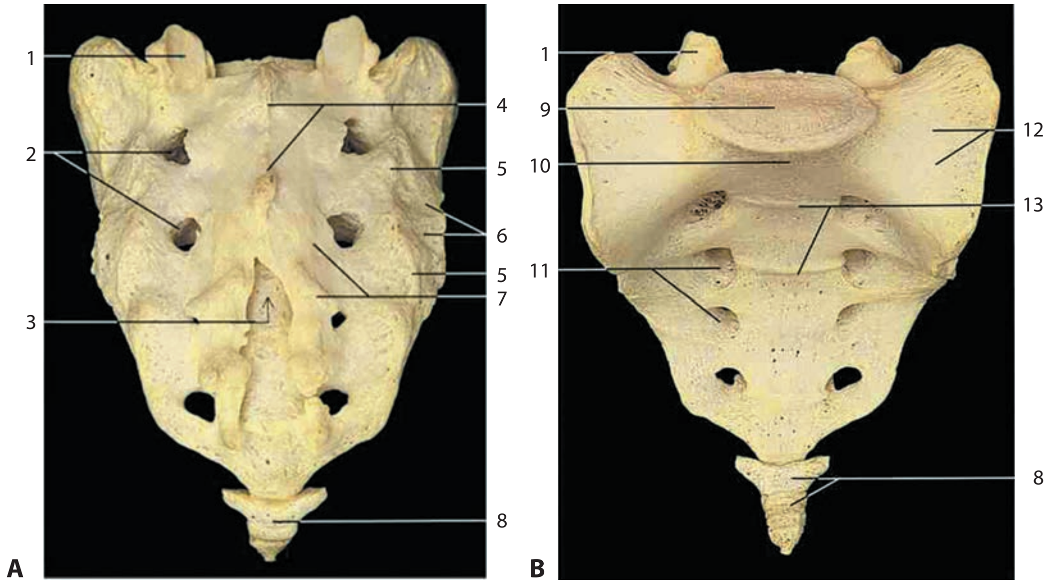


Fig. 119. Sacrum.

A – posterior aspect. **B** –anterior aspect. 1 – superior articular process of sacrum; 2 – dorsal sacral foramina; 3 – sacral hiatus; 4 – median sacral crest; 5 – lateral sacral crest; 6 – sacral tuberosity; 7 – intermediate sacral crest; 8 – coccyx; 9 – base of sacrum; 10 – sacral promontory; 11 – anterior sacral foramina; 12 – lateral part of sacrum (ala); 13 – transverse line of sacrum

Joints and ligamentous connections of the pelvis

The *symphysis pubis* is the name given to the cartilaginous joint between the pubic bones. Each pubic bone is covered by a layer of hyaline cartilage and is connected across the midline by a dense layer of fibrocartilage. The centre of the latter may break down to form a cleft-like joint space which, however, is not seen before the first decade and which is not lined by a synovial membrane.

The joint is surrounded and strengthened by fibrous ligaments, especially above and below.

The *sacroiliac joints* are the articulations between the auricular surfaces of the sacrum and ilium on each side and are true synovium-lined and cartilage-covered joints.

The sacrum 'hangs' from these joints supported by the extremely dense *posterior sacroiliac ligaments* lying posteriorly to the auricular joint surfaces.

These support the whole weight of the body, tending to drag the sacrum forward into the pelvis and, not surprisingly, are the strongest ligaments in the body.

Their action is assisted by an interlocking of the grooves between the auricular surfaces of the sacrum and ilium.

The *sacrotuberous ligament* passes from the ischial tuberosity to the side of the sacrum and coccyx.

The *sacrospinous ligament* passes from the ischial spine to the side of the sacrum and coccyx.

These two ligaments help to define two important exits from the pelvis:

1) the *greater sciatic foramen* – formed by the sacrospinous ligament and the greater sciatic notch;

2) the *lesser sciatic foramen* – formed by the sacrotuberous ligament and the lesser sciatic notch.

Note. There is a useful surface landmark in this region, the dimple constantly seen on each side immediately above the buttock, which defines:

1. The posterior superior iliac spine.
2. The centre of the sacroiliac joint.
3. The level of the second sacral segment.
4. The level of the end of the dural canal of the spinal meninges.

Differences between the male and female pelvis

The pelvis demonstrates a large number of sex differences associated principally with two features: first the heavier build and stronger muscles in the male, accounting for the stronger bone structure and better defined muscle markings in this sex; second, the comparatively wider and shallower pelvic cavity in the female, correlated with its role as the bony part of the birth canal.

The sex differences are summarized in Table 1, Figures 120–122.

When looking at a radiograph of the pelvis, the sex is best determined by three features:

1) the pelvic inlet, heart-shaped in the male, oval in the female;

2) the angle between the inferior pubic rami, which is narrow in the male, wide in the female. In the former, it corresponds almost exactly to the angle between the index and middle fingers when these are held apart; in the latter the angle equals that between the fully extended thumb and the index finger. This is a particularly reliable feature;

3) the soft tissue shadow of the penis and scrotum can usually be seen or, if not, the dense shadow of the lead screen used to shield the testes from harmful radiation.

Obstetrical pelvic measurements

The figures for the measurements of the inlet, mid-cavity and outlet of the true pelvis are readily committed to memory in the form shown in Table 2.

The *transverse diameter of the outlet* is assessed clinically by measuring the distance between the ischial tuberosities along a plane passing across the anus; the *anteroposterior outlet diameter* is measured from the pubis to the sacrococcygeal joint. The most useful measurement clinically is, however, the *diagonal conjugate* – from the lower border of the pubic symphysis to the promontory of the sacrum. This normal-

Table 1

Comparison of male and female pelvis

	Male	Female
General structure	Heavy and thick	Light and thin
Joint surfaces	Large	Small
Muscle attachments	Well marked	Rather indistinct
False pelvis	Deep	Shallow
Pelvic inlet	Heart shaped	Oval
Pelvic canal	Short and tapered	Short with almost parallel sides
Pelvic outlet	Comparatively small	Comparatively large
1st piece of sacrum	The superior surface of the body occupies nearly half the width of sacrum	Oval superior surface of the body occupies about one-third the width of sacrum
Sacrum	Long, narrow, with smooth concavity	Short, wide, flat, curving forward in lower part
Sacroiliac articular facet (auricular surface)	Extends well down the 3rd piece of the sacrum	Extends down only to upper border of 3rd piece
Subpubic angle (between inferior pubic rami)	'The angle between the middle and index finger'	'The angle between the thumb and index finger'
Inferior pubic ramus	Presents a strong everted surface for attachment of the crus of the penis	This marking is not present
Acetabulum	Large	Small
Ischial tuberosities	Inturned	Everted
Obturator foramen	Round	Oval

Table 2

Obstetrical pelvic measurements

	Transverse	Oblique	Anteroposterior
Inlet	5 in (12.5 cm)	4.5 in (11.5 cm)	4 in (10 cm)
Mid-pelvis	4.5 in (11.5 cm)	4.5 in (11.5 cm)	4.5 in (11.5 cm)
Outlet	4 in (10 cm)	4.5 in (11.5 cm)	5 in (12.5 cm)

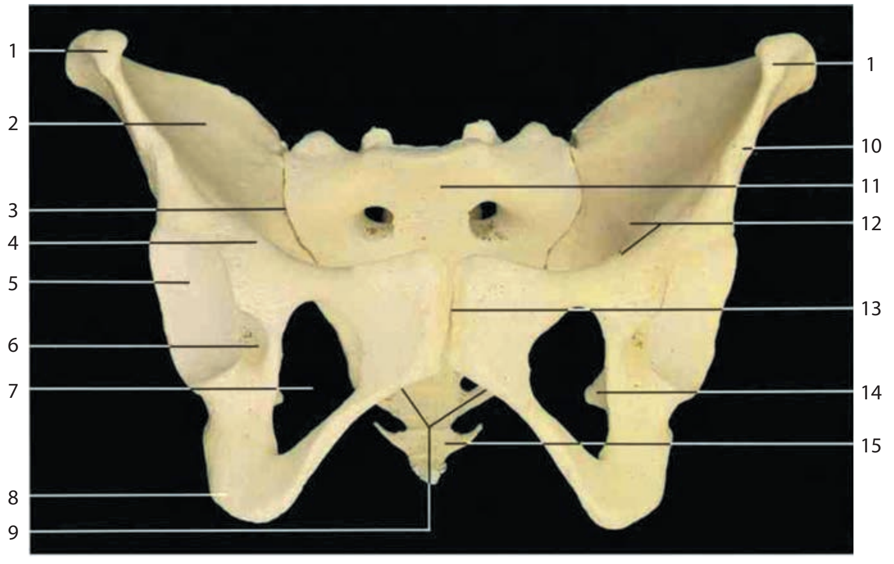


Fig. 120. Female pelvis (anterior aspect).

Note the differences between the form and dimensions of the male and female pelvis. The female pubic arch is wider than the male. The obturator foramen in the female pelvis is triangular, while that in the male pelvis is ovoid

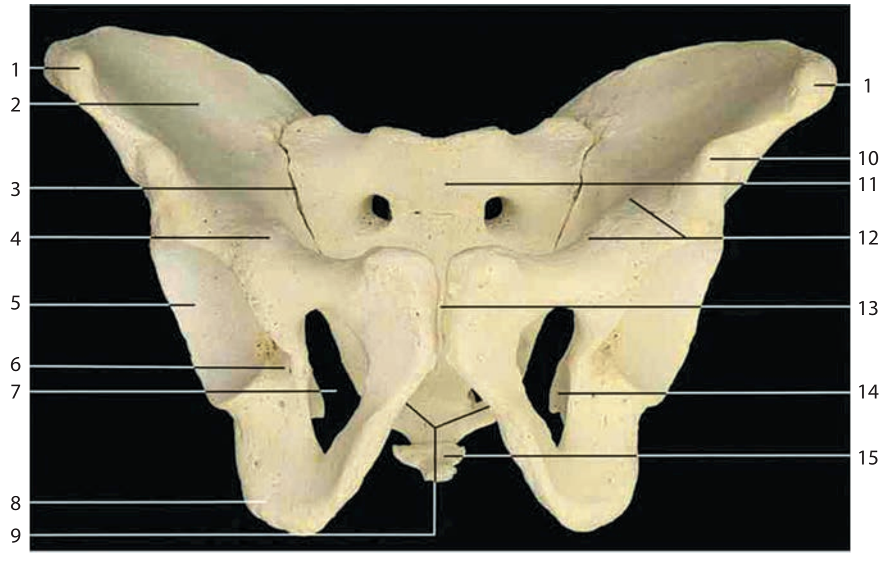


Fig. 121. Male pelvis (anterior aspect). Compare with the female pelvis (depicted above):

1 – anterior superior iliac spine; 2 – iliac fossa; 3 – position of sacro-iliac joint; 4 – iliopubic eminence; 5 – lunate surface of acetabulum; 6 – acetabular notch; 7 – obturator foramen; 8 – ischial tuberosity; 9 – pubic arch; 10 – anterior inferior iliac spine; 11 – sacrum; 12 – linea terminalis (at margin of superior aperture); 13 – pubic symphysis; 14 – ischial spine; 15 – coccyx

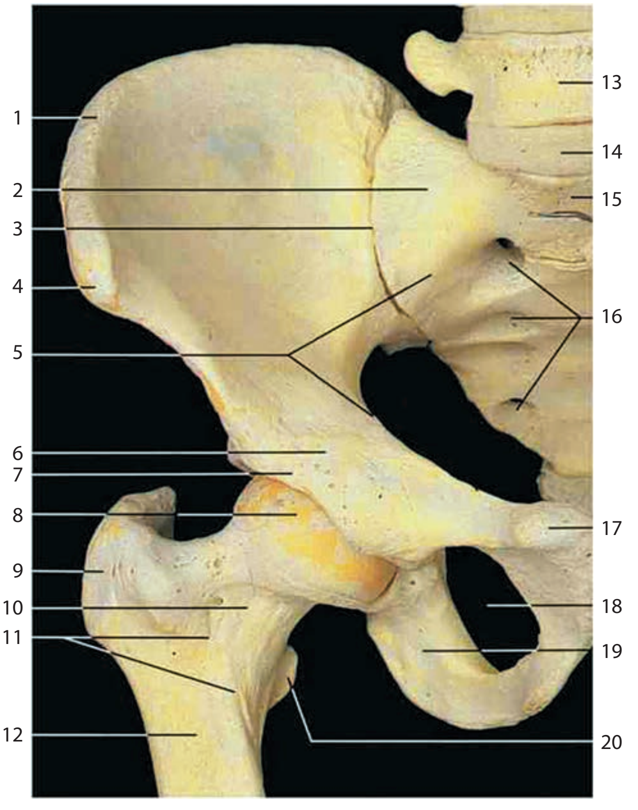


Fig. 122. Bones of right hip joint (anterior aspect):
1 – iliac crest; 2 – lateral part of sacrum (ala); 3 – position of sacro-iliac joint; 4 – anterior superior iliac spine; 5 – linea terminalis; 6 – iliopubic eminence; 7 – bony margin of acetabulum; 8 – head of femur; 9 – greater trochanter; 10 – neck of femur; 11 – intertrochanteric line; 12 – shaft of femur; 13 – fifth lumbar vertebra; 14 – imitation intervertebral disc between fifth lumbar vertebra and sacrum; 15 – sacral promontory; 16 – anterior sacral foramina; 17 – pubic tubercle; 18 – obturator foramen; 19 – ramus of ischium; 20 – lesser trochanter

ly measures 5 in (12.5 cm); from the practical point of view, it is not possible in the normal pelvis to reach the sacral promontory on vaginal examination either readily or without discomfort to the patient.

Another useful clinical guide is the *subpubic arch*: the examiner's four knuckles (i.e. his clenched fist) should rest comfortably between the ischial tuberosities below the pubic symphysis.

Note that these measurements are all of the bony pelvis; the 'dynamic pelvis' of the birth-canal, in fact, is narrowed by the pelvic musculature, the rectum and the thickness of the uterine wall. Today accurate imaging techniques enable exact measurements to be made of the bony pelvis.

Variations of the pelvic shape

The female pelvic shapes may be subdivided (after Caldwell and Moloy) as follows (Fig. 123).

1. The normal and its variants:
   a) *gynaecoid* – normal;
   b) *android* – the masculine type of pelvis;
   c) *platypelloid* – shortened in the anteroposterior diameter, increased in the transverse diameter (the 'non-rachitic flat pelvis');
   d) *anthropoid* – resembling that of an anthropoid ape with a much lengthened anteroposterior and a shortened transverse diameter.
2. Symmetrically contracted pelvis.

That of a small woman but with a symmetrical shape.

3. The Rachitic flat pelvis.

The sacrum is rotated so that the sacral promontory projects forward and the coccyx tips backwards. The anteroposterior diameter of the inlet is therefore narrowed,

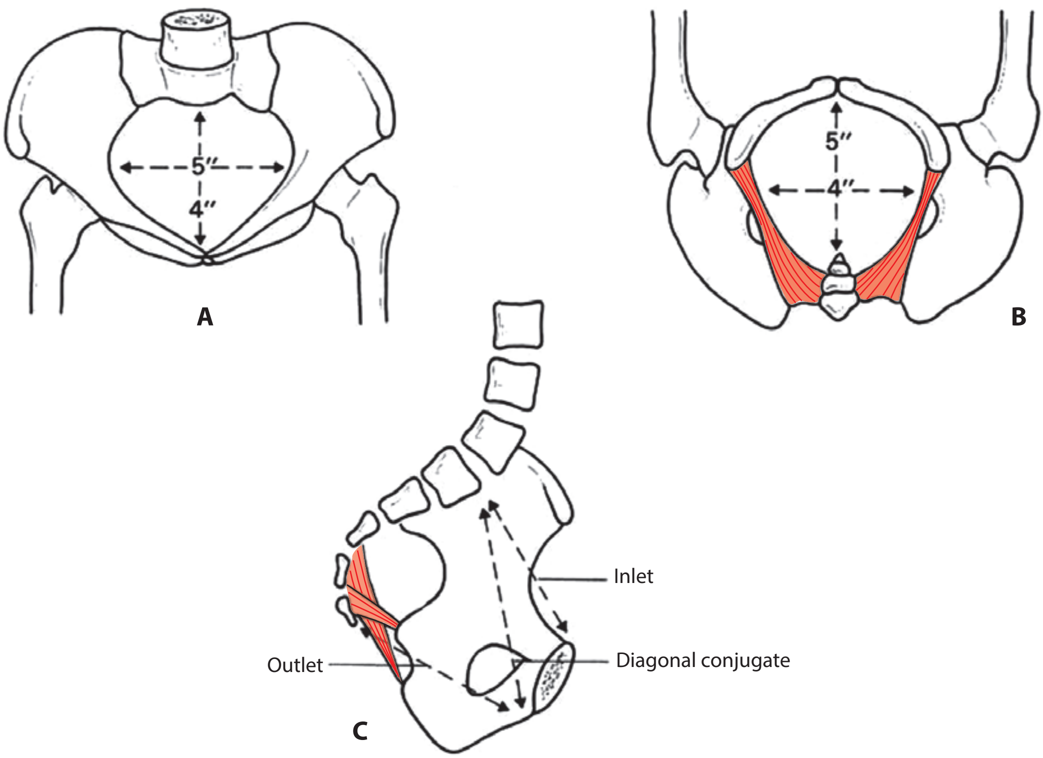


Fig. 123. The measurements of the female pelvis.
A – the inlet. **B** – the outlet. **C** – lateral view to show the diagonal conjugate

but that of the outlet is increased. This deformity is typical of rickets, the result of vitamin D deficiency.

4. The asymmetrical.

Asymmetry can be due to a variety of causes such as scoliosis, longstanding hip disease (e.g. congenital dislocation), poliomyelitis, pelvic fracture, congenital abnormality due to thalidomide and the *Naegele pelvis* which is due to the congenital absence of one wing of the sacrum or its destruction by disease.

Clinical applications

Fractures of the pelvis

These may be isolated lesions due to a localized blow or may be displacements of part of the pelvic ring due to compression injuries. Lateral compression usually results in fractures through both pubic rami on each side, or both rami on one side with dislocation at the symphysis; anteroposterior compression may be followed by dislocation at the symphysis or fractures through the pubic rami accompanied by dislocation at the sacroiliac joint.

Displacement of part of the pelvic ring must, of course, mean that the ring has been broken in two places.

Falls upon the leg may force the head of the femur through the acetabulum, the so-called central dislocation of the hip. Isolated fractures may be produced by local trauma, especially to the iliac wing, sacrum and pubis.

Associated with pelvic fractures one must always consider soft tissue injuries to bladder, urethra and rectum, which may be penetrated by spicules of bone or torn by wide displacements of the pelvic fragments.

Occasionally in these pelvic displacements the iliolumbar branch of the internal iliac artery is ruptured as it crosses above the sacroiliac joint; this may be followed by a severe or even fatal extraperitoneal haemorrhage.

Sacral (caudal) anaesthesia. The sacral hiatus, between the last piece of sacrum and coccyx, can be entered by a needle which pierces skin, fascia and the tough posterior sacrococcygeal ligament to enter the sacral canal. The hiatus can be defined by palpating the sacral cornua on either side immediately above the natal left.

Anaesthetic solution injected here will travel extradurally to bathe the spinal roots emerging from the dural sheath, which terminates at the level of the 2nd sacral segment. The perineal anaesthesia can be used for low forceps delivery, episiotomy and repair of a perineal tear (Fig. 124).

The perineum, perineum

The perineum stands for complex of soft tissues (skin, muscles and fasciae) that close the pelvic outlet. The perineum is bounded by the inferior border of pubic sym-

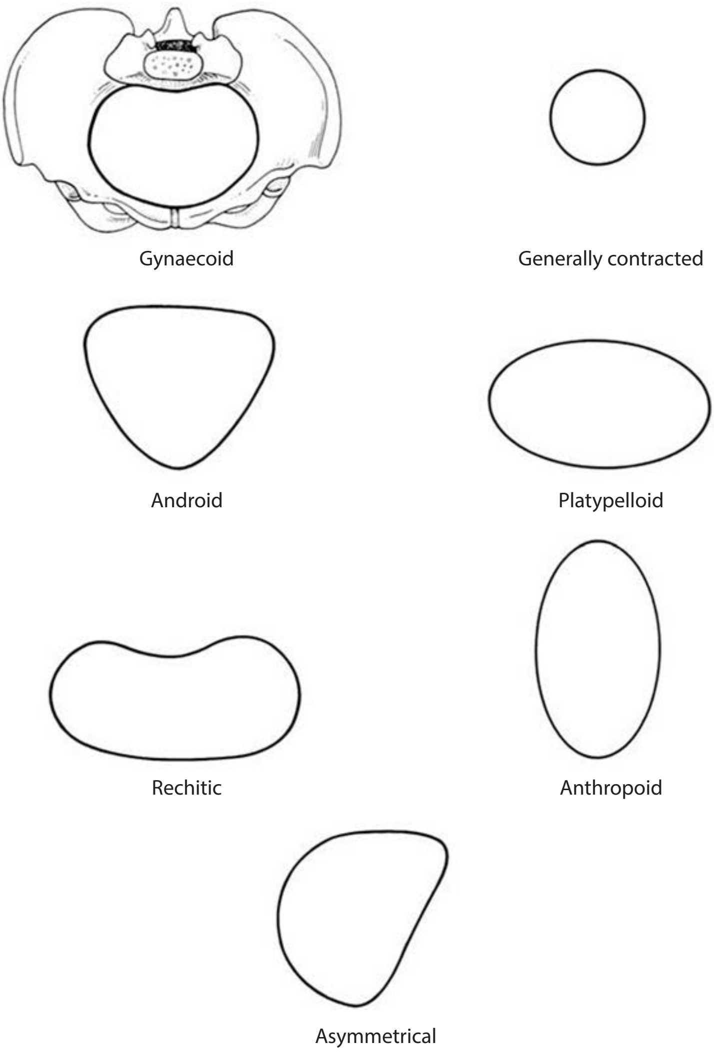


Fig. 124. Pelvic variations and abnormalities – shown as diagrammatic outlines of the pelvic inlet

physis anteriorly, the apex of coccyx – posteriorly, the inferior pubic rami, ischial rami and related tuberosities – laterally (Fig. 125).

The perineum contains the external genitalia and orifices of urinary and alimentary systems. The skin passing from neighboring surfaces merges to form midline perineal raphe, *raphe perinei*. Underlying muscles covered with fascia close the pelvic outlet. The deep muscles are directly responsible for closing the pelvic outlet, while the superficial muscles are related to the genitals and rectum. Deep muscles converge between the genitals and rectum to form the perineal body, centrum perinei (Fig. 126).

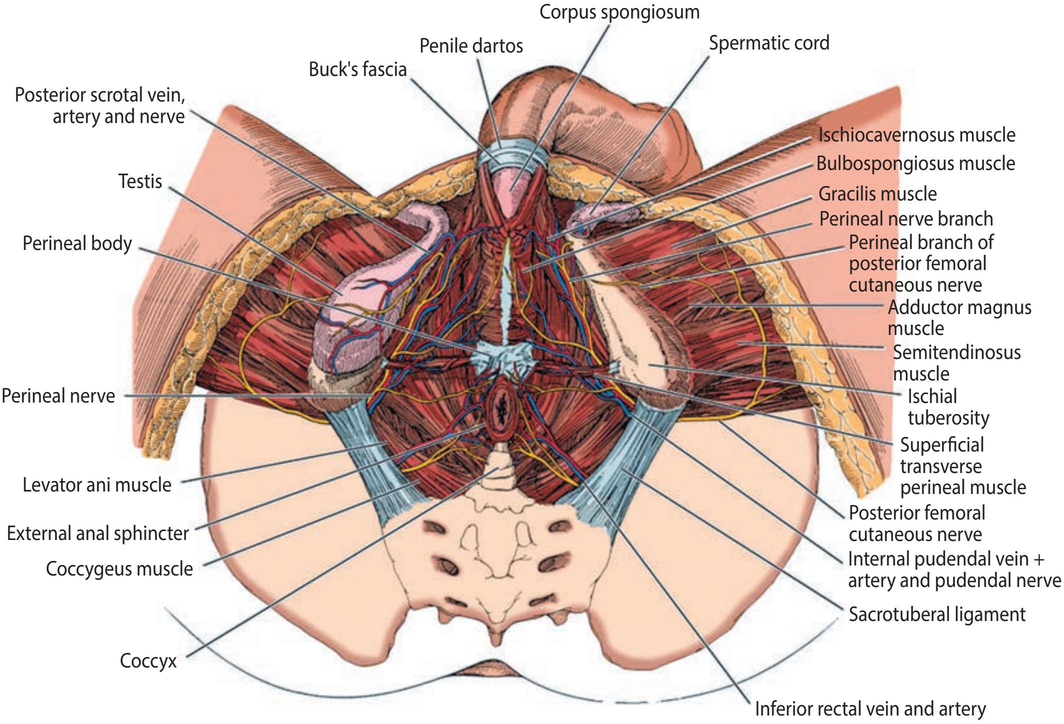


Fig. 126. Muscles oft he pelvic floor

Obstetricians consider the perineum as an area between the posterior border of pudendal cleft and anterior border of anus (obstetric perineum). Ruptures of this area during delivery are common and require surgical treatment.

Perineum divisions. A transverse line joining the ischial tuberosities divides the rhomb-shaped perineal area into two triangular areas: the anterior urogenital triangle, *regio urogenitalis* and posterior anal triangle, *regio analis*. The urogenital triangle is related to the perineal membrane, which passes the urethra and – in women – vagina. The anal triangle is related to the pelvic diaphragm, which passes the rectum.

The pelvic diaphragm, *diaphragma pelvis* closes the larger posterior portion of pelvic outlet. It comprises paired muscles – the levator ani and coccygeus.

The levator ani, *m. levator ani*. The right and left muscles join to form a wide funnel-shaped muscular plate, which arises from the pelvic walls and descends medially reaching the rectum, fundus of bladder and prostate (or vagina). Depending on arise point and fibers route, the muscle is subdivided into the medial and posterolateral parts.

The medial part of each levator ani arises from the pubic bone leaving a midline slit to be closed by the perineal membrane. Passing on, the muscle runs posteriorly rounding the bladder, prostate (or vagina), and rectum and attaches to the coccyx with short tendinous fibers. These fibers form the anococcygeal body (Fig. 127).

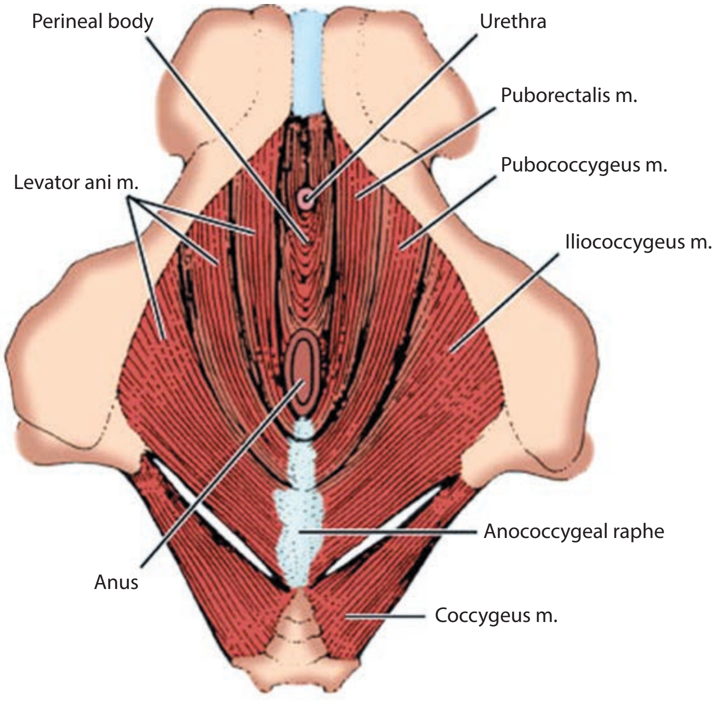


Fig. 127. Muscles of female pelvic diaphragm

The posterolateral part arises from the obturator fascia and ischial spine as the tendinous arch of levator ani, arcus tendineus m. levatoris ani; it runs posteromedially rounding the rectum and attaches to the coccyx and. anococcygeal body, which resides between rectum and coccyx.

The levator ani elevates the pelvic floor and narrows the vaginal ostium.

The coccygeus, *m. coccygeus* is a small muscle adjacent to the levator ani. It is penetrated by tendinous fibers. The muscle arises from the ischial spine and sacrospinous ligament and attaches to the lateral borders of sacrum and coccyx (Fig. 128).

Fascia of the pelvic diaphragm. The levator ani and coccygeus are invested with two fascial plates – the superior and inferior fascia of pelvic diaphragm. The superior fascia of pelvic diaphragm, *fascia diaphragmatis pelvis superior* is a continuation of parietal plate of pelvic fascia, which passes onto the superior surface of levator ani. Having covered the muscle, the fascia runs upwards to pass onto pelvic viscera. This portion of fascia is called the visceral pelvic fascia, fascia pelvis visceralis; it invests the prostate, bladder, vagina, anterior portion of cervix of uterus and rec turn. Running upwards it becomes thinner and eventually disappears. In some places, the fascia thickens to form fascial septa and ligaments as follows: the puboprostatic ligament, *ligamentum puboprostaticus* and rectovesical septum, *septum rectovesicale* – in

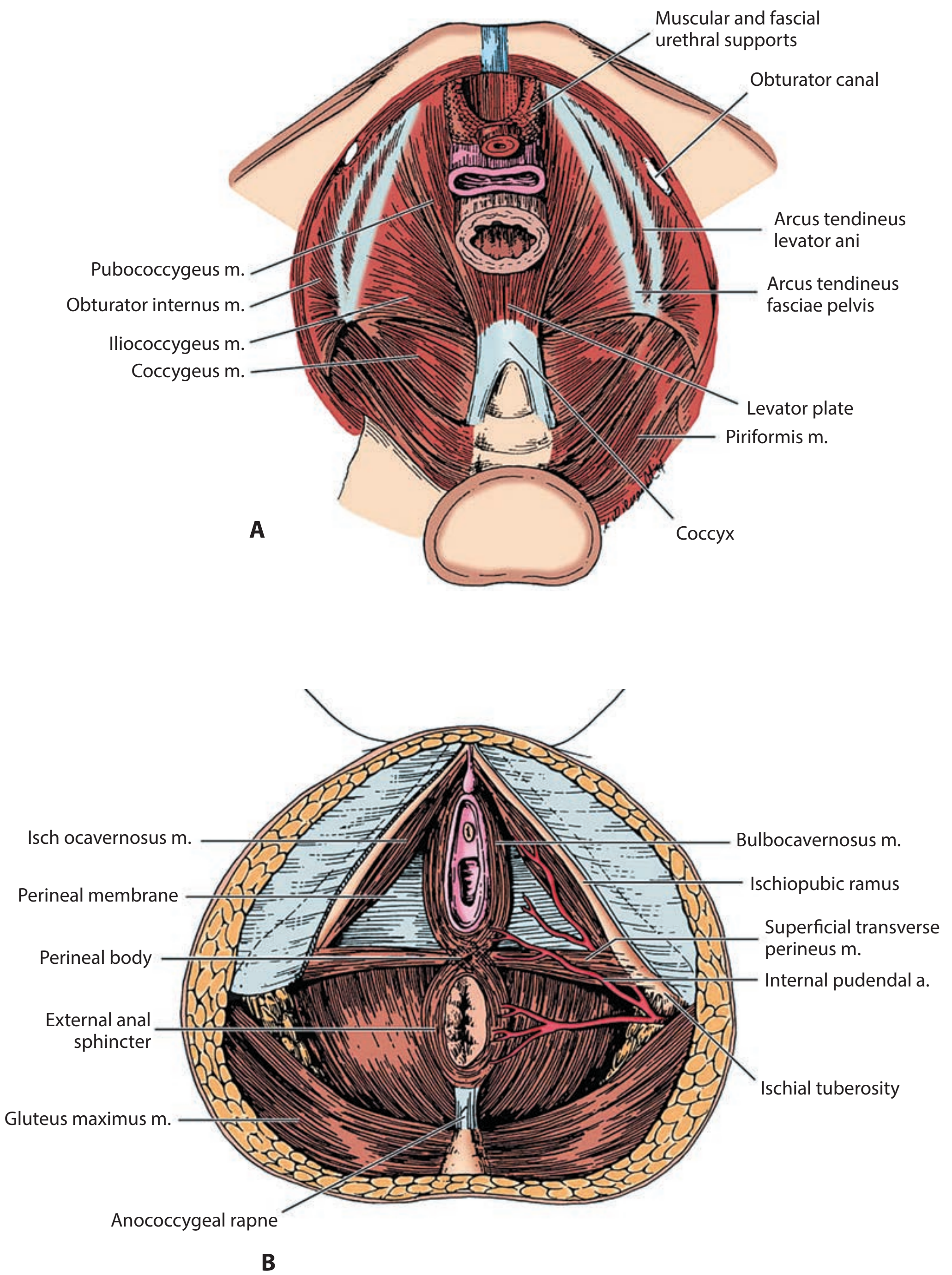


Fig. 128. Pelvic diaphragm from below. Levator ani composed of three muscles: puborectalis, pubococcygeus, and iliococcygeus

males and pubovesical ligament, lig. pubovesicale and rectovaginal sepum, *septum rectovaginale* – in females.

The inferior fascia of pelvic diaphragm, *fascia inferior diaphragmatis pelvis* covers the muscles from outside. Posteriorly it becomes continuous with gluteal fascia, laterally it invests the ischio- anal fossa and anteriorly fixes to the perineal membrane fascia.

The perineal membrane, *membrana perinei* closes the lesser anterior portion of pelvic outlet. It expands between pubic and ischial bones. The membrane consists of deep and superficial muscles and fasciae. The deep perineal muscles are the deep transverse perineal muscle and external urethral sphincter. These muscles are covered with fasciae.

The deep transverse perineal muscle, *m. transversus perinei profundus*, a paired muscle attached to ischial tuberosity on each side. It consists of transverse muscle fibers, which join the perineal body. The muscle reinforces the perineal diaphragm.

The external urethral sphincter, *m. sphincter urethrae externus* appears as circular muscle fibers, which encircle the intermediate part of urethra. In females, the muscle also encircles the vagina (Fig. 129).

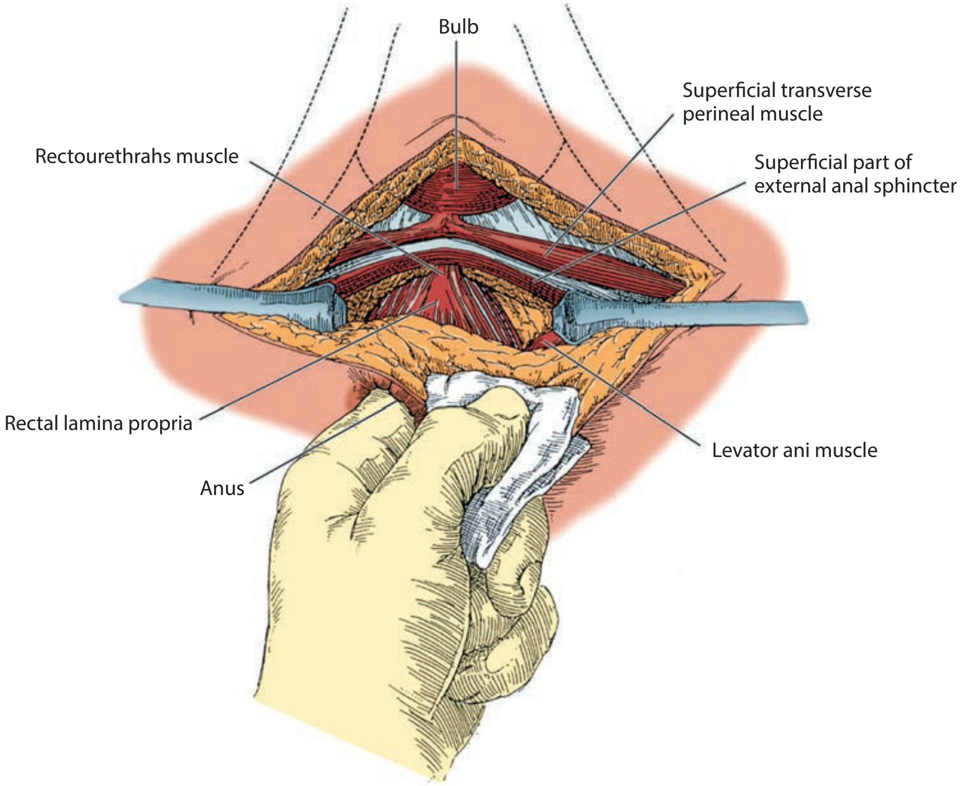


Fig. 129. Muscles of the perinei

Fasciae of the perineal membrane are represented with superior and inferior plates, which cover respective surfaces of perineal membrane.

The superior fascia of urogenital membrane, *fascia diaphragmatis urogenitalis superior* invests the pelvic surface of deep transversal perineal muscle and external urethral sphincter.

The inferior fascia of urogenital membrane, *fascia diaphragmatis urogenitalis inferior* invests the inferior surface of perineal muscles. The fasciae merge both anteriorly and posteriorly. In depth of perineal diaphragm between the fascial plates, there are bulbo-urethral glands (in males) or greater vestibular gland (in females) (Fig. 130).

The superficial perineal muscles and fasciae. The superficial muscles lie under the skin and are covered with superficial perineal fascia. These muscles are also subdivided into urogenital and anal triangle related groups. First group is related to genitalia, the second – to the rectum.

The superficial muscles of perineal membrane. This group comprises three small paired muscles: the superficial transverse perineal muscle, the ischiocavernosus and the bulbospongiosus.

The superficial transverse perineal muscle, *m. transversus perinei superficialis arises from the ischial tuberosity and passes in direction of perineal body where joins the external anal sphincter. The muscle reinforces the perineal membrane.*

The ischiocavernosus, *m. ischio-cavemosus* runs from the ischial tuberosity to the corpus cavernosusof penis (or clitoris). Compressing the deep dorsalvein of penis, the muscles assist erection.

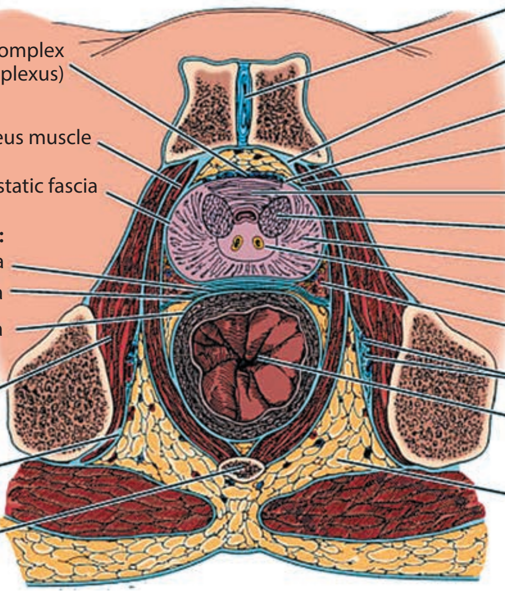


Fig. 130. Transverse section of male pelvis shows fascial layers surrounding prostate gland

The bulbospongiosus, *m. bulbospongiosus* encircles the bulb of penis in males. In the middle of bulb, the muscles join by means of tendinous band. The muscles also assist erection. In females, the muscle encircles the vaginal ostium.

The external anal sphincter, *m. sphincter ani externus* resides in pelvic diaphragm area. It arises from the coccyx, enfolds the rectum and runs anteriorly to join the perineal body and other perineal muscles. The muscle consists of crossing circular fibers. In the muscle the subcutaneous (superficial) and deep fibers are distinguishable.

The perineal fascia, *fascia perinei* invests the superficial muscles from outside. The fascia is merely a part of entire superficial fascia and is scarce in this region.

The ischio-anal fossa, *fossa ischioanalis* is the cone-shaped space related to both perineal areas, which expands laterally to the levator ani and anus (Fig. 131). Laterally the fossa is bounded by the internal obturator invested with obturator fascia and medial surface of ischial tuberosity Medially it is bounded by the levator ani and inferior fascia of pelvic diaphragm.

Anteriorly the fossa is bounded by perineal muscles and posteriorly – by the coccygeus. The fossa is filled with fat forming the fat body of ischioanal fossa, corpus adiposum fossae ischioanalis, which contains vessels and nerves. The fat body is covered with perineal fascia.

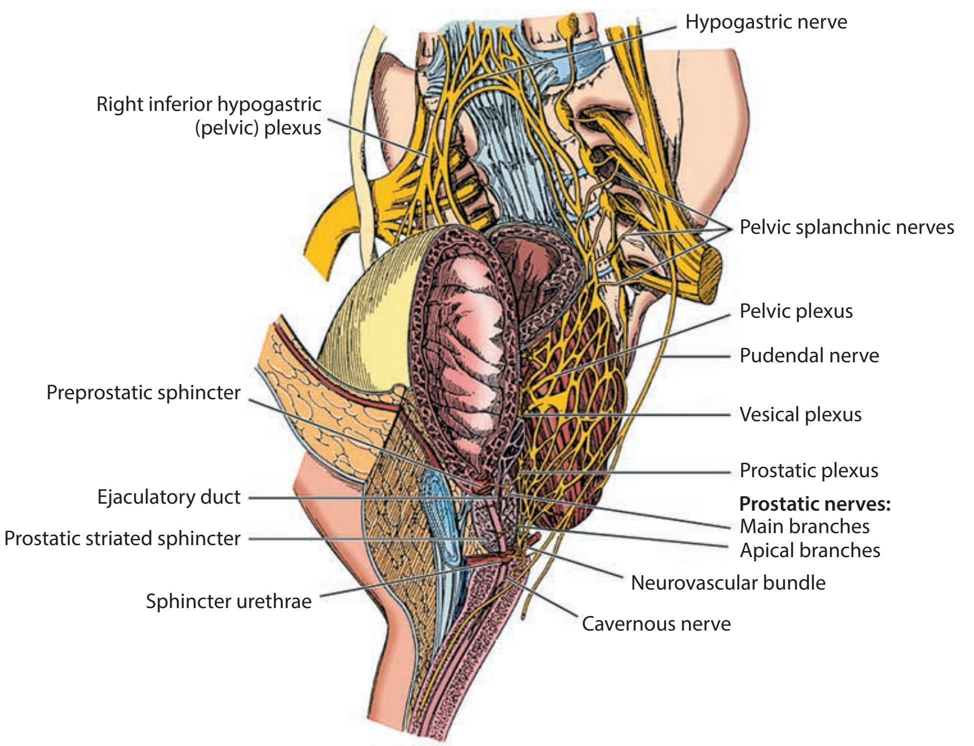


Fig. 131. Innervation of male pelvis

Clinical applications

Infection may expand from the rectum to ischio-anal fossa and cause inflammation called paraproctitis. In this case, surgical interference is required.

Blood supply. The perineum is supplied by the branches of internal pudendal artery, which leaves the lesser pelvis cavity through the greater sciatic foramen, loops around the ischial spine and passes through the lesser sciatic foramen to reach the ischio-anal fossa. In the fossa, the artery gives branches as follows: the inferior rectal artery (a. rectalis inferior), the perineal artery (a. perinea- lis) and the dorsal artery of penis/ clitoris (a. dorsalis penis/clitoris). Vein blood is drained via accompanying veins to the internal iliac vein.

Lymphatic vessels that drain the perineum run to the superficial inguinal nodes.

Innervation of the perineum is provided by the branches of pudendal nerve – the inferior rectal nerves (nn. rectales inferiores), the perineal nerves (nn. perineales) and by the branches of coccygeal nerve–the ano – coccygeal nerves (nn. anococcygei).

PRACTICE QUESTIONS

1. What organs belong to external and internal male genitalia?
2. Describe the exterior of male gonad (testis).
3. Where does the epididymis reside and what parts are distinguishable in it?
4. Describe the interior of testis and epididymis.
5. Where are the male gametes formed?
6. List the testicular tunics and explain what they are formed of.
7. List the constituents of spermatic cord.
8. Describe relations of the ductus deferens and name its parts.
9. What structures form the ejaculatory duct and where does it open?
10. Describe structure and relations of the seminal vesicles. Explain their physiological significance.
11. Describe exterior of the prostate.
12. Describe relations of the prostate.
13. Describe interior of the prostate.
14. What lobes are distinguishable in the prostate? What the lobes are delimited with? Explain practical significance of the isthmus of prostate.
15. Discuss the functional significance of prostate.
16. Where do the bulbo-urethral glands reside and where do their ducts open?
17. Explain functional significance of the bulbo-urethral glands.
18. Describe exterior of the penis.
19. Describe the interior of corpora cavernosa of penis.
20. Name the parts of corpus spongiosum of penis. What structure passes through the corpus spongiosum?
21. Name the fascia and ligaments of penis.
22. Describe the scrotum structure.
23. Name the parts of male urethra. Describe the prostatic part of male urethra.
24. Describe the intermediate and spongy parts of urethra.
25. Name male urethra flexures and explain their practical significance.
26. Name the male urethra sphincters.
27. What parts do clinicians distinguish in the male urethra?
28. Name the constrictions and dilations of male urethra.
29. What organs belong to external and internal female genitalia?
30. Describe the exterior and relations of ovary.
31. Is the ovary a peritoneum-related organ? Name the ovarian ligaments.
32. Describe the interior of ovary.
33. What types of follicles are distinguishable in the ovary? Where do they reside?
34. What changes occur in the follicle during oocyte development?

35. Give definition of the corpus luteum. Explain its functional significance.
36. What conditions lead to multiparous pregnancy?
37. Describe exterior of the uterine tube. Explain its function.
38. Describe wall layers of the uterine tube. What type of epithelium lines its mucosa?
39. How does the mesosalpinx form?
40. What factors cause ectopic pregnancy?
41. Describe exterior of the uterus and its ligaments.
42. List the uterine wall layers and describe each layer.
43. What is the shape of uterine cavity? What orifices open into' the uterine cavity?
44. What is the shape of cervical canal? Where does it open?
45. What are the internal and external os of uterus?
46. What terms describe normal position of the uterus?
47. What pathological positions of uterus may occur?
48. Describe peritoneal relations of uterus.
49. What structures belong to supporting apparatus of uterus?
50. Name the walls of vagina. Describe relations of vagina.
51. Where does the superior portion of vagina attach? Where does its ostium open?
52. How does the vaginal fornix form? What is the practical significance of the posterior part of fornix?
53. What layers are distinguishable in the vagina?
54. Discuss features of vaginal mucosa structure.
55. Describe the structure of female external genitalia:
    a) the mons pubis;
    b) the labia majores;
    c) the labia minores;
    d) the clitoris;
56. Name the spaces bounded by:
    a) the labia majores;
    b) the labia minores.
57. Describe the bulb of vestibule.
58. Where does the greater vestibular gland reside? Where does its duct open?
59. Describe the structure of female urethra. Where does its external orifice open?
60. Give definition of the perineum.
61. Describe divisions of perineum and explain how the dividing line runs.
62. What organs form the pelvic diaphragm?
63. Name the muscles, which form the pelvic diaphragm.
64. Name the pelvic diaphragm fascia.
65. What muscles form the perineal diaphragm? Describe their structure and functions.
66. Name the perineal diaphragm fascia.
67. Where does the ischio-anal fossa reside? Describe its boundaries.
68. What tissue fills the ischio-anal fossa? Discuss practical significance of the fossa.

69. Discuss features of genitalia in inferior invertebrates.
70. Describe differentiation of gonads in vertebrates.
71. Where do the gonads develop in mammals?
72. Characterize the indifferent stage of gonads development in humans:
    a) what structure gives rise to indifferent gonad primor- dia?
    b) what ducts develop at this stage?
73. What changes occur in the indifferent gonad during development of male gonads?
74. Which duct undergoes reduction in developing male fetus?
75. What structure gives rise to the ductus deferens?
76. What changes occur in the indifferent gonad during development of female gonads?
77. Which duct undergoes reduction in developing female fetus?
78. What structures give rise to the uterine tubes, uterus and vagina?
79. Where do the gonads primordia appear?
80. What processes assist the testes descent?
81. Describe development and fate of the processus vaginalis.
82. Give definition of terms'monorchism', 'anorchism' and 'cryptorchidism'.
83. Name the developmental anomalies of female internal genitalia.
84. Describe the structure of indifferent gonads primordia.
85. What changes occur in indifferent primordia during development of external genitalia:
    a) in male embryo;
    b) in female embryo.
86. Give definition of hermaphroditism. What major types of hermaphroditism do you know?

SITUATION TASKS

1. After a significant of loss weight a 70-year-old man has some dull pain in the loin. The diagnose is a floating kidney. In which part of the kidney fixative apparatus has the changes taken place?

A. Capsula adiposa*.
B. Capsula fibrosa.
C. M. iliopsoas.
D. Lig. hepatorenalis.
E. M. quadratus lumborum.

2. An elderly man has a complicated urination. Which part of urethra becomes narrower with age most often?

A. Pars spongiosa.
B. Glandulae urethrales.
C. M. sphincter urethrae externum.
D. Pars membranacea.
E. Pars prostatica*.

3. Urography has shown stones in the macroscopic parts of the kidney of urinary tracts. It was detected that they are located in:

A. Minor and major renal calices, renal pelvis*.
B. Gathering tubules, papillary ducts, minor renal calices.
C. Straight tubules, minor and major renal calices.
D. Papillary ducts, major renal calices, renal pelvis.
E. Papillary ducts, minor renal calices, straight tubules.

4. A woman of 58 has had the complete hysterectomy and salpingo-ooppriorectomy, and after that urinary excretions stopped. Cystoscopy has shown that the bladder docs not contain any urine; urine does not flow from the openings of ureters. Which part of the urinary excretion system is damaged?

A. Urethra.
B. Ureter*.
C. Vesica urinaria.
D. Pelvis renalis.
E. Ren.

5. A 40-year-old man had a ureteral calculus instrumentally removed, which was complicated by a rupture of the ureter wall in the abdominal part. Where will urine get through the rupture in the ureter wall?

A. Omental bursa.
B. Hepatic bursa.
C. Peritoneal cavity.

D. Retroperitoneal space*.
E. Vertebral canal.

6. During a urinary bladder catgheterization an abrupt catheter introduction caused bleeding as a result of the trauma of the urethral mucous tunic in the external sphincter muscle area. In which urethral area should the doctor should be careful and feel the resistance of soft tissues during catheterization?
A. In pars membranacea urethrae*.
B. In fossa navicularis urethrae area.
C. In bulbus urethrae.
D. In pars spongiosa urethrae.
E. In past prostatica urethrae.

7. During a surgery on the small pelvis there was a need to perform an intraoperative uterine artery ligation. Which one of the mentioned may be accidentally ligated together with it?
A. Urethra.
B. Uterine tube.
C. Round ligament of uterus.
D. Internal iliac vein.
E. Ureter*.

8. Ultrasonic examination of a young man of 19 has shown nephroptosis. At which vertebrae level is the kidneys' normal position?
A. $T_{XI} - L_{III*}$
B. $T_{IX} - T_{X}$.
C. $L_{IV} - L_{V}$.
D. $T_{XII} - L_{I}$.
E. $T_{IX} - T_{XII}$.

9. A woman of 25 has been hospitalized for an ovary tumor surgery. During the operation a ligament connecting the ovary with the uterus is to be dissected. Which one?
A. Lig. ovarii proprium*.
B. Lig. cardinale.
C. Lig. latum uteri.
D. Lig. suspensorium ovarii.
E. Lig. umbilicale laterale.

10. A man of 35 complains of pain and swelling of the right testicle. Examination has shown a tumor, the surgery of which requires dissection of testicle tunics. Which tunic will be dissected the last before tunica albuginea?
A. Tunica dartos.
B. Tunica spermatica externa.
C. Tunica vaginalis testis*.
D. Tunica spermatica interna.
E. Cutis orchis.

11. A 65-year-old male patient complains of urination disorder. Examination has shown prostatic hypertrophy. Enlargement of what parts of prostate may cause this disturbances?

A. Right lobe.
B. Isthmus (middle lobe)*
C. Left lobe.
D. Capsule.
E. Prostatic ducts.

12. A boy was diagnosed a scrotal hernia. The underdevelopment of which testicular membrane caused the hernia?

A. Fascia spermatica interna.
B. Fascia spermatica externa.
C. Tunica vaginalis testis*.
D. Fascia cremasterica.
E. Tunica dartos.

13. During a gynecologic examination a patient has endometritis (inflammation of endometrium) diagnosed. Which membrane of uterine wall is affected by the inflammatory process?

A. Mucous tunic*.
B. Serous tunic.
C. Muscular tunic.
D. Adventitious membrane.
E. Parametrium.

14. A patient is diagnosed with scrotal hydrocele – an increase of fluid quantity in serous sac. Between which testicular tunics is the pathologic content located?

A. Between parietal and visceral layers of vaginal tunic*.
B. Between skin and dartos muscle.
C. Between internal spermatic fascia and vaginal tunic.
D. Between dartos muscle and internal spermatic fascia.
E. Between skin and cremaster muscle.

15. A surgeon has detected scrotal hydrocele of a patient. Between the layers of which testicular tunic has the fluid accumulated?

A. Dartos muscle.
B. Tunica albuginea.
C. Serous (vaginal tunic)*.
D. Spermatica externa.
E. Spermatica interna.

16. A patient has left-side varicocele. Blood outflow disorder has taken place in:

A. V. testicularis sinistra*.
B. V. testicularis dextra.
C. V. renalis sinistra.
D.V. renalis dextra.

E. V. ovarica.

17. A 28-year-old woman was admitted to a gynecology department with complaints of pain in the abdominal region. An ovary tumor was clinically detected and prescribed to be removed. During the operation a ligament connecting the ovary with the uterus is to be dissected. Which ligament is it?

A. Lig. ovarii proprium*.
B. Lig. latum uteri.
C. Lig. cardinale.
D. Lig. umbilicalis lateralis.
E. Lig. suspensorium ovarii.

18. A man complains of frequent and complicated urination. Which internal genital organ pathology caused this?

A. Testicle.
B. Prostate*.
C. Bulbourethral glands.
D. Epididymis.
E. Seminal vesicles.

19. A patient with a knife wound in the left lumbal part was delivered to the emergency hospital. In course of operation a surgeon found that internal organs had not been damaged but the knife had injured one of muscles of renal pelvis. What muscle is it?

A. Erector muscle of spine.
B. Iliac muscle.
C. Greater psoas muscle*.
D. Abdominal internal oblique muscle.
E. Abdominal external oblique muscle.

20. During operation on kidneys, a surgeon must select the renal stalk. What goes out from a kidney gate?

A. Renal artery, ureter.
B. Renal artery, nerves.
C. Renal vessels and nerves.
D. Renal artery and vein.
E. Renal vein, ureter and lymphatic vessels*.

21. During operation on kidneys, a surgeon must select the leg of kidney. Which anatomical structures enter the kidney gate?

A. Renal artery and vein.
B. Renal artery, nerves and lymphatic vessels.
C. Renal artery and nerves*.
D. Renal vein, ureter.
E. Renal artery, ureter.

22. Ultrasonic examination of a young woman of 23 y.o. has shown nephroptosis. Name the structures which does not take part in the kidney support.

A. M. quadratus lumborum.
B. The perinephric fat.
C. The renal sinus*.
D. M. iliopsoas.
E. The renal bed.

23. A patient has urolithiasis that was complicated by a renal calculus passage. At what level of ureter is it most likely to stop?
A. 5 cm above the pelvic part.
B. In the pelvis.
C. In the middle abdominal part.
D. 2 cm above the flowing into urinary bladder.
E. Between abdominal and pelvic part*.

24. During complicated labour the symphysis pubis was ruptured. What organ can be damaged mostly?
A. Urinary bladder*.
B. Rectum.
C. Ovaria.
D. Uterine tubes.
E. Uterus.

25. During cystoscopy, mucous membrane of urinary bladder normally makes folds except for a single triangular area with smooth mucosa. This triangle is located in the following part of urinary bladder:
A. Bladder cervix.
B. Bladder floor*.
C. Bladder apex.
D. Bladder body.
E. Bladder isthmus.

26. A patient was diagnosed with bartholinitis (inflammation of greater vulvovaginal glands). In which organ of urogenital system are these glands located?
A. Clitoris.
B. Small lips of pudendum.
C. Large lips of pudendum*.
D. Vagina.
E. Uterus.

27. While performing a woman's inguinal canal operation because of hernia a surgeon damaged the canal's contents. What exactly was damaged?
A. Lig. inguinale.
B. Urachus.
C. Funiculus spermaticus.
D. Lig. teres uteri*.
E. Broad ligament of uterus.

28. A 28-year-old woman has been diagnosed with extrauterine pregnancy complicated by the fallopian tube rupture. The blood is most likely to penetrate the following peritoneal space:

A. Intersigmoid sinus.
B. Vesicouterine.
C. Right mesenteric sinus.
D. Left mesenteric sinus.
E. Rectouterine*.

29. A woman needed an operation because of extrauterine (tubal) pregnancy. In course of the operation the surgeon should ligate the branches of the following arteries:

A. Superior cystic and ovarian.
B. Uterine and ovarian*.
C. Inferior cystic and ovarian.
D. Uterine and superior cystic.
E. Uterine and inferior cystic.

30. Inflammatory process of modified subserous layer around cervix of the uterus caused an intensive pain syndrome. In what region of genitals does the pathological process take place?

A. Myometrium.
B. Mesometrium.
C. Parametrium.
D. Endometrium.
E. Perimetrium*.

31. During the examination of a patient, the presence of suppurative exudation in the straight rectouterine pouch was suspected. Through what anatomical formation is it better to puncture the pouch?

A. Anterior vaginal wall.
B. Anterior vaginal fornix.
C. Rectal ampulla.
D. Posterior vaginal fornix*.
E. Pelvic diaphragm.

32. A patient complains of having urination disorder. He is diagnosed the hypertrophy of prostate gland. Which part of gland is damaged?

A. Base.
B. Left lobe.
C. Right lobe.
D. Median lobe*.
E. Apex.

33. Patient complains of frequent and difficult urination. Imperfection of which formation can cause it?

A. Sperm bubbles.
B. Testicles.

C. Bulb-uretic glands.
D. Testicle adnexa.
E. Prostate*.

34. Examination of a newborn boy's genitals revealed a cleft of urethra that opens on the inferior surface of his penis. Which developmental anomaly is meant?
A. Hypospadia*.
B. Hermaphroditism.
C. Epispadia.
D. Monorchism.
E. Cryptorchism.

35. A young man consulted a doctor about disturbed urination. Examination of his external genitals revealed that urethra is split on top and urine runs out of this opening. Which anomaly of external genitals development is the case?
A. Phimosis.
B. Epispadia*.
C. Hermaphroditism.
D. Paraphimosis.
E. Hypospadia.

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LITERATURE

1. Associated urologic anomalies in children with solitary kidney/ K. Kaney-ama, A. Yamataka, S. Satake et al. II J. Pediatr. Surg. 2004. – Jan. – Vol. 39(1). – P. 85–7.
2. Cascio S. Associated urological anomalies in children with unilateral renal agenesis/ S. Cascio, S. Paran, P. Puri II J. Urol. 1999. Sep. – Vol. 162(3 Pt 2). – P. 1081–1083.
3. Chiara A. The pediatrician and urinary tract malformation / A. Chiara II Ped. Med. Chir. 1997. – Vol. 19. – № 5. – P. 349–352.
4. Guignard J. P. Neonatal nephrology/ J. P. Guignard II Pediatric. Nephrology. Under edition of Barratt T. M. Baltimore: USA. – 1999. – P. 960–1015.
5. A syndrome of female pseudohermaphrodism, hypergonadotropic hypogonadism, and multicystic ovaries associated with missense mutations in the gene encoding aromatase (P450arom)/ F. A. Conte et al.// J Clin. Endocrinol. Metab. – 1994 Jun; 78(6): 1287–1292.
6. Cascio S. Associated urological anomalies in children with unilateral renal agenesis/ S. Cascio, S. Paran, P. Puri // J. Urol. – 1999 Sep; 162(3 Pt 2):1081–3.
7. Cryptorchidism: anomalies of excretory ducts and azoospermia/ S. D'Agostino etal.//Pediatr. Med. Chir.- 1994 Nov-Dec;16(6):509–12.
8. Differentiation of normal male prepuberty and hypogonadotrophic hypogonadism using an ultrasensitive luteinizing hormone assay/D.C. Brown et al.//Horm. Res. – 1996;46(2):83–7.
9. Dutkiewicz, S. Health of Man. Urinary and Sexual Tract Warsaw: Amedic, 2002. –224 p.
10. Elmore J. M. Topical steroid therapy as an alternative to circumcision for phimosis in boys younger than 3 years/ J. M. Elmore, L. A. Baker, W. T. Snodgrass // J. Urol. – 2002 Oct;168(4 Pt 2):1746–7; discussion 1747.
11. Campbell-Walch Urology / [Alan J. Wein, Louis R. Kavoussi, Andrew C. Novick, Alan W. Partin, Crag A. Peters]. – [10th ed.]. – 2012. – section I. – 3753p.
12. Hiraoka Y. Anatomy of the prostate from fetus to adult-origin of bening prostatic hyperplasia / Y. Hiraoka, M. Akimoto // Urol. Res. – 1987. – Vol. 15, № 3. – P. 177–180.
13. Karam I. The structure and innervation of the male urethra: histological and immunohistochemical studies with three-dimensional reconstruction / I. Karam, S. Moudouni, S. Droypu et al. // J. Anat. – 2005. – Vol. 206(4) – P. 395–403.
14. Mills S. E. Histology for Pathologists / S. E. Mills, E. Stacey. – [3th ed.]. – 2004. – section 36. – P. 923–942.
15. Standring S. Gray's Anatomy: The Anatomical Basis of Clinical Practice / S. Standring. – [39th ed.]. – 2004. – 1600p.
16. Tanagho E. A. Smith's General Urology / E. A. Tanagho, J. W. McAninch. N. Y.: McGraw-Hill, 2000. – 868 p.

17. Human Anatomy. In three volumes. Volume 1 / Edited by V.G. Koveshnikov. – Lugansk: LTD "Virtualnaya realnost", 2009. – 328 p.
18. Human Anatomy. In three volumes. Volume 2 / Edited by V.G. Koveshnikov. – Lugansk: LTD "Virtualnaya realnost", 2008. – 248 p.
19. Human Anatomy. In three volumes. Volume 3 / Edited by V.G. Koveshnikov. – Lugansk: LTD "Virtualnaya realnost", 2009. – 384 p.
20. Gray's anatomy for students / Richard L. Drake, A. Wayne Vogl, and Adam W. M. Mitchell; illustrations by Richard M. Tibbitts and Paul E. Richardson; photographs by Ansell Horn. – 2nd ed. – 1103 p.
21. Sobotta Atlas of Human Anatomy / Edited by R. Putz and R. Pabst, 14th ed. – Elsevier GmbH, Munich, 2008. – 895 p.
22. Clay JH, Pounds DM. Basic Clinical Massage Therapy: Integrating Anatomy and Treatment. 2003.
23. Grant's atlas of anatomy / Anne M.R., Arthur F. Dalley II, 12th ed. – Baltimore: Wiliams & Wolters, 2009. – 864 p.
24. Martini Frederic H. Martini's atlas of the human body, 8th ed. – Pearson Education, 2009. – 250 p.
25. Report on the study of spatial organization of the human prostate glands (Wyniki badania przestrzennej struktury gruczołu krokowego u mężczyzn) / V. N. Hryn, N. L. Svintsytska, A. V. Piliuhin [at al.] // Wiadomosci Lekarskie. – 2017. – T. LXX, nr. 6. – P. 1034–1036.
26. Stereomorphology of the glandular parenchyma of the inferoposterolateral area of human prostate gland (Stereomorfologia miąższu powierzchni dolno-tylno-bocznej ludzkiego gruczołu krokowego / O. O. Sherstyuk, V. H. Hryn, N. I. Vynnyk [at al.] // Wiadomosci Lekarskie. – 2018. – T. LXXI, nr 1, cz II. – P. 184–187.
27. Ustenko RL, Svintsytska NL, Kobets AA. Three-dimenional organization of the glands of peripheral zone of the human prostate gland. Aktualni pytannya teoretychnoyi ta klinichnoyi medytsyny : zbirnyk tez dopovidey Mizhnarodnoyi naukovo-praktychnoyi konferentsiyi studentiv ta molodykh vchenykh, m. Sumy, 10-12 kvitnya 2013 r. / Vidp. za vyp. M.V. Pohoryelov. Sumy: SumDU, 2013. P. 20.

NOTES

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