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# UROGENITAL SYSTEM

# МОЧЕПОЛОВАЯ СИСТЕМА

**The manual for medical students**

*Учебное пособие для медицинских вузов*
*(специальность «Лечебное дело»)*

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Данное пособие является английской версией учебника профессора И. В. Гайворонского «Нормальная анатомия человека», который был издан в России 9 раз и одобрен Министерством образования Российской Федерации.

Структура пособия соответствует современным стандартам медицинского образования в России и важнейшим европейским стандартам. Английская и латинская терминология приведены в соответствии с Международной анатомической номенклатурой.

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## LIST OF ABBREVIATIONS

Art., art., — articulatio
Artt., artt., — articulationes
For., for. — foramen
Lig., lig. — ligamentum
Ligg., ligg. — ligamenta
M., m. — musculus
Mm., mm. — musculi
N., n. — nervus
Nn., nn. — nervi
R., r. — ramus
Rr., rr. — rami
S., s. — sulcus

# PREFACE

The creation of the manual “Urogenital System” in English meets the requirement of modern Russian medicine and education. Nowadays many English-speaking oversea students study in Medical Universities of Russia. Besides, many Russian school leavers have a good command of the English language so they will be able to use this manual taking into consideration the fact that many Russian specialists in medicine work abroad after graduating from the universities or take part in different international conferences and symposiums.

The English version of the manual is based on the Russian manual by professor I. V. Gayvoronskiy “Normal Human Anatomy” which has been published in Russia 9 times and is approved by the Ministry of education of Russia.

This manual introduces the main principles of Russian Anatomy School such as: detailed study of the general aspects and items of Anatomy including the development of organs and anomalies of the development. If we compare theoretical approaches to Anatomy in Russia and in other countries we`ll see that our approach is based on the system descriptions of organs, i. e. we describe separately Skeletal system, Articulations, Muscular system etc. Moreover, we use Latin terminology while describing the organs and discuss clinicoanatomical and functional problems. As for the manuals in other countries many of them describe Anatomical systems in accordance with the regional and topographical principles.

The structure of our manual meets the requirements of modern standards of medical education in Russia which in their turn correspond to the major European standards. After each chapter we give test questions and clinicoanatomical problems. The English and Latin terminology is given in accordance with International Anatomical Nomenclature.

The authors strongly believe that the manual will allow future doctors to form the morphological foundation for the further study of theoretical and clinical disciplines. We also hope that it will be of great help to Anatomy teachers.

# ПРЕДИСЛОВИЕ

Создание учебного пособия «Мочеполовая система» на английском языке является требованием современной системы медицинского образования в России. В настоящее время в медицинских университетах нашей страны обучаются студенты из различных регионов дальнего зарубежья. Кроме того, многие выпускники российских школ хорошо владеют английским языком, поэтому они также смогут пользоваться данным пособием, принимая во внимание, что зачастую русские специалисты в медицине после окончания университета уезжают работать за рубеж или принимают участие в различных международных конференциях и симпозиумах.

Английская версия пособия базируется на русском учебнике профессора И. В. Гайворонского «Нормальная анатомия человека», который был издан в России 9 раз и одобрен Министерством образования Российской Федерации.

Данное пособие познакомит читателей с главными принципами Русской анатомической школы, которые заключаются в подробном изучении общих вопросов, в том числе развития органов и аномалий развития. В России преподавание анатомии ведется с функционально-клинических позиций и основано на описании органов по системам, т. е. отдельно изучается опорно-двигательная система, артросиндесмология, миология и другие системы. Также при описании строения органов акцентируется внимание на латинской терминологии. Что касается зарубежных руководств по анатомии человека, многие из них основываются на регионально-топографическом принципе без использования латинской терминологии.

Структура данного пособия соответствует современным стандартам медицинского образования в России, которые, в свою очередь, соответствуют важнейшим европейским стандартам. После каждой главы мы приводим контрольные вопросы и ситуационные клинические задачи. Английская и латинская терминология приведена в соответствии с Международной анатомической номенклатурой.

Авторы выражают уверенность, что данное пособие позволит будущим докторам сформировать морфологический фундамент для последующего изучения теоретических и клинических дисциплин. Мы также надеемся, что оно принесет определенную пользу и преподавателям анатомии человека.

# 1. URINARY SYSTEM

The urinary system, *systema urinarium*, includes anatomically and functionally interrelated organs, *organa urinaria*, that produce, store and eliminate urine. These organs are:

1. The kidney, a paired organ, producing urine.
2. The ureter, a paired organ, excreting urine from the kidney.
3. The urinary bladder, the storage of urine.
4. The urethra, which serves as a passage way for the elimination of urine.

It should be noted that more than 80 % of the final products of metabolic activities are excreted with urine. Apart from the excretory function, the urinary organs provide: the support of homeostasis, acid-base balance, osmotic pressure; participate in the regulation of the blood pressure; produce the erithropoetic factors and participate in the synthesis of the biological active substances (renin, bradykinin, prostaglandins, urokinase etc.).

The urethra has significant sex differences. In males it is more complex and excretes not only urine but also sperm. Regarding this, the male and female urethrae will be described separately, in the chapters of the male and female reproductive organs respectively.

## 1.1. Kidneys

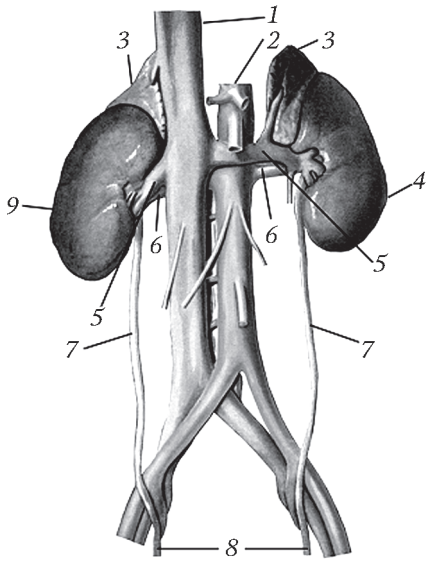


Fig. 1.1. Kidneys, suprarenal glands, abdominal aorta and inferior vena cava (anterior aspect):

*1* — inferior vena cava; *2* — abdominal aorta; *3* — suprarenal glands; *4* — left kidney; *5* — renal vein; *6* — renal artery; *7* — ureter (abdominal part); *8* — ureter (pelvic part); *9* — right kidney

The kidney, *ren* (in Greek *nephros*), is a paired organ, which produces and excretes the urine (fig. 1.1). The kidney is bean-shaped, reddish-brown, has a smooth surface and dense consistency. The average sizes of the kidney: the length is 10—12 cm, the width is about 6 cm, the thickness is 3—4 cm; the average weight is 120 g. The kidney has two surfaces: more convex anterior, *facies anterior*, and flattened posterior, *facies posterior*; two ends, or poles, rounded superior, *extremitas superior*, and sharpened inferior *extremitas inferior*; two borders, convex lateral, *margo lateralis*, and concave medial, *margo medialis*. The notch on the medial border is called the renal hilum, *hilum renale*, through which the renal artery and nerves enter the kidney, and the renal vein, lymphatic vessels and ureter leave it. All these structures are united into the concept of the ‘renal leg’. The renal hilum, bounded by the anterior lip and more expressed posterior lip, leads into the renal cavity, or renal sinus, *sinus renalis*. The sinus contains the blood and lymphatic vessels, nerves, major and minor renal calyces, renal pelvis and adipose tissue.

From outside the kidney is covered by thin but strong fibrous capsule, *capsula fibrosa*, which is loosely linked with the renal parenchyma. External to this capsule is a thick layer of loose fat tissue, called the adipose capsule, *capsula adiposa*. Through the renal hilum the fat penetrates the renal sinus. The part of the adipose capsule, covering the posterior renal surface, is thicker than in front of, and is called the pararenal (paranephral) body, *corpus adiposum pararenale*. Superficial to the adipose capsule is the renal fascia, *fascia renalis*, covering the kidney anteriorly and posteriorly and considered to be a part of the endoabdominal fascia.

**Topography of kidney.** The kidneys are situated in the lumbar region, on the posterior wall of the abdominal cavity to the right and to the left of the vertebral column. The depression, where each kidneys lies, is called the 'renal bed' and is bounded laterally by the transversus abdominis, posteriorly by the quadratus lumborum, medially by the psoas major and superiorly by the diaphragm.

The longitudinal axes of the kidneys are directed obliquely up and forwards. The distance between the inferior poles is about 11 cm, between the superior poles is about 7 cm.

The right kidney is slightly lower than the left kidney: the left XII rib crosses the left kidney approximately in the middle, while the right XII crosses the right kidney at the junction between its upper and lower thirds. The left kidney lies at the level of the XII thoracic and upper two lumbar vertebrae; the right kidney is at the level of the I, II and III lumbar vertebrae (fig. 1.2).

The syntopy of the left and right kidneys is different. The superior pole of the left kidney is related to the suprarenal gland; the upper third of the anterior surface adjoins the stomach, the middle third is in contact with the pancreas, the lower third adjoins the coils of the small intestine; the upper part of the lateral border is related to the spleen, the lower part of the lateral border adjoins the left colic flexure and the commencement of the descending colon. The superior pole of the right kidney also is in contact with the suprarenal gland; the most part of the anterior surface adjoins the liver, the lower third is related to the right colic flexure; the medial border adjoins the duodenum.

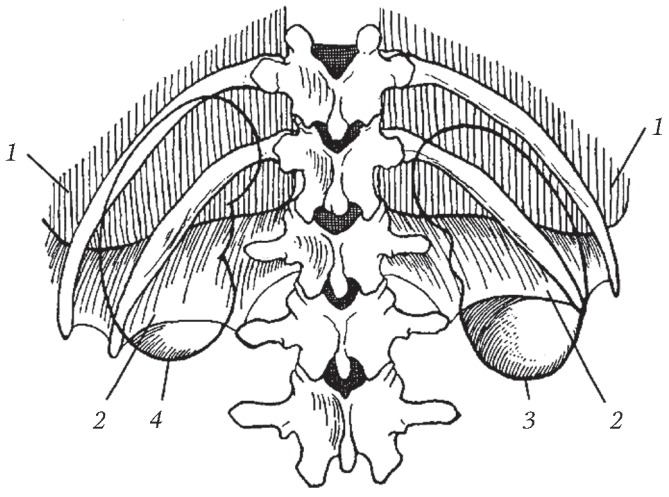


Fig. 1.2. Skeletotopy of kidneys (posterior aspect):
*1* — parietal pleura; *2* — diaphragm; *3* — right kidney; *4* — left kidney

Relatively to the peritoneum the kidney lies retroperitoneally. The reflexion of the peritoneum from the liver to the anterior surface of the right kidney is called the hepatorenal ligament, *ligamentum hepatorenale.*

In the fixation of the kidneys the renal fascia, *fascia renalis*, plays the greatest role. The renal fascia consists of the anterior (prerenal) and posterior (retrorenal) layers. The prerenal layer extends in front of the both kidneys and 'renal legs', abdominal aorta and inferior vena cava. The retrorenal layer separates each kidney from the fasciae of the muscular 'renal bed' and is attached to the vertebral bodies from the right and the left. The anterior and posterior layers of the renal fasciae fuse above the kidneys and at their lateral border to form for the kidneys the fascial sacs opened down. From the both layers of the renal fascia the numerous connective tissue cords arise; they pierce the adipose capsule to be connected with the fibrous capsule of the kidney that is important for the kidney fixation. Besides the renal fascia, the adipose capsule, muscular 'renal bed', 'renal leg' and intra-abdominal pressure hold the kidneys.

**Internal structure.** If we make the frontal section of the kidney, dividing it into the anterior and posterior halves, we will see the renal sinus with its content and surrounding layer of the renal substance (fig. 1.3).

The renal parenchyma is distinctly divided into two layers: peripheral, darker (reddish-brown), renal cortex, *cortex renalis*, and inner, lighter-coloured, renal medulla, *medulla renalis.*

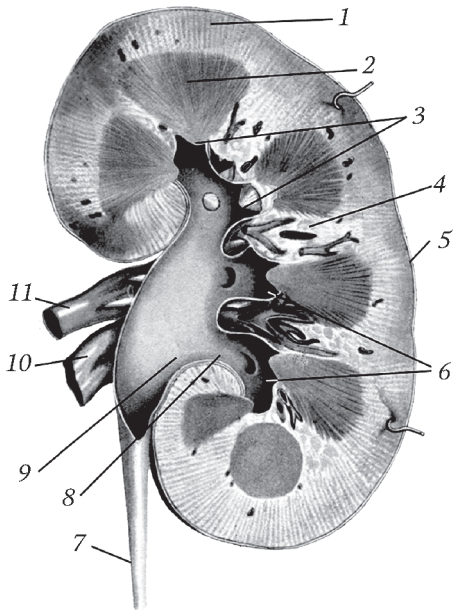


Fig. 1.3. Right kidney (frontal section):

*1* — renal cortex (*cortex renalis*); *2* — renal medulla (*medulla renalis*); *3* — renal papillae (*papillae renales*); *4* — renal column (*columna renalis*); *5* — fibrous capsule of kidney (*capsula fibrosa renis*); *6* — minor calyces (*calyces renales minores*); *7* — ureter (*ureter*); *8* — major calyx (*calyx renalis major*); *9* — renal pelvis (*pelvis renalis*); *10* — renal vein (*vena renalis*); *11* — renal artery (*arteria renalis*)

The renal medulla is arranged as the pyramids, the number of which varies from 7 to 20 and even more (most commonly 12). The renal pyramids (Malpighian), *pyramides renales (Malpighii)*, have the bases, *basis pyramidis*, directed to the renal surface and rounded apices, or papillae, *papilla renalis*, directed to the renal sinus. Sometimes, the apices of the several renal pyramids (2—4) merge into a common papilla therefore, the number of the pyramids does not coincide with the number of the papillae; the number of the papillae is always less. The renal cortex extends between the pyramids as the renal columns (of Bertin), *columnae renales (Bertinii)*. Thus, the wall of the renal sinus is formed by the renal medulla (as the renal papillae) and the renal cortex (as the renal columns).

The cortex is visible on the section as a narrow rim, arching over the bases of the pyramids, i. e. forming the outer layer of the renal parenchyma, and as Bertin`s columns, which have been already described above. The cortex has a grain structure and is traversed by radial darker strips, separated by lighter-coloured tissue. The latter forms so called medullary rays, starting from the bas-

es of the pyramids and constituting the radiate part, *pars radiata*, of the renal cortex. The darker strips form the convoluted part, *pars convoluta*.

The structural and functional unit of the renal parenchyma is a nephron, *nephron* (fig. 1.4). The total number of the nephrons in each kidney is more than 1 million. The nephron is an unbranched long tubule whose commencement envelopes, like a double-walled cup, the capillary glomerulus, while the terminal part opens into the collecting tubule. The nephron is comprised of four parts, the localization of which is strictly ordered. Thus, anatomically the following parts are distinguished in the nephron:

1) renal corpuscule (Malpighian);
2) proximal convoluted tubule;
3) straight tubule as the ansa nephroni (renal loop of Henle);
4) distal convoluted tubule.

The parts of the nephron have different structural and topographical features and carry out different functions (filtration, resorption, secretion). Therefore, one more, functional-morphological, classification of the nephron`s parts exists. According to it, the following parts of the nephron are distinguished:

1) renal corpuscule (Malpighian) consisting of the capillary glomerulus which is surrounded by the glomerular capsule (of Shumlansky & Bowmen);
2) proximal part including the proximal convoluted tubule and next to it thick segment of the descending limb of Henle`s loop (the commencement of Henle`s loop).
3) thin segment consisting of thin parts of the descending and ascending limbs of Henle`s loop;
4) distal part including the thick segment of the ascending limb of Henle`s loop and the distal convoluted tubule.

The renal corpuscle (Malpighian), *corpusculum renale (Malpighii)*, consists of the vascular glomerulus and glomerular capsule surrounding the glomerulus. The glomerulus is a collection of convoluted, capillary blood vessels, fed by an afferent arteriole, *arteriola glomerularis afferens (vas afferens)*; the blood from the glomerulus flows into an efferent arteriole, *arteriola glomerularis efferens (vas efferens)*. The afferent arteriole is larger in caliber than the efferent arteriole. This part of the renal blood stream, including the afferent arteriole, branched into the capillary network of the glomerulus, and the efferent arteriole, derived from the glomerulus, got the name 'renal wonderful net', *rete mirabile renis*.

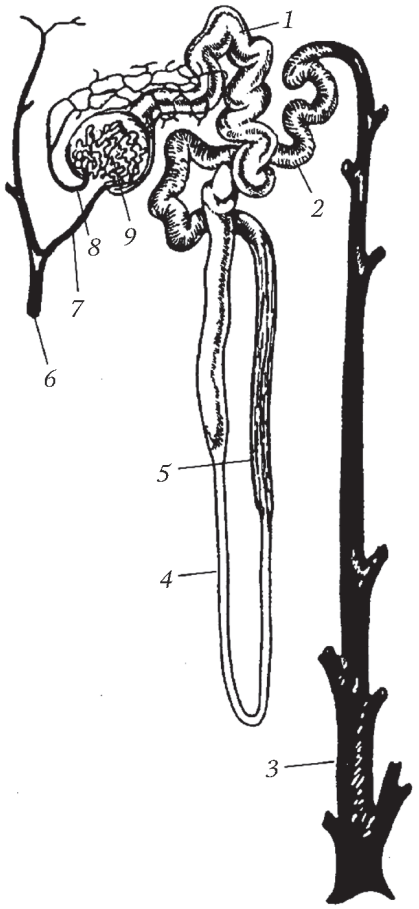


Fig. 1.4. Scheme of the nephron structure:
*1* — proximal convoluted renal tubule; *2* — distal convoluted renal tubule; *3* — renal collecting tubule; *4* — descending limb of ansa nephroni; *5* — ascending limb of ansa nephroni; *6* — interlobular artery; *7* — afferent glomerular arteriole; *8* — efferent glomerular arteriole; *9* — renal corpuscle

The glomerulus lies in the capsule consisting of two walls: outer, parietal, layer and inner, visceral, layer which is fused with the capillaries of the glomerulus. Between these two layers there is a slit-like space which is continuous with the proximal convoluted tubule. The renal corpuscles are placed in the renal cortex giving it the grain structure. The next to the renal corpuscle is the proximal part of the nephron tubule, *pars proximalis tubuli nephroni*. It comprises the proximal convoluted tubule, the lumen of which communicates with the space of the glomerular capsule, and thick segment of the descending limb of Henle`s loop (the proximal straight tubule) up to its continuation into the descending thin segment of Henle`s loop. This part of the nephron is also located in the renal cortex: the proximal straight tubules are mainly located in the medullary part, while the proximal convoluted tubules are mainly located in the convoluted part. The next part is thin segment of Henle`s loop which is divided into the descending and ascending parts.

The descending limb of Henle`s loop runs directly into the pyramid, then turns back to become the ascending limb which returns into the renal cortex again. The diameter of the lower portion of the descending limb abruptly decreases but in the certain place of the ascending limb it increases again. The narrow portion of the ansa nephroni is distinguished as thin segment of the nephron; the upper portion of the ascending limb, where the lumen expands again, is known as thick segment of the ascending limb of Henle`s loop (the distal straight tubule). The thin segment is placed in the medulla. The thick segment of the ascending limb of Henle`s loop and distal convoluted tubule form the distal part of the nephron tubule, *pars distalis tubuli nephroni*, which lies already in the renal cortex (the distal convoluted tubules are in the convoluted part, the distal straight tubules are in the medullary part).

The visceral layer of the glomerular capsule is composed of specialized epithelial podocytes; the wall of the adjoining capillary is formed by one layer of epitheliocytes. The caliber of the efferent arteriole is significantly smaller than the caliber of the afferent arteriole. The difference between the calibers creates the most favorable conditions for the filtration of the water with various dissolved organic and inorganic substances having a low molecular weight from the blood. This liquid, called primary urine, then passes into the tubules of the nephron. The volume of the primary urine is 150—180 liters per day.

The efferent arteriole, *arteriola glomerularis efferens (vas efferens)*, is branched again into the capillary network (peritubular capillary plexus) surrounding the tubules of all the parts of the nephron. Primary urine passes from the glomerular capsule into the proximal part of the nephron tubule and moving through all other parts of the nephron, undergoes the complex processes (resorption, secretion) resulting in the formation of secondary urine. The volume of secondary urine is 1,5—2 liters per day. The urine formed in the nephron passes into the urinary tract.

The nephrons open into the collecting tubules, *tubuli renales colligens*, which commence the urinary tract. They are straight, start in the cortex and pass through the medullary rays into the pyramid, reaching its apex. Here several collecting tubules are united into short papillary ducts (of Bellini), *ductuli papillares (Bellinii)*, which end on a papillary apex by numerous papillary orifices, *foramina papillaria*, forming an area cribrosa, *area cribrosa* (fig. 1.5).

In summary it should be noted that the cortex consists of the renal corpuscles and mainly convoluted tubules of nephron; the medulla consists of the straight tubules (Henle`s loop, collecting tubules, Bellini ducts).

The human kidney has two types of nephrons: cortical (80 %), *nephroni corticales*, Malpighian corpuscle of which is in the outer zone of the cortex, and juxtamedullary (20 %), *nephroni juxtamedullares*, whose Malpighian corpuscle lies in the inner zone of the cortex, near the border of the medulla.

The juxtamedullary nephrons as compared to the cortical nephrons have three features. Firstly, their glomeruli are larger than in the cortical nephrons and the afferent arteriole is equal to the efferent arteriole in caliber. Secondly, Henle`s loop is long, descends almost to the papillary apex, while the thin segment of Henle`s loop of the cortical nephron lies only within the outer zone of the cortex. Thirdly, the efferent arterioles are not branched into the peritubular capillary plexus but descend into the medulla, where each of the arterioles is branched into several straight parallel vessels (*vasa recta*), the caliber of which is slightly smaller than the caliber of the efferent arteriole. Vasa recta approach the apex of pyramid and returns into the cortex, flowing into the venules which drain into the interlobular or arcuate veins, i. e. the direct arteriolovenular anastomoses are formed. The juxtamedullary nephrons function only in extreme situations accompanied by ischemia of the renal cortex (the decrease of the renal arterial perfusion).

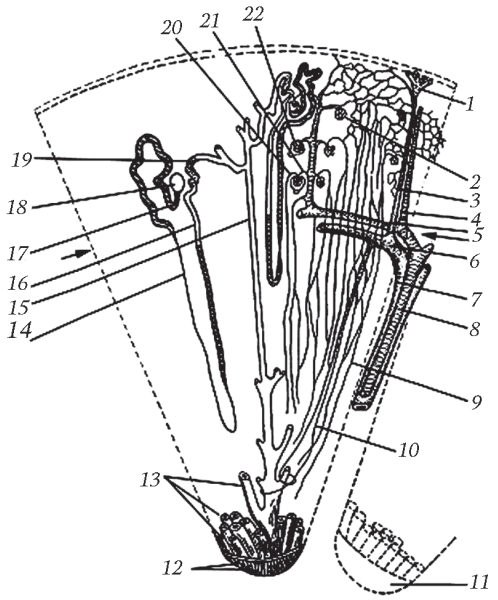


Fig. 1.5. Structure of the renal cortex and medulla (the arrows show the boundary between renal cortex and medulla):

*1* — stellate vein; *2* — glomerulus; *3* — interlobular vein; *4* — interlobular artery; *5* — arcuate artery; *6* — arcuate vein; *7* — interlobar vein; *8* — interlobar artery; *9* — straight arterioles; *10* — straight venules; *11* — renal papilla; *12* — papillary foramina; *13* — papillary ducts; *14, 16* — ansa nephroni; *15* — collecting renal tubule; *17* — proximal convoluted renal tubule; *18* — renal corpuscle; *19* — distal convoluted renal tubule; *20* — efferent glomerular arteriole; *21* — afferent glomerular arteriole; *22* — glomerular capsule

The kidney is divided into segments, lobes and lobules. This division is based on the certain constancy of the disposition of the large intra-renal arteries. The renal artery, *a. renalis*, entering the renal hilum, divides into two branches, anterior and posterior, passing respectively in front of and behind the renal pelvis. The anterior branch, the prepelvic artery, divides into four segmental arteries which supply the certain areas of the renal parenchyma, the segments. The posterior branch, the retropelvic artery, is one of the segmental arteries and does not branch out. Thus, the kidney consists of the five segments: superior, *segmentum superius*; anterior superior, *segmentum superius anterius*; anterior inferior, *segmentum inferius anterius*; inferior, *segmentum inferius*, and posterior, *segmentum posterius*. The first four segments correspond to the ramifications of the four branches of the prepelvic artery, while the last segment corresponds to the ramification of the retropelvic artery.

The segmental arteries give off the interlobar arteries, *aa. interlobares*, which pass through the renal columns to the bases of the pyramids, where each of them divides into the terminal branches, the arcuate arteries, *aa. arcuatae*. The interlobar arteries with the interlobar veins, which accompany the arteries, are considered as the borders of the renal lobes, *lobus renales* (fig. 1.5). The renal lobe includes the pyramid surrounded by the cortical tissue. Each segment contains 2—3 lobes.

The arcuate arteries are located in the cortex at the junction of the cortex and medulla; they give off the numerous interlobular arteries, *aa. interlobulares*, diverging radially into the cortex. The interlobular arteries separate the cortical lobules, *lobuli corticales*, each includes the medullary ray surrounded by the convoluted part of the cortex. Each renal lobule contains more than 600 lobules.

The interlobular arteries divide into the numerous afferent arterioles, *arteriolae glomerulares afferentes (vasa afferentes)*, which bring the blood to Malpighian corpuscles. The afferent arterioles branch into the glomeruli, and the efferent arterioles arising from the glomeruli soon divide to form a dense peritubular capillary plexus around the convoluted tubules and Henle`s loops. Then the blood flows into the venous stream. Thus, the distinct feature of the intrarenal vascular system is the presence of the double capillary network. One of them (glomerular) is formed by the division of the afferent arteriole (the filtration of the blood occurs in it); the other is formed by the division of the efferent arteriole (it supplies all renal tissues) connecting the arterial stream with venous.

The intrarenal veins mainly correspond to the intrarenal arteries (*vv. interlobulares*, *vv. arcuatae* etc.). The small veins of the outer layers of the cortex merge with the small veins of the fibrous capsule to form the stellate veins, *vv. stellatae*, draining into the interlobular veins. Finally, the venous blood flows out via the renal veins, *vv. renales*, which open into the inferior vena cava.

***Juxtaglomerular apparatus.*** Each nephron contains the highly specialized juxtaglomerular cells which are the part of the neurohumoral system providing water-salt homeostasis and the constancy of blood pressure. These cells produce the biological active substance, renin, whose action promotes the synthesis of the vasopressor substance, angiotensin, in blood. The juxtaglomerular apparatus is located in the area of the vascular stalk of the glomerulus, through which the afferent and efferent arterioles pass. The juxtaglomerular apparatus consists of three main parts:

1) juxtaglomerular cells in the wall of the afferent arteriole;
2) cells of the macula densa;
3) granular peripolar cells.

The juxtaglomerular cells surround the afferent arteriole, like a cuff, in the site of its entrance into the Malpighian corpuscle.

The macula densa is the part of the wall of the distal convoluted tubule, which is located in the area of the vascular stalk of the glomerulus, between the afferent and efferent arterioles. The cells of this area are taller and narrower and closely aggregated together hence this region is called macula densa.

The granular peripolar cells form a compact group located in the triangular space of the vascular stalk between the macula densa, afferent and efferent arterioles.

## 1.2. Urinary Tract of Kidney

The renal urinary tract is divided into intrarenal (located in the renal tissue) and extrarenal (located outside the renal tissue). The intrarenal urinary tract includes the collecting tubules and Bellini ducts.

The extrarenal urinary tract includes the minor and major calyces and renal pelvis located within the renal sinus (fig. 1.3).

The collecting tubules, into which the distal convoluted tubules open, commence the urinary tract. As mentioned above, several collecting tubules unite into the papillary (Bellini) ducts which open on a papillary summit by the orifices, *foramina papillaria*, forming the cribriform area.

The excreted urine passes through the openings of the cribriform area into the minor calyces, *calyces renales minores*. The minor calyx is a short funnel-shaped tube surrounding the renal papilla. The expanded part of the minor calyx, into which the renal papilla is inserted, is termed the fornix, *fornix*; the narrow part is called the neck, *collum*. The total number of the minor calyces in one kidney is 7—10 (fig. 1.6). Three-four minor calyces join together by their necks to form two (superior and inferior) or three (superior, middle and inferior) major calyces, *calyces renales majores*, which open into the renal pelvis, *pelvis renalis* (in Greek *pyelos*).

The walls of the renal pelvis and of the minor and major calyces are composed of the mucous, muscular and adventitial layers. The smooth muscle fibers form the inner longitudinal and outer circular layers.

The smooth muscle fibers of the wall of the fornix are arranged as two muscles: levator of fornix, *m. levator fornicis*, and sphincter of fornix, *m. sphincter fornicis*. The passage of urine from the papillary ducts is not passive process but the result of the work of the fornical apparatus. The latter includes: the fornix with its epithelial covering; levator and sphincter muscles of fornix; fat of the renal sinus, which surrounds the fornix and contains a lot of elastic fibers, vessels and nerves; the renal papilla and venous plexus surrounding the fornix. Besides two mentioned above muscles, the wall of the minor calyces includes the longitudinal muscle of calyx, *m. longitudinalis calycis*, and the spiral muscle of calyx, *m. spiralis calycis.* The levator fornicis and longitudinalis calycis expands the cavity of the calyx to contribute to the accumulation of urine. The sphincter fornicis and spiralis calycis narrows the calyx, emptying it.

Thus, the complex of functionally interrelated structures, providing the excretion of urine from the intrarenal urinary tract into the minor calyces, is called the fornical apparatus.

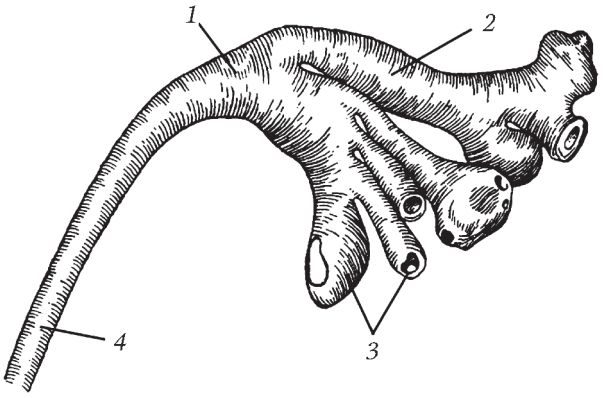


Fig. 1.6. The form of renal urinary tract:
*1* — renal pelvis; *2* — major renal calyx; *3* — minor renal calyx; *4* — ureter

## 1.3. Ureter

The ureter, *ureter*, is a paired organ representing the muscular tube, 30—35 cm long; it constantly and uniformly conveys urine from the renal pelvis to the urinary bladder. At the renal hilum the ureter is situated behind the renal vessels (fig. 1.1, 1.3). It then descends along the psoas major and enters the pelvic inlet, crossing the iliac vessels (on the

right the internal iliac vessels, on the left the common iliac vessels). Below, the ureters descend along the walls of the lesser pelvis to open into the base of the urinary bladder. In males the ureters cross the deferent ducts; in females they pass behind the ovaries, lateral to the uterine cervix. The ureters are located retroperitoneally.

Topographically the ureter is divided into the abdominal part, *pars abdominalis*, pelvic part, *pars pelvica*, and intramural part, *pars intramuralis*. The first two parts are almost equal in length (each is 15—17 cm long); the pelvic part perforates the wall of the urinary bladder obliquely, at an acute angle, passing 1,5—2 cm within the bladder`s wall as the intramural part. The lumen of the ureter is uneven. The greatest diameter of the abdominal part is 8—13 mm, of the pelvic part is 6 mm. The ureter has three constrictions: the first is at its commencement (the lumen is 2—4 mm); the second is at the level of the pelvic inlet (the lumen is 4—6 mm); the third is throughout the intramural part (the lumen is 4 mm).

The ureter`s wall consists of three layers: mucous, muscular and adventitial. The mucosa forms the longitudinal folds. Throughout the length of the ureter, the muscle coat is constructed differently: in the upper two thirds the ureter is composed of the inner longitudinal and outer circular layers; in the lower third it has one more, third layer, outer longitudinal; in the intramural part of the ureter the circular layer disappears, remaining only longitudinal layers.

## 1.4. Urinary Bladder

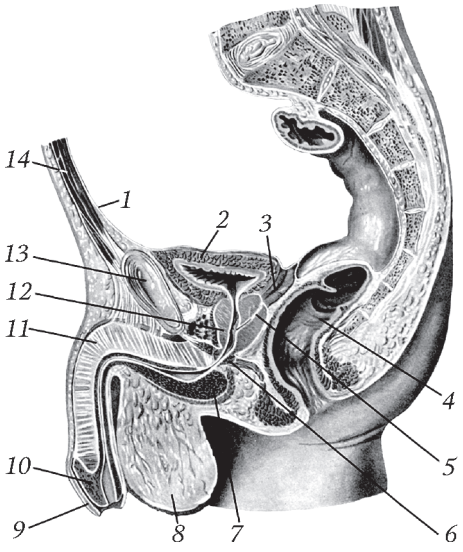


Fig. 1.7. Male pelvis (median section):

*1* — parietal peritoneum; *2* — urinary bladder; *3* — seminal vesicle; *4* — rectum; *5* — ejaculatory duct; *6* — sphincter urethrae externus; *7* — corpus spongiosum penis; *8* — scrotum; *9* — preputium penis; *10* — glans penis; *11* — corpus cavernosum penis; *12* — prostate; *13* — pubic symphysis; *14* — rectus abdominis

The urinary bladder, *vesica urinaria* (in Greek *cystis*), is a reservoir for urine passing from the ureters; it also performs the evacuation of urine resulting in urination. It varies in size and shape, according to the amount of urine. Its capacity is individual and ranges from 250 ml to 700 ml. When the bladder is empty entirely, it is a dense ovoid body; when full it is rounded. The urinary bladder has a slightly narrow anterosuperior part, the apex, *apex vesicae*, an expanded inferior part, the fundus, *fundus vesicae*, and a middle part, body, *corpus vesicae*. The part of the bladder where it is continuous with the ureter is called the neck, *cervix vesicae*. In the neck region there is an internal urethral orifice, *ostium urethrae internum*.

**Topography.** The urinary bladder is situated in the lesser pelvis, immediately behind the pubic symphysis, being separating from it by a mass of fatty tissue (fig. 1.7).

The relations between the bladder and neighboring organs are different in males and females. In males behind the bladder are the rectum, seminal vesicles and ampullae of the defferent ducts; above it there are the coils of small intestine; the fundus of urinary

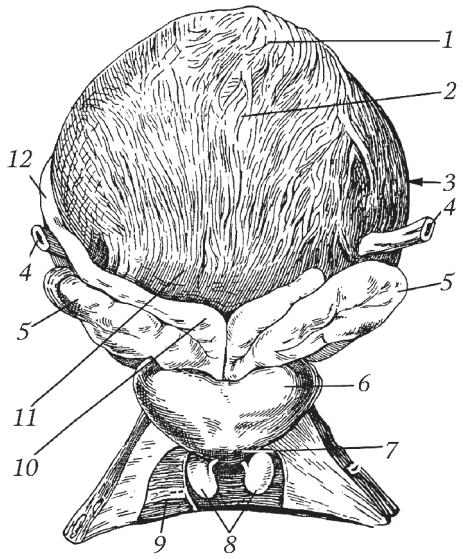


Fig. 1.8. Urinary bladder, seminal vesicles and prostate (posterior aspect):

*1* — apex of urinary bladder; *2* — muscular layer; *3* — urinary bladder; *4* — ureter; *5* — seminal vesicle; *6* — prostate; *7* — apex of prostate; *8* — bulbourethral glands; *9* — transversus perinei profundus; *10* — ampulla ductus deferentis; *11* — fundus of urinary bladder; *12* — ductus deferens

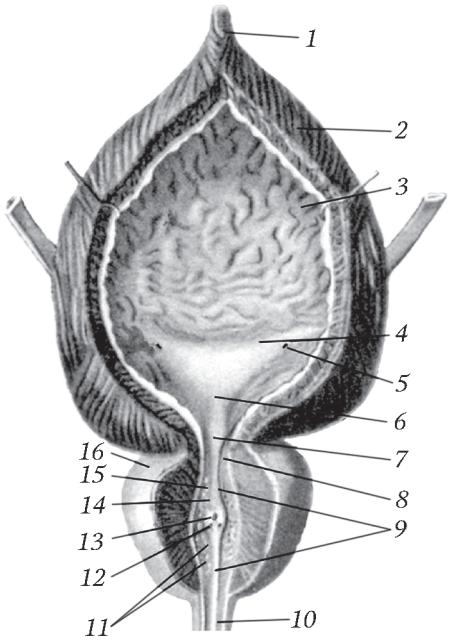


Fig. 1.9. Anterior aspect of the interior of the urinary bladder and prostatic part of urethra:

*1* — median umbilical ligament; *2* — muscular layer; *3* — mucous membrane; *4* — interureteric fold; *5* — ureteric orifice; *6* — vesical trigone; *7* — vesical uvula; *8* — internal urethral orifice; *9* — urethral crest; *10* — membranous part of urethra; *11, 15* — prostatic ductules; *12* — opening of ejaculatory duct; *13* — prostatic utriculus; *14* — seminal colliculus; *16* — base of prostate

bladder adjoins the prostate (fig. 1.8). In females behind the bladder are the uterine cervix and vagina; above it there are the body and fundus of the uterus; the fundus of the urinary bladder lies on the urogenital diaphragm.

The empty urinary bladder is covered by the peritoneum posteriorly, i. e. it has extraperitoneal (anteperitoneal) relation to the peritoneum. When the bladder is full, its apex protrudes above the pubic symphysis, elevating the peritoneum which now covers the bladder posteriorly, above and on the sides (mesoperitoneal position). Due to the continuation of the peritoneum from the wall of the bladder to the viscera located behind it, the depressions of the peritoneal cavity are formed: in males the rectovesical pouch, *exavatio rectovesicalis*; in females the vesicouterine pouch, *exavatio vesicouterina*.

The urinary bladder is fixed by the fibrous and muscular fascicles. The most important of them are the ligaments at the region of the fundus: in males the puboprostatic ligament, *ligamentum puboprostaticum*, in females the pubovesical ligament, *ligamentum pubovesicale*. The apex of the bladder is attached to the anterior abdominal wall by the median umbilical ligament, *ligamentum umbilicale medianum*.

**Internal structure.** The wall of the urinary bladder is composed of the mucous, submucous and muscular layers (fig. 1.9). From outside the bladder is partly covered by the peritoneum, partly by the adventitia.

Due to loose submucous layer the mucosa is mobile and easily forms the numerous folds which also easily disappear during the extension of the bladder. In the fundus region there is a triangular area, fully devoid of the folds, because here the mucosa does not have a submucous layer and is firmly fused with the muscular layer. This area, called the vesical trigone (Lieutaud triangle), *trigonum vesicae (Lieutaud)*, is between the urethral orifices, *ostium ureteris*, located on the posterior wall of the bladder, and internal urethral orifice, located at the neck of the bladder. Behind the internal urethral orifice there is a mucosal fold termed the uvula, *uvula vesicae*.

The muscular coat of the bladder is considerably thicker than in other hollow organs. It consists of the interwoven smooth muscle fascicles running in different directions. Customarily they are divided into three muscular layers: outer and inner longitudinal and middle circular. The complex interlacement of the muscle fibers provides the evacuation of urine from the bladder. The muscular coat of the bladder as a whole is called the detrusor muscle, *m. detrusor vesicae*.

The circular fibers form the internal sphincter muscle of urethra, *m. sphincter urethrae internus*, around the internal urethral orifice.

## 1.5. Development of Urinary Organs. Developmental Abnormalities

The kidney develops from the mesoderm of the intermediate cell mass and passes through several stages.

I stage — the formation of pronephros (synonyms are the anterior or head kidney because it is situated in the cranial part of the embryo). It is a paired organ, appearing during the 3 week of the development; it functions during 40—50 hours. It is formed by several segmentally located primitive tubules called the protonephridium. One end of each tubule opens into the coelom; this end is expanded as a funnel and has cilia. The arteries, segmentally arising from the aorta, anastomose with each other and form the vascular glomeruli in vicinity of the protonephridium. The other end of the tubules drains into the excretory duct of the pronephros, opening into the cloaca.

II stage — the formation of the primary or trunk kidney, mesonephros (Wolffian body), which appears caudal to the pronephros. It starts to develop by the end of the 3d week and functions until the end of the 2d month. The mesonephros is a system of 20—25 greatly convoluted tubules. One end of each tubule already resembles a double-walled cup, enveloping the glomerulus, i. e. the renal corpuscle is formed in this stage. The other end of the tubule drains into the excretory duct of the pronephros which is called now the mesonephric duct (Wolffian), *ductus mesonephricus*, opening into cloaca. Simultaneously another, paramesonephric (Mullerian) duct, *ductus paramesonephricus*, is formed near the mesonephric duct; further, the female reproductive organs develop from the paramesonephric duct.

III stage — the formation of the permanent kidney, metanephros (fig. 1.10). The caudal end of Wolffian duct protrudes near the cloaca as a diverticulum, or metanephric duct. It elongates, grows towards the mesoderm and penetrates it. At the same time the cells of mesoderm condense around the end of the metanephric duct to form so called metanephrogenic mass, or blastema. The further development of the permanent kidney occurs simultaneously with the formation of the urinary tracts. Thus, the metanephros develops from the metanephrogenic blastema and metanephric duct. The caudal end of the diverticulum elongates to form the ureter which still keeps the link with cloaca on

this stage. The cranial end, growing into the metanephrogenic tissue, is expanded to develop into future renal pelvis; then the outgrowths are formed on it. They develop into the major and minor renal calyces, and further into the collecting tubules. At the same time the hystogenesis of the nephrogenic blastema, i. e. its conversion into the renal tissue, occurs. From this time the permanent kidney starts to migrate. The metanephros appears in the caudal end of the embryo, below the bifurcation of the aorta. From the 8—10 th weeks the kidneys migrate in the cranial direction, and by the 9—10th weeks settle above the bifurcation. Simultaneously the rudiments of kidneys start to displace into the retroperitoneal fat of the posterior surface of the embryo, and the kidneys rotate 90 ° degrees around the vertical axis.

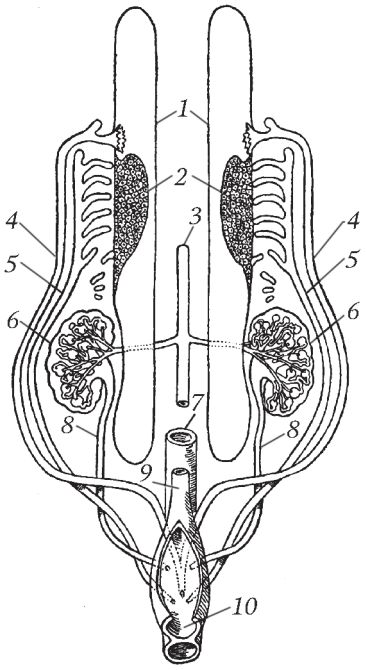


Fig. 1.10. Scheme of the development of the permanent kidney:

*1* — splanchnotom; *2* — indifferent reproductive gland; *3* — aorta; *4* — Mullerian duct; *5* — Wolffian duct; *6* — kidney; *7* — gut; *8* — ureter; *9* — allantois; *10* — urogenital sinus

Primarily the Wolffian and Mullerian ducts open into the cloaca, and the metanephric ducts through the Wolffian ducts also open into the cloaca. At the beginning of the second month the cloaca is divided by the urorectal septum, *septum urorectale*, into the dorsal part (the rectum) and the ventral part. The ventral part develops into the urinary bladder, ureter and the urogenital sinus proper, into which the Wolffian and Mullerian ducts open. Wolffian ducts further develop into the male reproductive organs, while Mullerian ducts give rise to the female reproductive organs.

The developmental anomalies of the urinary organs are so often that it was necessary to classify them. The classification by Gimpelson E. I. is the most suitable. According to it, all the developmental anomalies are united into 4 groups: anomalies of number, anomalies of position, anomalies of relation and anomalies of structure.

1. Anomalies of number: aplasia of kidney, i. e. the absence of one or both kidneys; an accessory (third) kidney, *ren accessorium*; double kidney, *ren duplex*; fused kidney (horseshoe, L-shaped, S-shaped).

2. Anomaly of renal position is called distopia. Depending on the place of the localization, the kidney may be pelvic, iliac or thoracic.

3. One of severe anomalies of relation is an ectopia of the ureter into the intestine, urethra, male reproductive organs (seminal vesicles, deferent duct) and female reproductive organs (uterine tube, uterus, external reproductive organs).

4. Anomalies of structure include polycistosys of kidneys and the disorder of the fusion of the anterior wall of the urinary bladder accompanied by the formation of the defect in the anterior abdominal wall.

## TEST QUESTIONS

1. What surfaces, poles, borders does the kidney have? How will you differentiate the anatomical preparation of the right kidney from the left one? Describe the sizes of the kidney.
2. What is the renal hilum?
3. What is the renal 'leg'?
4. What is the renal sinus? What structures does it contain?
5. What structures cover and surround the kidney? (list in series all of them, beginning from the renal parenchyma)
6. What muscles form the renal 'bed'?
7. What mechanisms of kidneys fixation do you know?
8. Describe the skeletotopy and syntopy of both kidneys.
9. What components does the renal cortex include?
10. What components does the renal medulla include?
11. List in series the branches of the renal artery up to the afferent arterioles.
12. List in series the parts of the nephron.
13. What does the renal corpuscle consists of?
14. Describe in details the functioning of the nephron.
15. What are the juxtamedullary nephrons? Describe the features of their functioning.
16. Describe the juxtaglomerular apparatus of kidneys.
17. List in series the pathway of urine beginning from collecting tubules.
18. Describe the kidney`s fornical apparatus.
19. Describe the walls of the minor and major calyces and of the renal pelvis.
20. What is the length of the ureter? List the parts of the ureter.
21. What is the structure of the wall of the ureter?
22. Describe the places of the ureter`s constrictions.
23. What parts of the urinary bladder do you know? Where is its apex directed? Where is its fundus directed? What is the capacity of the bladder?
24. What is the structure of the wall of the urinary bladder? Describe the features of the muscular and mucous layers. What is the vesical triangle? Why is it formed?
25. Describe the topography of the urinary bladder in males and in females.
26. Describe the relation of the urinary bladder to the peritoneum.
27. Describe the development of the urinary organs in stages.
28. What developmental anomalies of the urinary system do you know?

## CLINICOANATOMICAL PROBLEMS

1. The inflammatory process in a patient with acute glomerulonephritis is localized in the renal cortex. Which parts of the nephron are damaged?

2. The radiological examination shows the ptosis of the left kidney to the level of the V lumbar vertebra. Which mechanisms of the kidney fixation are failed?

3. A patient has a knife wound in the region of the back, on the left. During the revision of the wound, the injury of the superior renal pole is observed. Which organs should be examined for integrity?

4. The radiological examination of a patient with urolithiasis shows the stone, 7 mm in diameter. If the stone will pass through the ureter, in which parts of the ureter can it be delayed?

# 2. MALE REPRODUCTIVE SYSTEM

The male reproductive organs can be grouped in accordance with the function as follows:

1. Male reproductive gland, or testis, an organ providing the production and maturation of the male reproductive cells, the spermatozoa (spermatogenic function); besides, the testis is an endocrine gland secreting the male reproductive hormones, androgens (endocrine function).

2. Epididymis, deferent duct, ampulla of deferent duct, ejaculatory duct are the organs forming a paired tubular excretory tract, through which the spermatozoa pass into the male urethra.

3. Seminal vesicles, prostate, bulbo-urethral (Cowper`s), mucous glands of the spongy part of the male urethra (glands of Littre) are the accessory reproductive glands producing the secretion for the dilution and nutrition of the spermatozoa, i. e. for the sperm formation. Besides, this secretion provides the optimal conditions for the keeping of the viability and motility of the spermatozoa on all their way.

4. Penis, the male copulatory organ, together with urethra excretes urine from the urinary bladder and brings the sperm into the female reproductive tract.

Practically it is important to divide the reproductive organs of the male into external and internal. The external reproductive organs (mons pubis, scrotum and penis) are visible externally. They are located in the urogenital region, *regio urogenitalis*. Other organs are in the scrotum or lesser pelvis hence they refer to the internal reproductive organs.

The mons pubis, *mons pubis*, is a fatty cushion lying over the anterior surface of the pubic symphysis and superior pubic rami. The skin of this region is covered by hairs (pubarche). It should be noted that the mons pubis in males is less distinct than in females. However, the hairs in males cover not only mons but may reach the level of the umbilicus. In men with asthenic body type the mons is less distinct; also in elderly men it is flattened.

Other male reproductive organs have a complex structure and are described below.

## 2.1. Scrotum

The scrotum, *scrotum*, is a cutaneous fibro-muscular sac containing the testes and located between the root of the penis anteriorly and the perineum posteriorly (fig. 2.1). The apex of the scrotum is directed down, and the base is continuous with the skin of the mons pubis and medial surfaces of the thighs.

Usually the scrotum is contracted, elevated and is wrinkled in numerous folds. When the temperature outside is raised, the scrotum extends, and its walls become thinner. The skin of the scrotum is thin, rich in elastic fibers and absolutely devoid of subcutaneous fat, due to which it easily stretches. In strong stretching the plexuses of blood vessels are visible to unaided eye. The skin is covered by sparse hairs (like pubarche), is greatly pigmented and has numerous sweat and sebaceous gland compared with other parts of the body. The scrotum is divided into two halves by a raphe of scrotum, *raphe scroti*. It arises from the inferior surface of the penile root, passes from the scrotum to the perineum (raphe of perineum) and ends at the anus. The raphe of scrotum differs from the surrounding parts of the skin in darker pigmentation.

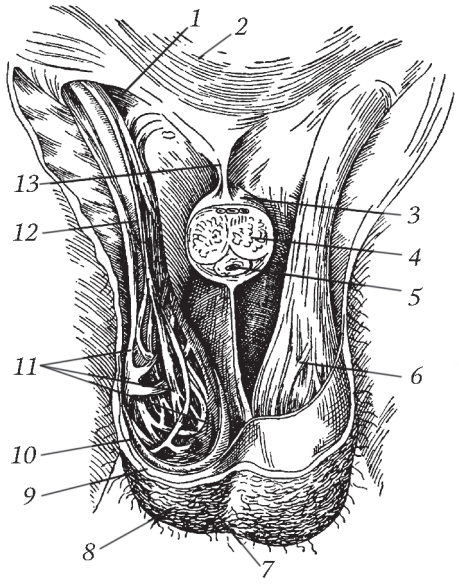


Fig. 2.1. Scrotum and coverings of testis. Transverse section of penis:

*1* — superficial inguinal ring; *2* — sheath of rectus abdominis; *3* — dorsum of penis; *4* — corpus cavernosum penis; *5* — corpus spongiosum penis; *6, 10* — cremasteric fascia; *7* — raphe of scrotum; *8* — skin; *9* — tunica dartos; *11* — cremaster; *12* — internal spermatic fascia; *13* — fundiform ligament of penis

Immediately under the skin of the scrotum is the tunica dartos, *tunica dartos*. It is a dense connective tissue lamina, 1—2 mm thick, containing elastic fibers and smooth muscle tissue termed the dartos muscle, *m. dartos*. The tunica dartos forms a fibro-muscular sac enveloping the testes. The properties of the tunica dartos determine the ability of the skin to contract significantly and pull the testes to the mons pubis; also it allows the skin to stretch strongly and contribute to the descent of testes.

Inside the scrotum the tunica dartos forms the scrotal septum, *septum scroti*, which separates the testes from each other. Superiorly the septum is attached to the root of the penis, and on the rest of its length it is attached to the raphe of scrotum.

Thus, in the scrotum there are two separate sacs, each contains the testis of the corresponding side.

So, the scrotal wall is composed of two layers: skin and tunica dartos, which are firmly linked together (fig. 2.1). The scrotum of the 3-month old fetus has only these two layers. Further, during the 7th month of the fetal development several fascial coverings, being the coats of the testis and spermatic cord, descend into the scrotum.

## 2.2. Fascial Coverings of Testis and Spermatic Cord

The most external covering of the testis and spermatic cord is the external spermatic fascia, *fascia spermatica externa*. It is formed only by a thin layer of loose connective tissue, which corresponds to the superficial abdominal fascia in genesis. Deep to this covering is the cremasteric fascia, *fascia cremasterica*, which is like the tunica dartos in structure. It contains a lot of elastic fibers hence very extensible. The cremasteric fascia and tunica dartos are fused together by means of the external spermatic fascia, i. e. by loose connective tissue.

The cremasteric fascia is thin but strong connective tissue lamina. It arises from the edges of the superficial inguinal ring, *anulus inguinalis superficialis*, envelopes the spermatic cord entirely; it then descends to cover the testis (here it is less distinct) and connects with the fascicles of the cremaster. The cremasteric fascia is the continuation of the proper abdominal fascia, which covers the outer surface of the obliquus abdominis externus, and of the aponeurotic fascicles of the same muscle, being closely fused with them.

The cremasteric fascia covers the cremaster, *m. cremaster*, which consists of thin pale pink fascicles, entirely enveloping the testis as a network. Through the gaps of this network the deeper whitish fascial covering is visible.

The cremaster, *m. cremaster*, originates from the lower bundles of the obliquus internus abdominis, which separate from this muscle, penetrate through the superficial inguinal ring and are included into the spermatic cord. Within the spermatic cord the cremaster becomes a continuous thin fascicle. Near the testis it divides into the separate bundles enveloping the testis in the form of loops. The most part of the bundles do not return to the place of their beginning therefore, the loops of the cremaster are incomplete. Though the cremaster is constructed from the striated muscle fibers, it usually contracts involuntarily with the smooth musculature of the tunica dartos. However, it may act voluntary to elevate the testes. Sometimes the cremaster is weakly developed.

Deep to the cremaster is the internal spermatic fascia, *fascia spermatica interna*. It is the continuation of the fascia transversalis and is fused by its inner surface with the parietal layer of the tunica vaginalis (serous covering of the testis). The internal spermatic fascia, *fascia spermatica interna*, has a distinct fibrous structure. It has the greatest density around the testis; towards the inguinal canal it gradually becomes loose.

The deeper covering is the tunica vaginalis, *tunica vaginalis testis*; it is a serous covering, developed from the peritoneum. It is divided into the parietal layer, *lamina parietalis*, and the visceral layer, *lamina visceralis*. The parietal layer lines the internal spermatic fascia from inside. Like any serous covering, it consists of the mesothelium, connective tissue stroma and plexuses of the blood and lymphatic capillaries. The visceral layer, covering the testis and epididymis, slightly differ in structure. It does not have fibrous basement and vascular plexuses. The mesothelium is immediately fused to the tunica albuginea. Within the spermatic cord the tunica vaginalis becomes the obliterated processus vaginalis peritonei, *vestigium processus vaginalis peritonei.*

Due to the fact that the development of the scrotal layers and of the testicular coverings is associated with the development of the anterior abdominal wall, for better memorization they are represented in the form of the table (table 1).

*Table 1*

**The comparison of the layers of the anterior abdominal wall with the layers of the scrotum, the coverings of the testis and spermatic cord**

| The layers of the anterior abdominal wall | The layers of the scrotum; the coverings of the testis and spermatic cord |
|---|---|
| Skin Subcutaneous adipose tissue<br><br>Superficial abdominal fascia Proper abdominal fascia Obliquus internus abdominis and transversus abdominis Transversalis fascia Peritoneum | The layers of the scrotum<br>Skin Tunica dartos<br>The coverings of the testis and spermatic cord<br>External spermatic fascia Cremasteric fascia Cremaster<br>Internal spermatic fascia Tunica vaginalis testis: a) parietal layer; b) visceral layer |

## 2.3. Male reproductive gland (testis)

The testis, *testis seu didymis,* (in Greek *orchis*), is a paired organ situated in the scrotum. Its function is the production of the spermatozoa and secretion of the male reproductive hormones (androgens).

The testis has two surfaces: more convex lateral surface, *facies lateralis*, and flattened medial surface, *facies medialis*; two borders: anterior, *margo anterior*, and posterior, *mar-*

*go posterior*; two ends (extremitas) superior, *extremitas superior*, and inferior, *extremitas inferior*. The epididymis adjoins the superior end and posterior border of the testis. Average testicular dimensions of an adult man are 4—5 cm in length, 2,5—3 cm in breadth, and 2—3 cm in thickness. Its weight is 20—30 g. In a newborn the testes have relatively big sizes, 1,0 × 0,7 × 0,5 correspondently. They intensively grow in puberty. In old age they a little decrease in size.

The testis has its own dense fibrous covering called the tunica albuginea, *tunica albuginea* (fig. 2.2), 1 mm thick. From the parenchyma of the testis the numerous thin septa pass towards the tunica albuginea, being loosely connected with it. These septa constitute the stroma of the testis and divide the parenchyma of the testis into the lobules.

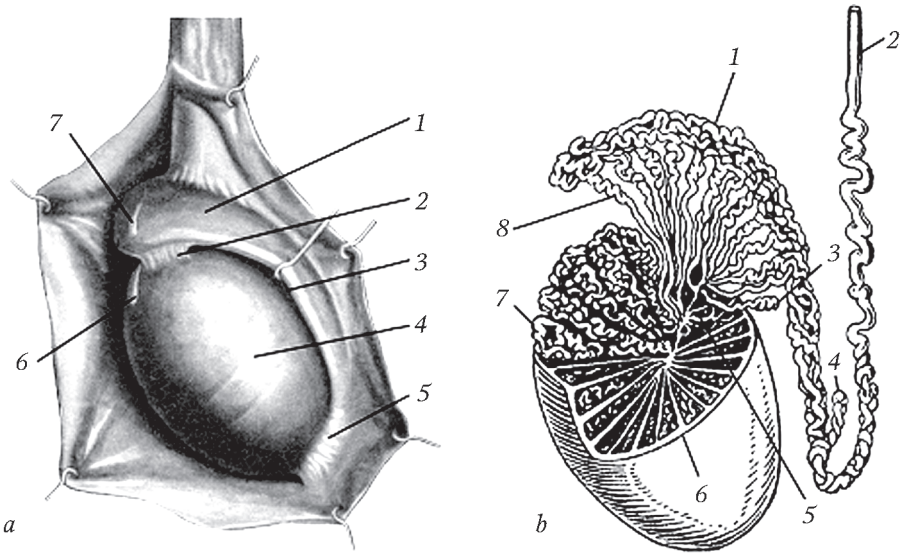


Fig. 2.2. Testis:

*a* — external structure: *1* — epididymis; *2* — superior ligament of epididymis; *3* — sinus of epididymis; *4* — testis; *5* — inferior ligament of epididymis; *6* — appendix of testis; *7* — appendix of epididymis;

*b* — internal structure (scheme): *1* — duct of epididymis; *2* — deferent duct; *3* — superior aberrant ductule; *4* — inferior aberrant ductile; *5* — rete testis; *6* — tunica albuginea; *7* — lobules of testis; *8* — efferent ductule of testis

The tunica albuginea is covered by the visceral layer of the tunica vaginalis (vide supra). The latter is smooth, shiny, moistened, transparent and closely linked with the tunica albuginea. It covers the testis entirely except the posterior border and partly superior pole, where it continues to the epididymis. It should be noted that from the lateral side the serous covering enters deeply between the testis and epididymis, covering them separately from each other and forming the sinus of the epididymis, *sinus epididymidis*. Superiorly and inferiorly the sinus is limited by the serous ligaments, superior and inferior ligaments of the epididymis.

The superior ligament of the epididymis, *ligamentum epididymidis superius*, connects the superior pole of the testis with the head of the epididymis. The inferior ligament of the epididymis, *ligamentum epididymidis inferius*, passes from the lower part of the pos-

terior border of the testis to the epididymis, at the junction between its body and tail. On the posterior border of the testis, in the place where it is fused with the epididymis and is not covered by the serous covering, there is a hilum of the testis, containing the testicular vessels and nerves.

**Internal structure of testis**. The parenchyma of the testis is heterogeneous (fig. 2.3). At the posterior border of the testis the tunica albuginea projects into it as a thick connective tissue septum called the mediastinum of the testis, *mediastinum testis*. The mediastinum of the testis contains the interstitial cells of Leydig, surrounded by the capillary plexuses. The Leydig cells elaborate the male reproductive hormones, androgens.

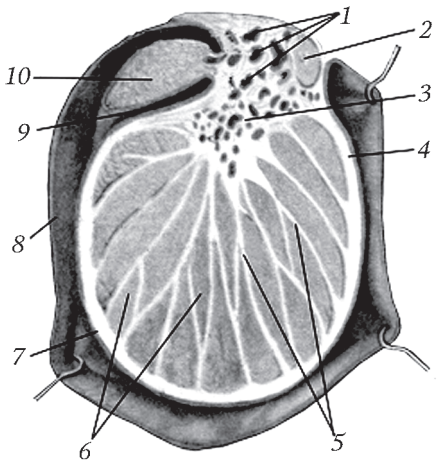


Fig. 2.3. Horizontal section of testis:

*1* — testicular arteries and veins; *2* — deferent duct; *3* — mediastinum testis; *4* — tunica albuginea; *5* — septulae testis; *6* — lobules of testis; *7* — visceral layer of tunica vaginalis; *8* — parietal layer of tunica vaginalis; *9* — sinus of epididymis; *10* — body of epididymis

From the mediastinum the numerous thin septula, *septulae testis*, radiate towards the surface of the testis; they gradually become thinner and only some fibers reach the inner surface of the tunica albuginea by their opposite ends. The septula divide the parenchyma into the separate lobules, *lobuli testis*; each testis includes 250—300 of the lobules. Each lobule contains one-two convoluted seminiferous tubules, *tubuli seminiferi contorti*. The length of each is 70—100 cm, but due to the strong tortuosity and close arrangement, the tubule surrounded by four capillaries fits in the limits of the lobule. Before 12 years of age the tubule represents a cord which does not have a lumen. The wall of the convoluted seminiferous tubule contains the spermatogenic and supportive cells. The spermatogenic cells pass through several developmental stages and transform into the spermatozoa (male reproductive cells). These are the elongated cells, 60 mcm long, consisting of the head, neck and tail. The tail performs the wave-shaped movements to provide the motility of the spermatozoon, but in the limits of the convoluted seminiferous tubule the spermatozoa are immobile. They are covered by the lecithin-like substance.

Near the mediastinum the convoluted seminiferous tubules join each other to form the straight seminiferous tubules, *tubuli seminiferi recti*, which open into a close network, rete testis, *rete testis*, located in the mediastinum. From the rete testis 12—15 efferent ductules, *ductuli efferentes testis*, pass into the lobules of the epididymis, providing the passage of the spermatozoa into the duct of the epididymis. It should be noted that the spermatogenic cells are situated only in the convoluted seminiferous tubules; all other tubules form the excretory way.

**Epididymis**, *epididymis*, is an elongated body adjoining the posterior border and superior pole of the testis. It has a head, body and tail. The head, *caput epididymidis*, is a superior thickened and rounded end of the epididymis, situated above the superior pole of the testis. The body, *corpus epididymidis*, is a middle part of the epididymis, which is in contact with the posterior and partially lateral surface of the testis. The tail, *cauda epididymidis*, is the lower part which is continuous with the deferent duct. The latter abruptly turns and runs as a part of the spermatic cord up and backwards.

The convex surface of the head, the lateral surface and partly anterior side of the epididymial body and also lateral surface of the tail are covered by the visceral layer of the tunica albuginea. Through the serous covering the tunica albuginea is visible; the tunica albuginea of the epididymis is thinner than that of the testis. From the tunica albuginea thin loose connective tissue septula pass into the epididymial head. They contain elastic fibers and numerous blood vessels. The septula divide the head into 12—15 lobules of the epididymis, *lobuli epididymidis*, or cones, *coni epididymidis*. The bases of the cones are directed to the convex surface of the epididymis, and the apices are directed to the mediastinum of the testis. From the mediastinum of the testis the efferent ductule enters each lobule; inside the lobule it becomes very convoluted. Thus, each cone is formed by its ductule. The terminal part of the ductule of the superior cone exits from its base and descends, sequentially taking the terminal parts of other efferent ductules from other lobules. Thus, the main ductule gradually expands and becomes the duct of the epididymis, *ductus epididymidis*. The latter starts in the head and passes throughout the body and tail. It forms numerous coils, lying closely to each other, in all its extent. The diameter of the duct of the epididymis in its middle part is 0,5 mm, the total length reaches 6 m. In the end of the tail of the epididymis the duct abruptly turns up and become the deferent duct.

In summary it should be noted that on the superior pole of the testis and head of the epididymis the small (about 1 mm) rudimentary structures may be observed. These are the appendix of testis, *appendix testis*, and the appendix of epididymis, *appendix epididymidis*. Both are the remnants of the Mullerian duct (blindly ending ducts surrounded by the vessels).

Inside the head of the epididymis the rudimentary highly coiled tubule may be present; it ends blindly, arises from the mediastinum of the testis and called the superior aberrant ductule, *ductulus aberrans superior*. The same tubule is situated in the body of the epididymis; it is an inferior aberrant ductule, *ductulus aberrans inferior*, arising from the duct of the epididymis, in the region of its tail. The aberrant ductules are the vestiges of the reduced tubules of the Wolffian body. One more rudiment, called the paradidymis, 5—6 mm in size, lies in the connective tissue of the spermatic cord immediately above the head of the epididymis. All these rudimentary structures are especially well defined in newborns and children up to 10 years; in adults they become unnoticeable. Very rarely they significantly increase in sizes.

## 2.4. Deferent Duct

The deferent duct, *ductus deferens*, is the direct continuation of the duct of the epididymis (fig. 2.2). Its total length reaches 40 cm; at the commencement it is tortuous, then it becomes straight. The diameter of the duct is 2,5—3 mm however, its lumen occupies just $^1/_6$ of the total caliber. Hence, its wall is very thick. From inside the duct is lined by the mucous membrane which forms the longitudinal folds. The thickest layer of the duct`s wall (about 1 mm) is a muscle coat, *tunica muscularis*. Due to the muscle layer, the deferent duct has a particular density, always keeps a cylindrical form and is easily palpated in the spermatic cord. This has a practical importance.

The outer layer of the duct, adventitia, is thin and rich in elastic fibers; it is gradually continuous with the surrounding fat.

The deferent duct is topographically divided into the four parts: epididymial, funicular, inguinal and pelvic.

The epididymial part, *pars epididymica*, (scrotal part, *pars scrotalis*), the shortest, is the commencement of the duct, corresponding to the length of the epididymis. This part of the duct is situated at the posterior border of the testis, medial to epididymis; it is con-

voluted and surrounded by the pampiniform venous plexus.

The funicular part, *pars funicularis*, is the portion of the duct contained within the spermatic cord, *funiculus spermaticus*. Its length is 10—15 cm. In the spermatic cord the duct is medial and posterior to the vessels. At the junction of the epididymial and funicular parts the deferent duct forms a bend at an obtuse angle.

The inguinal part, *pars inguinalis*, extends from the superficial inguinal ring throughout the inguinal canal. Its length is 4—5 cm (corresponds to the length of the canal). The inguinal part of the duct is also a component of the spermatic cord, i. e. surrounded by the vessels and fascial coverings.

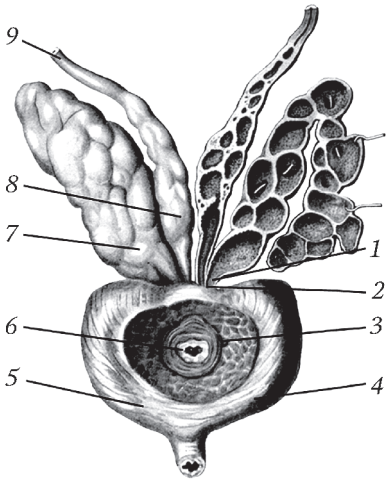


Fig. 2.4. Prostate, seminal vesicles, deferent duct (anterosuperior aspect):

*1* — excretory duct; *2* — ejaculatory duct; *3* — prostate (section through the urethra); *4, 5* — right lobe and left lobe; *6* — urethra; *7* — seminal vesicle; *8* — ampulla ductus deferentis; *9* — deferent duct

The pelvic part, *pars pelvica*, starts at the deep inguinal ring. Here the deferent duct leaves the spermatic cord and has a complex syntopy. It curves round the lateral side of the commencement of the inferior epigastric artery, crosses the external iliac vessels at a right angle and then passes down and backwards along the lateral wall of the lesser pelvis. In the lesser pelvis the duct runs across the obturator vessels and nerve, umbilical artery, superior vesical arteries and ureter. When it reaches the lateral surface of the urinary bladder, it turns backwards and passes between the bladder and rectum. The pelvic part lies extraperitoneally, immediately under the peritoneum, having the medial position relatively to all organs, which it crosses. Only last part of the duct, near the fundus of the urinary bladder, passes in the depth of the retroperitoneal fat.

At this place the right and left deferent ducts abruptly converge, and when reach the prostate, they run close together, near the median plane. The whole last portion of the pelvic part, lying at the fundus of the urinary bladder, much expands to form the ampulla, *ampulla ductus deferentis*. The ampulla is fusiform, 4 cm long and 7—10 mm thick; its external surface is uneven. The lumen of the ampulla has the lateral protrusions. Below, the ampulla of the deferent duct gradually narrows, and at the level of the superior edge of the prostate it merges with the excretory duct of the seminal vesicle. After the merger, the deferent duct is called the ejaculatory duct, *ductus ejaculatorius* (fig. 2.4).

The ejaculatory duct immediately enters the prostate, penetrating its parenchyma. The ducts of both sides converge and open by the separate openings on the seminal colliculus in the prostatic part of the urethra. The total length of the ejaculatory duct is 1,5—2 cm, the diameter of the lumen is 1 mm in the commencement and 0,5 mm in the end.

## 2.5. Spermatic Cord

The spermatic cord, *funiculus spermaticus*, is a collection of the structures, including the deferent duct, vessels and nerves of the spermatic cord and of the testis, surrounded by the coverings of the spermatic cord and of the testis (fig. 2.5).

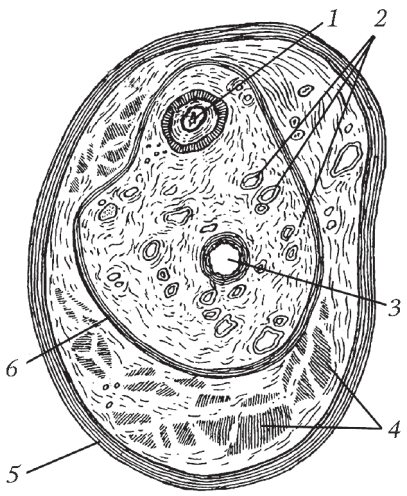


Fig. 2.5. Spermatic cord (transverse section):
*1* — deferent duct; *2* — pampiniform plexus; *3* — testicular artery; *4* — cremaster; *5* — cremasteric fascia; *6* — internal spermatic fascia

The spermatic cord extends from the deep inguinal ring to the superior pole of the testis. Hence, it can be divided into the pelvic and scrotal parts. The length of the spermatic cord is 15—20 cm and it changes according to the position of the testis.

The components of the spermatic cord:

1) deferent duct, *ductus deferens*;

2) artery of ductus deferens, *a. ductus deferentis*;

3) testicular artery, *a. testicularis*;

4) testicular vein, *v. testicularis*, arising from pampiniform plexus, *plexus pampiniformis*;

5) nervous plexuses of deferent duct and testis, *plexus nervorum deferentialis et testicularis*;

6) lymphatic vessels, *vasa lymphatica*;

7) vestiges of processus vaginalis, *vestigium processus vaginalis peritonei*;

8) smooth muscle tissue;

9) loose connective tissue containing a lot of elastic fibers and devoid of adipose tissue;

10) rudimentary structure, the paradidymis, located in the lowermost part of the spermatic cord.

The spermatic cord is enveloped by the coverings which have already been described above. Now we will describe the coverings of the spermatic cord from outside inwards:

1) external spermatic fascia, *fascia spermatica externa*, is poorly distinct;

2) cremasteric fascia, *fascia cremasterica*, starts just below superficial inguinal ring;

3) cremaster, *m. cremaster*;

4) internal spermatic fascia, *fascia spermatica interna*, is also poorly distinct and is gradually continuous with loose connective tissue enveloping the structures of the spermatic cord.

## 2.6. Seminal Vesicles

The seminal vesicle, *vesicula seminalis*, (seminal gland, *glandula seminalis*) is a paired structure, representing the lateral outgrowth of the deferent duct`s terminal part. It looks like an elongated sac, sharpened above and flattened from front to back. It is lateral to the ampulla of the deferent duct, between the fundus of the urinary bladder and the rectum, above the prostate (fig. 1.8). The superior blind end of the vesicle, the base, is often sharpened, rarely expanded and rounded. The inferior end is always narrow and is continuous with a short canal, the excretory duct, *ductus excretorius*, which opens into the lateral wall of the lower part of the deferent duct`s ampulla (fig. 2.4). The anterior surface of the seminal vesicle faces the urinary bladder, while the posterior surface is directed to the rectum. Both surfaces are uneven.

The sizes of the seminal vesicles depend on age and the degree of their filling. The average sizes are: the length is 5 cm; the breadth is 2 cm; and the thickness is 1 cm. Often the right and the left seminal vesicles are asymmetric. The seminal vesicle is formed by

a single highly coiled canal, 10—12 cm long, with the lateral protrusions (diverticula) of its wall. The sizes of the canal, the number and form of the diverticula greatly vary. Usually the upper diverticula, situated at the base of the seminal vesicle, are developed better than the lower. The seminal vesicles lie extraperitoneally (the peritoneum covers just small area near their bases).

The wall of the seminal vesicle is composed of three layers: adventitia, muscular and mucous. The adventitia is thin, rich in elastic fibers. It is closely linked with the fibro-muscular lamina, which envelops the ampullae of the deferent ducts and the seminal vesicles and is continuous with the capsule of the prostate below and the adventitia of the urinary bladder on the sides. During orgasm the fibro-muscular lamina contracts that causes the simultaneous extrusion of the secretion from the seminal vesicles, the ampullae of the deferent ducts and prostatic glands. Their own smooth muscle coat of the seminal vesicle`s wall is weakly developed. The mucosa has a well-developed submucous layer and the numerous glands lined by the columnar epithelium. Due to such a structure, the mucosa forms the numerous folds crossing each other and creating a reticular mucosal pattern.

The glands of the mucous membrane of the seminal vesicles elaborate the viscous yellowish alkaline fluid containing the proteins and fructose which is an energy source for spermatozoa. This secretion passes through the excretory duct into the ampullae of the deferent ducts to make the spermatozoa movable. Thus, the fluid of the seminal vesicles dilutes the spermatozoa situated in the ampullae of the deferent ducts and creates the optimal conditions for their activity and trophic processes.

Hence, the seminal vesicle is not a reservoir for spermatozoa. The main places of the accumulation and storage of spermatozoa are the epididymes and ampullae of the deferent ducts. The seminal vesicles are the accessory reproductive glands.

In children (up to 10—12 years) when the spermatozoa have not matured yet, the seminal vesicles are quite small. In puberty they intensively grow, and reach full development in adult. With age the seminal vesicles and ampullae of the deferent ducts decrease in size, their mucosa atrophies and the walls become thinner.

## 2.7. Prostate

The prostate, *prostata*, is an unpaired dense organ having grayish-red color. It is situated in the lesser pelvis, under the urinary bladder, and envelopes the commencement of the urethra. In the form and size it resembles a chestnut, slightly flattened from front to back (fig. 1.8, 2.4).

In accordance with the location, three surfaces are distinguished in the prostate: anterior, posterior and inferolateral, *facies anterior, facies posterior et facies inferolateralis*.

The prostate consists of two lobes: right and left, *lobus dexter et lobus sinister*, separated along the anterior surface by a slight groove, *sulcus prostatae*. The surface of the prostate, directed up, is flattened and called the base, *basis prostatae*; the lower part of the prostate gradually narrows and is named the apex, *apex prostatae*. Apart from the right and left lobes, one more, middle lobe, *lobus medius*, is distinguished; it is on the prostatic base. The middle lobe is inconstant, wedge-shaped and looks like a tubercle protruding upwards and bounded anteriorly by the urethra and posteriorly by the ejaculatory ducts. The middle lobe is also called a pathological lobe because in elderly men it often hypertrophies and compresses the lumen of the urethra. The average sizes of the prostate in adult men are: the length is 3 cm; the breadth is 4 cm; the thickness is 2 cm. The weight is about 20 g.

The prostate has complex topographical relations. Its base adjoins the fundus of the urinary bladder and ampullae of the deferent ducts. Approximately 10 mm anterior to the prostate is the pubic symphysis. Between the symphysis and prostate in loose connective tissue there is a vesical venous plexus, *plexus venosus vesicalis*. On the sides the prostate is surrounded by a proper prostatic venous plexus, *plexus venosus prostaticus*. Some fascicles of the levator ani pass through this plexus to the prostatic capsule. The apex of the prostate lies on the urogenital diaphragm, *diaphragma urogenitalis*.

The posterior surface of the prostate is in contact with the ampulla of the rectum. Between them there is a rectovesical fascia and small quantity of fat.

Such a position of the prostate allows doctors to palpate it through the rectum to determine its size, form and sensitivity. In cases of chronic prostatitis, the prostate, seminal vesicles and ampullae of the deferent ducts are massaged through the rectum for the therapeutic purpose.

The prostate is firmly fixed to the surrounding tissues and organs. It is connected to the symphysis by a paired puboprosatic ligament, *ligamentum puboprostaticum*. The base of the prostate is fused with the fundus of the urinary bladder and the apex of the prostate is connected to the urogenital diaphragm by the fibrous tissue. Besides, the prostate together with the surrounding venous plexus is enclosed into a strong fibrous capsule, *capsula prostatica*. The capsule is especially well- developed posteriorly, where it forms the rectovesical septum, *septum rectovesicale*, separating the prostate and rectum.

Unlike other glands, the prostate has a specific structure. Only half of the prostatic parenchyma is composed of the glandular tissue forming the collection of the individual prostatic glandules. The total number of these glandules reaches 30—50, but the excretory ductules, *ductuli prostatici*, of many glandules join together. The united excretory ductules open into the prostatic part of the urethra at the area of the prostatic sinus, *sinus prostaticus*. The prostatic glandules are mainly located in the posterior and lateral parts of the prostate. In the anterior part they are almost absent.

The prostatic glandules lie in the mucosa, submucosa and in the smooth muscles of the prostate. They are tubulo-alveolar glands producing a whitish slightly alkaline secretion which provides alkalization of the prostatic urethra before the passage of the sperm from the ampullae of the deferent ducts and additionally dilutes the sperm during ejaculation. The secretion of the deeply located (in smooth muscle tissue) glandules contains a fat-like substance, lecithin, therefore, the long retention of the secretion in the ducts of these glandules may lead to the formation of lecithin ‘stones’ that worsens the chronic prostatitis.

The other half of the prostatic parenchyma is composed of the smooth muscle and connective tissue, which are contained in the prostate in equal amounts. The smooth muscle tissue is mainly located in the anterior part and in the middle lobe of the prostate. The smooth muscle fascicles penetrate the prostate between the glandules and concentrate around the lumen of the urethra. All the muscle fascicles comprise the muscular substance, *substantia muscularis*. Some smooth muscle fibers enter the muscle coat of the urinary bladder`s wall in the area of the vesical trigone. These fibers are also involved in the formation of the internal urethral sphincter, *m. sphincter urethrae internus seu m. sphincter vesicae*.

The connective tissue, chiefly made up of elastic fibers, forms a capsule of the prostate. From the capsule the numerous processes pass inside the prostate and intertwine with the smooth muscle tissue. Due to such a structure the prostate has a dense elastic consistency and smooth external contours.

The prostate is pierced by the commencement of the urethra, which is called the

prostatic part, *pars prostatica urethrae*. The urethra enters the base of the prostate approximately centrally. It passes through the prostate obliquely, between its anterior and middle thirds. Hence, the urethra lies closer to the anterior surface of the prostate and exits near the prostatic apex.

If the urethra is cut along its anterior wall, the posterior wall shows an elongated prominence named the urethral crest, *crista urethralis*. It lies in the midline and extends throughout the prostatic urethra, sometimes descending into the membranous part of the urethra. On the sides of the crest there are two depressions, the prostatic sinuses, *sinus prostatici*, into which the excretory ducts of the prostatic glandules open by the numerous orifices (fig. 1.9).

The urethral crest carries a distinct tubercle called the seminal colliculus, *colliculus seminalis*. Its breadth and height is about 3 mm, and the length is 6 mm. It is composed by the spongy tissue containing a lot of smooth muscle fibers. In the center of the seminal colliculus there is a thin slit-like opening leading into a small cavity, the prostatic utriculus, *utriculus prostaticus*. The latter is a rudiment of Mullerian ducts, which develop in females into the vagina, uterus and uterine tubes. Hence, the prostatic utriculus is a homologue of the internal female reproductive organs. The prostatic utriculus varies in its development: sometimes it branches, sometimes is absent. The epithelium lining the prostatic utriculus is hormonally active.

On the sides of the opening of the prostatic utriculus on the seminal colliculus the ejaculatory ducts open; they arise from the ampullae of the deferent ducts and then pass immediately through the prostatic parenchyma.

**Age changes in prostate.** In children the prostate has small sizes, is composed of mainly muscle and connective tissues, while the glandular tissue is poorly developed. During puberty the prostate rapidly grows, especially the glandular tissue. In elderly men the pathological increase of the prostate, hypertrophy, is often observed. It occurs due to the overgrowth of the connective tissue and the transformation of the muscle tissue into connective tissue.

## 2.8. Bulbo-urethral Glands

The bulbo-urethral gland, *glandula bulbourethralis*, or Cowper`s gland, is a paired pea-sized organ. The gland is rounded and slightly uneven, has yellowish color and quite dense consistency. It lies between the fascicles of the transversus perinei profundus, posterior to the membranous part of the urethra, at a distance of 5 mm from each other (fig. 1.8).

The excretory duct of the bulbo-urethral gland, *ductus glandulae bulbourethralis*, is very thin but rather long (about 3—4 cm). It passes through the urogenital diaphragm and penetrates the spongy substance of the bulb of the penis; then it passes some distance under the mucosa of the spongy part of the urethra and only after that pierces the urethra. The orifice of the duct is slit-like and invisible to unaided eye because of its small size. Sometimes the both ducts are united and open by a common orifice.

## 2.9. Penis

The penis, *penis*, is the organ that eliminate urine and deliver sperm to the female reproductive tract. It consists of the fixed part, *pars fixa*, and mobile part, *pars mobilis*. The fixed part, the root, *radix penis*, is attached to the pubic bones and is covered by the skin of the perineum and of the scrotum. The mobile part is a pendulous anterior part of

the penis, called the body, *corpus penis*. The body of the penis has a dorsum, *dorsum penis*, or anterosuperior surface, and the urethral surface, *facies urethralis*, or inferoposterior surface. The base of the dorsum is formed by two conjoined corpora cavernosa, and the base of the urethral surface is formed by the unpaired corpus spongiosum. The body of the penis ends in the glans penis, *glans penis*, on the top of which is a sagittal slit, the external urethral orifice, *ostium urethrae externum*.

The corpus cavernosum, *corpus cavernosum penis*, is a paired cylindrical body with the sharpened ends. The posterior end of each corpus cavernosum is firmly attached to the periosteum of the pelvic bone at the junction between the ischial and pubic rami, arising almost from the ischial tuberosity (fig. 2.6). This end is termed the root, or crus, *crus corporis cavernosi*. At the level of the symphysis the right and left corpora cavernosa converge and fuse along the midline. Between the fused corpora cavernosa on the superior (anterior) and inferior (posterior) surface the grooves are formed. The superior groove is less deep; it is occupied by the dorsal vessels and nerves of the penis. The inferior, urethral groove, *sulcus urethralis*, is significantly deeper and contains the corpus spongiosum.

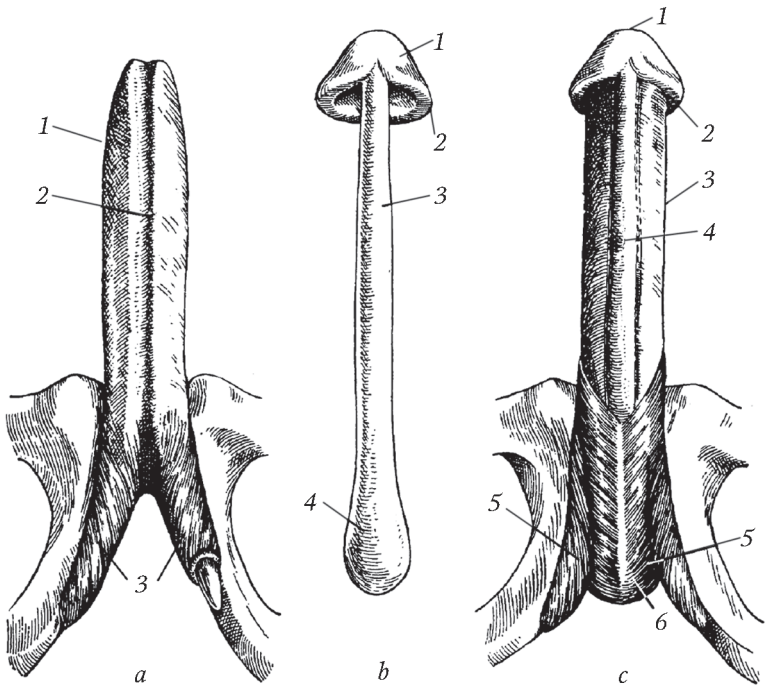


Fig. 2.6. Corpora cavernosa and corpus spongiosum of penis (inferior aspect):

*a* — corpora cavernosa: *1* — corpus cavernosum penis; *2* — urethral groove; *3* — ischiocavernosus;

*b* — corpus spongiosum: *1* — glans penis; *2* — corona glandis; *3* — corpus spongiosum penis; *4* — bulb of penis;

*c* — muscles of penis: *1* — external urethral orifice; *2* — corona glandis; *3* — corpus cavernosum penis; *4* — corpus spongiosum penis; *5* — ischiocavernosus; *6* — bulbospongiosus

The corpus spongiosum, *corpus spongiosum penis*, unpaired, is also cylindrical. Compared to the paired corpus cavernosum it is smaller in the diameter but longer. However, the main difference is the presence of the longest part of the urethra, *pars spongiosa urethrae masculinae*, inside the corpus spongiosum. Besides, the ends of the corpus spongiosum do not narrow but expand. The posterior end forms the bulb, *bulbus penis*, located in the perineal muscles, in front of the lower part of the rectum. The bulb of the penis is like a hazelnut in size and can be palpated through the skin of the perineum. On the superior surface of the bulb there is a shallow groove showing the origin of the corpus spongiosum from the paired rudiments, the genital folds.

The anterior end of the corpus spongiosum expands into a conical enlargement like a bell, termed the glans penis. The sharpened ends of the paired corpora cavernosa enter the concave part of the glans. The glans is connected to the main part of the corpus spongiosum by its posterior border. This border is flattened, much shorter and has a notch along the midline, to which the frenulum of prepuce is attached. The frenulum is composed of thin, soft, highly innervated skin which is continuous posteriorly with the raphe of the penis, *raphe penis*. The rounded free edge of the glans penis is called the corona glandis, *corona glandis*; posterior to the corona glandis is the neck of glans, *collum glandis*.

**Structure of corpora cavernosa.** Each corpus cavernosum is enclosed by a strong tunica albuginea, *tunica albuginea corporum cavernosorum*. When the penis is flaccid the thickness of the tunica albuginea reaches 2 mm. It is constructed from the fibro-elastic tissue therefore, is capable to stretch significantly to become thinner under the pressure of blood during erection. The tunica albuginea of the corpus spongiosum is thinner and more elastic.

Along the midline the tunica albuginea of the corpora cavernosa is fused, forming an unpaired septum of the penis, *septum penis* (fig. 2.7). The septum is perforated by the numerous slits, through which the blood passes from one corpus cavernosum to the oth-

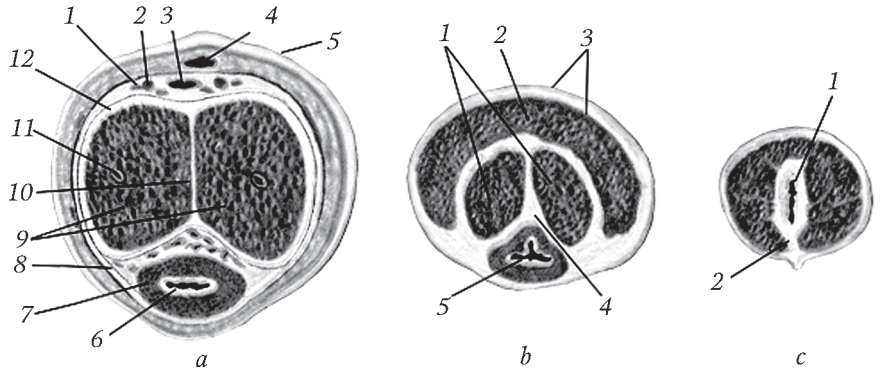


Fig. 2.7. Transverse sections of penis:

*a* — through the body of penis: *1* — dorsal nerve of penis; *2* — dorsal artery of penis; *3* — deep dorsal vein of penis; *4* — superficial dorsal vein of penis; *5* — skin; *6* — urethra; *7* — corpus spongiosum penis; *8* — fascia of penis; *9* — corpora cavernosa penis; *10* — septum penis; *11* — deep artery of penis; *12* — tunica albuginea; *b* — through the posterior region of glans penis: *1* — corpora cavernosa penis; *2* — glans penis; *3* — prepuce; *4* — septum penis; *5* — urethra;

*c* — through the anterior region of glans penis: *1* — urethra; *2* — septum glandis

er. From the inner surface of the tunica albuginea the numerous trabeculae arise; they run in all directions, intersecting and forming the cavernous spaces (lacunae, or cavernae, *cavernae corporum cavernosorum*). The lacunae of the corpus spongiosum, *cavernae corporis spongiosi*, are smaller in size. The trabeculae of the corpora cavernosa and corpus spongiousum, *trabeculae corporum cavernosorum et corporis spongiosi*, are composed of the fibro-elastic fibers with smooth muscle fibers. From inside the cavernae are lined by the endothelium. Into each caverna the helicine artery, *arteria helicina*, opens; the orifice of this artery is surrounded by smooth muscle pads working like sphincters. During sexual arousal the muscle pads contract to open the lumens of the arteries; the arteries become straight, and the cavernae are rapidly filled with blood. Thus, during erection the cavernae expand, their lumens are much increased and the trabeculae become thinner. During erection the outflow of the blood from the cavernae is restrained by the compression of the dorsal vein. The outflow of blood from the lacunae of the corpus spongiosum is almost not restrained because the blood passes into the veins of the inferoposterior surface. That is why the part of urethra, passing through the corpus spongiosum, is not compressed during erection. In flaccid penis the sizes of the cavernae are considerably decreased, they become like thin slits filled with small quantity of blood, and the septa are thickened.

**Structural features of penile skin.** The skin of the penis is very thin, soft and has a lot of tactile receptors. Instead of subcutaneous fat, connective-tissue containing elastic fibers is under the skin. Due to the elastic fibers the penile skin is capable to stretch and form the numerous folds in flaccid condition. The penile skin is slightly pigmented and is covered by hairs at the root. Under the skin in the loose connective tissue the large subcutaneous veins pass. The main vein, having about 4 mm in diameter, is on the inferoposterior surface of the penis, almost along the line of the median raphe; the lateral branches of this vein round the corpora cavernosa and anastomose on the dorsum of penis. Due to the position of the main subcutaneous vein, the skin of the inferoposterior penile surface between the frenulum and root possesses high sensitivity (erogenous zone).

Deep to the elastic base of the skin and subcutaneous veins is the superficial fascia of the penis, *fascia penis superficialis.* It is a thin connective tissue lamina firmly linked with the skin and loosely connected with the proper, deep, fascia of the penis, *fascia penis profunda*. Due to this, the penile skin is easily displaced over the surface of the corpora cavernosa, which are surrounded by the proper fascia. The proper fascia of the penis is the continuation of the fasciae of the adjacent body regions (abdominal and femoral fasciae). It ends along the line of the attachment of the prepuce, i. e. at the neck of glans. On the dorsum of the penis, near the root, the proper fascia is thicker because the tendons of the muscles (ischiocavernosus and bulbospongiosus) blend with it. It should be noted that under the proper fascia the large dorsal vessels and nerves pass.

At the neck of glans the skin is folded to form the prepuce, or foreskin, *preputium penis*, which overlaps the glans almost entirely (fig. 2.8). Only the most front area, where the external urethral orifice opens, remains free. The prepuce is comprised of the outer and inner skin layers. The outer layer is similar to the rest of the penile skin. The inner layer is thinner and softer; its keratinized layer is less distinct. Unlike the rest of the penile skin it forms not circular but longitudinal folds. The inner layer reflexes behind the glans forwards and envelops the corona glandis and the glans itself by a thin covering. It ends at the edges of the external urethral orifice, where it is continuous with the mucosa. Thus, the glans of penis and inner preputial layer are covered by a very soft thin skin, through which the vessels are visible. This skin has a pink color and possesses high sensitivity to the tactile stimuli (erogenous zone).

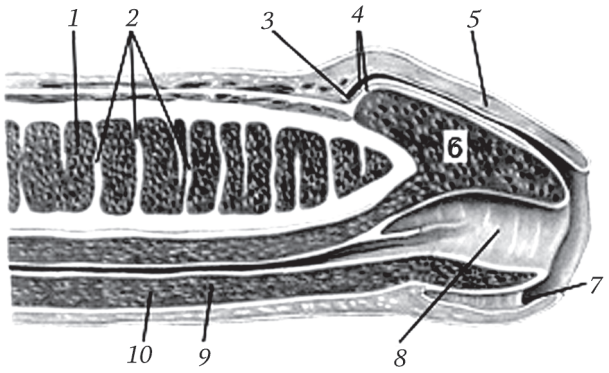


Fig. 2.8. Sagittal sections of penis:

*1* — corpus cavernosum penis; *2* — trabeculae of corpus cavernosum; *3* — neck of glans; *4* — corona glandis; *5* — prepuce; *6* — glans penis; *7* — frenulum of prepuce; *8* — navicular fossa of urethra; *9* — cavernae of corpus spongiosum; *10* — corpus spongiosum penis

The inner layer of the prepuce is attached to the neck of the glans. During erection the outer and inner layers separate from each other, the penile skin is elongated by the length of both layers and the glans of penis opens. In flaccid penis the prepuce may close the glans partially or entirely.

In children before 9—10 years of age the skin of the prepuce is less elastic hence less stretchy; the inner preputial layer is fused with the skin of the glans. Further the inner layer is detached from the glans, and the preputial sac (cavity) is formed. It is deeper anteriorly and shallow posteriorly because here the prepuce is connected to the frenulum, *frenulum preputii*. The latter is an unpaired skin fold in the area of the posterior edge of the glans.

The penile skin has the sweat and sebaceous glands. They are most abundant on the inferior (posterior) surface of the penis. In the region of the glans, neck and frenulum the glands are absent. The small quantity of the sebaceous glands is on the inner layer of the prepuce. The secretion produced by these glands mixes with the exfoliated epithelium of the skin of the preputial sac to form the small quantity of the whitish substance having specific odour, the smegma. Accumulated in the preputial sac, it can provide a favorable condition for the bacterial growth.

**Ligamental apparatus of penis.** At the root of the penis there are two suspensory ligaments. The superficial ligament of the penis, *ligamentum suspensorium penis superficiale*, arises from the superficial abdominal fascia near the linea alba. In front of the symphysis it is continuous with the superficial fascia of the penis, forming two thickenings which flank the corpora cavernosa. The ligament contains a lot of the elastic fibers.

The deep suspensory ligament is called the fundiform ligament of the penis, *ligamentum fundiforme penis*. It has the shape of a triangle, whose base is directed down. The ligament arises from the lower part of the anterior surface of the symphysis and ends in the tunica albuginea of the dorsal side of the corpora cavernosa. The ligament consists of short strong fibrous fascicles. The spaces between the ligaments are traversed by the dorsal vessels and nerves. The mentioned ligaments suspend the mobile part of the penis and fixate it to the region of the symphysis.

**Muscles of penis.** Two muscles functionally relate to the penis: the bulbospongiosus and ischiocavernosus. According to their development, they belong to the muscles of the perineum.

***Bulbospongiosus***, *m. bulbospongiosus*, paired, is a thin rounded lamina closely adjoining the anterior part of the penile root. The muscle fascicles arise from the raphe and central tendon of the perineum and embrace the bulb of the penis and posterior part of the corpus spongiousum. In the region of the corpora cavernosa they are continuous with the tendons which are attached to the dorsal surface of the corpora cavernosa and to the proper fascia of the penis. The lower surface of the muscle is covered by the proper fascia of the perineum; lateral to the bulbospongiosus is the ischiocavernosus.

The bulpospongiosi compress the corpora cavernosa, the dorsal vein of the penis, the bulb and posterior part of the corpus spongiosum and bulbo-urethral glands. During the contraction of these muscles, the commencement of the spongy part of the urethra is narrowed and shortened. The muscles assist in erection by compressing of the dorsal veins of the penis that results in the prevention of the outflow of venous blood from the corpora cavernosa; also they help to extrude the sperm from the urethra during orgasm and to extrude the last drops of urine during urination.

***Ischiocavernosus***, *m. ischiocavernosus*, is a paired and long muscle having tendinous origin and insertion. The muscle arises behind the root of the corpus cavernosum and the sacrotuberous ligament, passes to the crus and inferior surface of the corpus cavernosum and blend by its tendon with the tunica albuginea of the corpus cavernosum. Some tendinous bundles end on their lateral surface and others reach the dorsal surface. These bundles cross those of the opposite side to form a loop. During contraction the muscle presses the root of the corpus cavernosum to the bone, erects the penis and compresses its dorsal veins. Thus, it maintains the erection.

## 2.10. Male Urethra

The male urethra, *urethra masculinars*, has significant functional and morphological differences in comparison with the female urethra. It eliminates not only urine but also expels sperm during ejaculation.

The male urethra is a narrow long duct extending from the internal urethral orifice in the fundus of the urinary bladder to the external urethral orifice on the glans penis (fig. 1.7, 1.9).

The urethra is topographically divided into four parts: intramural (preprostatic), prostatic, membranous and spongiose. Also the male urethra can be divided into the fixed and mobile parts. These parts are separated by the attachment of the fundiform ligament to the penis.

The total length of the male urethra is greatly variable (from 15 to 22 cm), at birth it is 5—6 cm, at puberty it is 10—12 cm. The average diameter of the male urethra is 5—7 mm; it may be expanded by the medical instruments to 10 mm. However, it should be remembered that the breadth of the urethra is uneven throughout the urethra: it has narrow and expanded parts.

**Parts of male urethra.** At the commencement, the lumen of the urethra is narrow because here is the internal urethral orifice. The intramural part, *pars intramuralis*, 0,5 cm long, is in the region of the neck of the urinary bladder. The prostatic part of the urethra, *pars prostatica urethrae*, pierces the prostate, passing almost vertically. It is about 3 cm long and concave forwards. In the middle, the prostatic part significantly expands, reaching 9—12 mm in diameter. Then the lumen of the urethra gradually tapers.

The structural features of the posterior wall of the prostatic urethra are described in the section «Prostate».

The membranous part of the urethra, *pars membranacea urethrae*, is the shortest and narrowest. Its length is 1—1,5 cm, and the diameter is 4—5 mm. This part extends from the prostate to the bulb of the penis. It is surrounded by the muscles of the urogenital diaphragm. With the help of the muscles, fasciae and transverse perineal ligament the membranous part of the urethra is firmly fixed to the pubic bones therefore, it is almost ummobile. It pierces the urogenital diaphragm almost vertically, forming a slight dorsal convexity. In front of the membranous urethra there are the transverse perineal ligament, venous plexus of the urinary bladder and the pubic symphysis. Lateral to the membranous urethra, in the transversus perinei profundus, are the bulbo-urethral glands however, their ducts open into the commencement of the spongiose part of the urethra.

The spongiose part, *pars spongiosa urethrae*, is the longest portion of the urethra. It is contained in the corpus spongiosum, closer to its anterior (superior) surface. It should be noted that when the urethra leaves the urogenital diaphragm it passes 5—6 mm outside the corpus spongiosum, being covered by the skin only. This is vulnerable place of the urethra because it is surrounded only by loose connective tissue and skin. Here the wall of the urethra may be easily damaged by careless enter of metallic catheter or other instruments. Then the urethra descends obliquely and gradually immerses into the bulb of the penis as the commencement of the spongiose part, called the bulbar part, *pars bulbosa*. Within the bulb the lumen of urethra is much expanded, and throughout the spongiose part of the urethra it remains uniform, about 7 mm in diameter. Before the glans penis the urethra slightly narrows and then much dilates into the navicular fossa, *fossa navicularis*. The external urethral orifice is narrow and less dilatable because it is surrounded by the fibro-elastic ring.

It is necessary to remember the places of the constrictions and dilations of the urethra during the performing of urological manipulations. Thus, the male urethra has three constrictions: the internal urethral orifice, membranous part, external urethral orifice; and three dilations: the prostatic part, bulbar part and navicular fossa.

**Course of male urethra.** The male urethra forms two curves which are clearly visible on the median sections of the pelvis. The first, or posterior, curve is beneath the pubic symphysis and called the infrapubic curve, *curvatura infrapubica*. It starts from the internal urethral orifice and ends at the attachment of the fundiform ligament to the dorsum of the penis. This curve appears because the urethra surrounds the symphysis posteriorly, inferiorly and anteriolrly. It is directed forwards and up by its concavity and situated in the limits of the fixed part of the urethra, including the intramural, prostatic, membranous parts and the commencement of the spongiose part.

The second curve, or anterior, is in front of the pubic symphysis and called the prepubic curve, *curvatura prepubica*. It starts from the junction of the fixed and mobile parts of the penis. The prepubic curve is directed by its concavity down and backwards. This curve is not fixed (changeable). If the penis is raised to the anterior abdominal wall, the prebubic curve disappears, only the constant infrapubic curve remains and the urethra makes a single common curve directed by the concavity upwards. During the catheterezation of the urinary bladder or insertion of the instruments into the urethra, doctors should give the penis such a position.

**Urethral sphincters.** The male urethra is surrounded by two sphincters: internal sphincter vesicae and external sphincter urethrae. The internal sphincter, *m. sphincter vesicae*, is situated at the commencement of the urethra (surrounds the internal urethral orifice), and in the neck of the urinary bladder. The internal sphincter is directly linked

with the smooth musculature of the vesical trigone and of the prostate. Hence, it is involuntary, i. e. is not controlled by consciousness.

The external sphincter, *m. sphincter urethrae externus*, constricts the membranous part of the urethra. It is composed of striated muscle fascicles, which surround the membranous urethra and continue upwards to the region of the prostate. This muscle is included into the urogenital diaphragm; it occupies the space between the inferior pubic rami and upper edge of the transversus perinei profundus. The external sphincter is voluntary.

**Structure of mucous membrane of male urethra.** The mucous membrane of the male urethra, *tunica mucosa urethrae*, has a pink color. It is smooth in the prostatic and membranous parts, while in the spongiose part it forms the longitudinal folds and shallow depressions (crypts or lacunae). The epithelium lining these depressions does not differ from the rest of the epithelial covering of the urethra.

Apart from the longitudinal folds, one transverse fold is in the spongiose part; it has the shape of a semilunar flap and called the valve of the navicular fossa, *valvula fossae navicularis*. It is situated on the anterior wall of the urethra, opposite to the external urethral orifice and bounds the navicular fossa from the side. It should be noted that it may intercept the tip of a catheter or cystoscope in its passage along the urethra.

The mucous membrane of the male urethra has a well-developed glandular apparatus. All the glands can be divided into specific and proper. The specific glands are functionally associated with the reproductive function; they produce the secretion during sexual arousal. These glands are prostatic, *glandulae prostaticae*, and bulbo-urethral, *glandulae bulbourethrales*. The proper glands of the urethra are minute and elaborate the alkaline mucus. They produce secretion constantly, moistening the surface of the mucous membrane and providing the close contact of the urethral walls. The proper glands include the simple and branched alveolar urethral glands, *glandulae urethrales*, which are especially abundant on the anterior (superior) wall of the spongiose part of the urethra. Some of these glands are modified and transform into the paraurethral ducts which are also called the glands of Littre. They are rather large and have the length about 1 mm and breadth about 0,5 mm. The paraurethral ducts represent the canals which are directed opposite the passage of urine and open on the surface of the mucous membrane lining the anterior portion of the spongiose part of the urethra, mainly near the external urethral orifice. The paraurethral ducts are potential sites to infections.

## 2.11. Development of Male Reproductive Organs

Primarily on the wall of the coelom of embryo a bilateral urogenital fold appears. It lies on either side of the mesenteric root, extending throughout 7 segments, beginning from the IV cervical. Further the cranial part of the fold reduces, while the caudal part intensively grows, and by the end of the second month of embryogenesis the fold reaches the level of the lumbar segments.

The testes are derived from the visceral layer of splanchnotom, the coelomic epithelium of which forms the projections, the gonadal ridges, on the surface of the pronephros. It should be noted that before the second month of embryonic life the gonads are indifferent i. e. they are identical in both sexes. The germ cells (gonocytes) migrate to the rudiments of gonads from the region of yolk ectoderm.

The rudiment of gonad gradually separates from the pronephros. The urogenital fold is divided by the longitudinal groove into the gonadal fold, *plica genitalis*, located medially, and mesonephric fold, located laterally. The gonadal fold transforms into the

testis; the mesonephric fold gives rise to the Wolffian body, Wolffian duct and Mullerian duct.

During the third month of the development, if the embryo is a male, the cells of the coelomic epithelium penetrate the gonadal fold, forming the cords. The migrating germ cells, spermatogonia, are placed on the cells of the coelomic epithelium (sustentocytes). The surrounding mesenchyme forms the septa between the cords, mediastinum and tunica albuginea. The interstitial cells (of Leydig), situated in the mediastinum, start to intensively produce the male reproductive hormones, androgens, which control the development of other male reproductive organs. The ducts of the mesonephros become the excretory ducts of the testis. The Wolffian body transforms into the epididymis, the Wolffian duct develops into the deferent duct and seminal vesicles. During the fourth month the excretory ducts of the testis join the excretory ducts of the epididymis, and Mullerian ducts reduce.

The development of the external reproductive organs is closely associated with the development of the perineum (fig. 2.9). The cavity of the cloaca is divided by the urorectal septum, *septum urorectale*, into the ventral part, the urogenital sinus, *sinus urogenitalis*, and the dorsal part, the rectum. The urogenital sinus is continuous upwards with the urinary bladder.

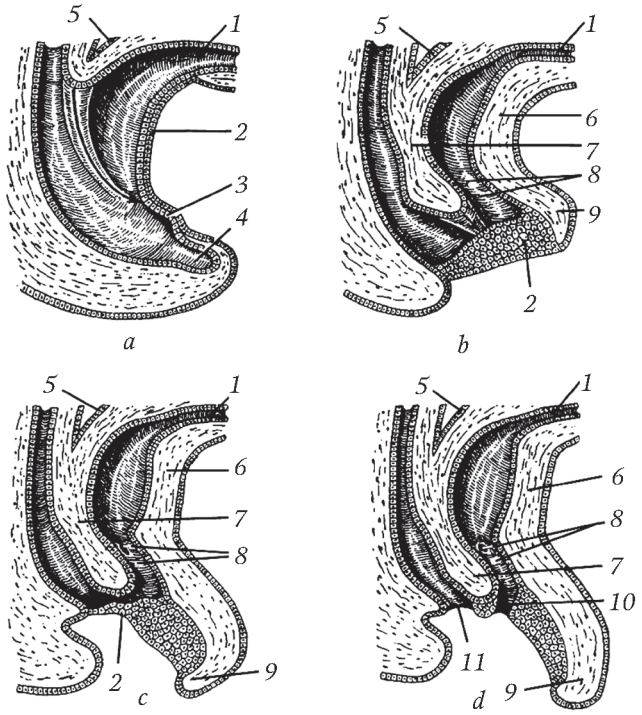


Fig. 2.9. Scheme of the development of the rectum and urinary bladder:

*a* — 2 weeks; *b* — 3 weeks; *c* — 5 weeks; *d* — 8 weeks;

*1* — urachus; *2* — cloacal membrane; *3* — the place of the disappearance of anal membrane; *4* — hindgut; *5* — peritoneum; *6* — anterior abdominal wall; *7* — urorectal septum; *8* — opening of Wolffian duct and urogenital sinus; *9* — genital tubercle; *10* — urogenital sinus; *11* — anus

The inferior edge of the urorectal septum reaches the cloacal membrane, *membrana cloacalis*, and thus divides it into two parts: anterior, urogenital, and posterior, anal. So, the urogenital sinus is closed anteriorly and inferiorly by the urogenital membrane, while the rectum is closed by the anal membrane. Further, the urogenital and anal membranes reduce (partially disappear) that leads to the formation of two independent openings: primary urogenital orifice, *ostium urogenitale primitivum*, and anus, *anus* (fig. 2.10).

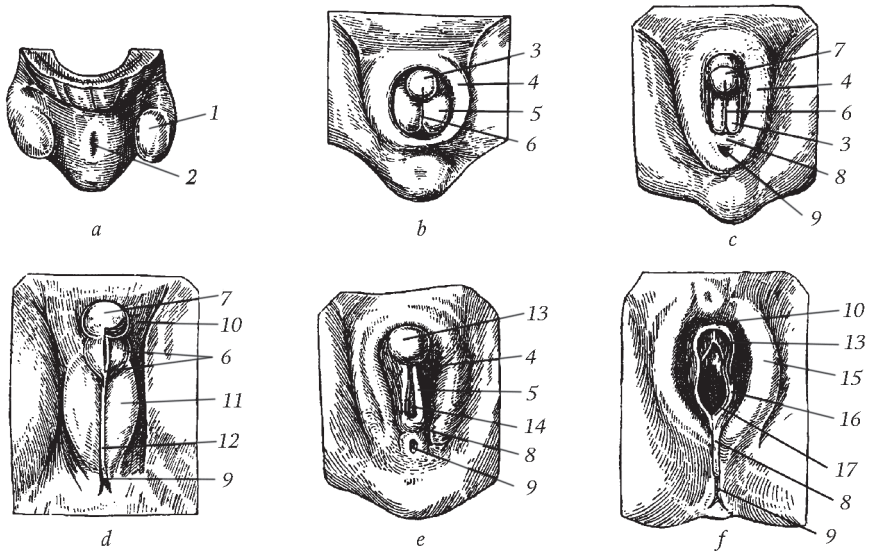


Fig. 2.10. Development of the external reproductive organs in embryos, male and female fetuses:
*a, b* — indifferent stage; *c, d* — development of male; *e, f* — development of female;
*1* — rudiment of lower limb; *2* — cloaca; *3* — genital tubercle; *4* — genital ridge; *5* — genital fold; *6* — cleft between genital folds; *7* — glans penis; *8* — perineum; *9* — anus; *10* — prepuce; *11* — scrotum; *12* — raphe of perineum and scrotum; *13* — clitoris; *14* — entrance to urogenital sinus; *15* — labium majus pudendi; *16* — labium minus pudendi; *17* — vaginal vestibule

The primary urogenital orifice is bounded anteriorly by the genital tubercle; laterally by the genital folds and labioscrotal (genital) swellings. The genital tubercle develops into the corpora cavernosa and glans penis; the genital folds give rise to the corpus cavernosum (except the glans); the labioscrotal swellings partially develop into the scrotum. When the indifferent stage of the development finishes, the mentioned sources in the female give rise to the clitoris, labia majora and minora pudendi. The origin of the reproductive organs from the indifferent sources in early stages of the development of embryo is shown in the table 2. The differentiation of the reproductive organs starts in the third month of the development. In male the genital tubercle intensively grows, and the urogenital sinus elongates. The primary urethral orifice transforms into the urethral groove located on the inferior side of the penis. This groove is bounded by the genital folds. During the fourth month the genital folds are gradually fused together along the midline, forming a long narrow urethra. The genital folds are fused from the base of the penis towards its free end. Then the prepuce starts to develop; later it is fused with

the glans. By the end of prenatal life the cells of the central layer of the prepuce start to degenerate and form slits between the glans and prepuce. The prepuce is completely separated from the glans only by 7—10 years of age. During the fifth month of the development in the site of the future corpora cavernosa the mesenchymal cells accumulate; later they become loose and form the cavernous tissue of the corpora cavernosa and corpus spongiosum.

The scrotum develops during the third month of pregnancy. The main role in its development plays an unpaired area of the perineum, situated between the root of the penis and anus. This area is complemented from the lateral sides by the labioscrotal swellings which are fused together. The place of the fusion remains as the scrotal raphe. By the end of the third month the scrotum represents the skin sac, into which later the testis with its coverings descends.

The prostate develops from the walls of the urogenital sinus. It appears as the numerous epithelial folds in the dorsal part of the urogenital sinus. Further the rudiments of the glandules grow into surrounding mesenchyme which differentiates partially into connective tissue, partially into muscular tissue. Finally the complex organ, consisting of the glands immersing into the muscular and connective tissues, is formed. The fusion of the rudiments of the urogenital sinus from the opposite sides occurs incompletely, keeping the lumen corresponding to the prostatic part of the urethra.

The bulbo-urethral glands develop as paired epithelial folds in the dorsal wall of the urogenital sinus, which grow into the aggregation of the mesenchyme. The latter gives rise to the perineal muscles.

*Table 2*

**The origin of the reproductive organs**

| Initial form | Male | Female |
|---|---|---|
| Indifferent reproductive gland | Testis | Ovary |
| Wolffian body | Epididymis | Epoophoron |
| Wolffian duct: | | |
| cranial part | Paradidymis | Paraophoron |
| caudal part | Deferent duct, seminal vesicle | |
| Mullerian ducts | Appendix testis, prostatic utriculus | Uterine tubes, uterus, vagina |
| Ligamentum gubernaculum | Ligamentum gubernaculum testis | Proper ovarian ligament, round ligament of uterus |
| Urogenital sinus | Prostatic part of urethra | Vaginal vestibule |
| Genital tubercle | Corpora cavernosa penis, glans penis | Clitoris |
| Genital folds | Corpus spongiosum penis | Labia minora pudendi |
| Genital ridge | Scrotum (partially) | Labia majora pudendi |

## 2.12. Descent of Testes

The process of the descent of the testis, *descensus testis*, is of great theoretical and practical interest because many developmental abnormalities are associated with it.

In embryonic life the rudiments of the testes are located in the retroperitoneal space and are represented by the genital folds. As mentioned above, during the first-second

months of the development the cranial end of the genital fold degenerates, while the caudal end grows. In 3-month old fetus the rudiment of the testis is at the level of the deep inguinal ring. The ligament called the gubernaculum testis is attached to the lower pole of the testis. It traverses the anterior abdominal wall, passing through the site of the future inguinal canal, and ends in the tissues of the scrotal bottom. The gubernaculum is a long fibro-muscular cord having two parts: cranial, fibro-muscular, and caudal, only fibrous. The first part is termed the gubernaculum proper. It extends from the rudiment of the testis to the level of the deep inguinal ring. The second part, considerably thickened, is called the scrotal ligament; it is fixed in the area of the deep inguinal ring.

The descent of the testis occurs because the gubernaculum does not grow in contrast to the growth of the fetus body. Firstly the growth of the caudal part of the gubernaculum, the scrotal ligament, stops. Due to this mechanism the fascial coverings of testis extend from the deep inguinal ring to the scrotum which is represented by the skin sac in this period. They pass throughout the inguinal canal and ultimately descend into the scrotum only by the end of the 7th month of pregnancy. The descended testicular coverings include: external spermatic fascia, cremasteric fascia, cremaster, internal spermatic fascia and processus vaginalis. It should be noted that the processus vaginalis communicates with the peritoneal cavity (fig. 2.11).

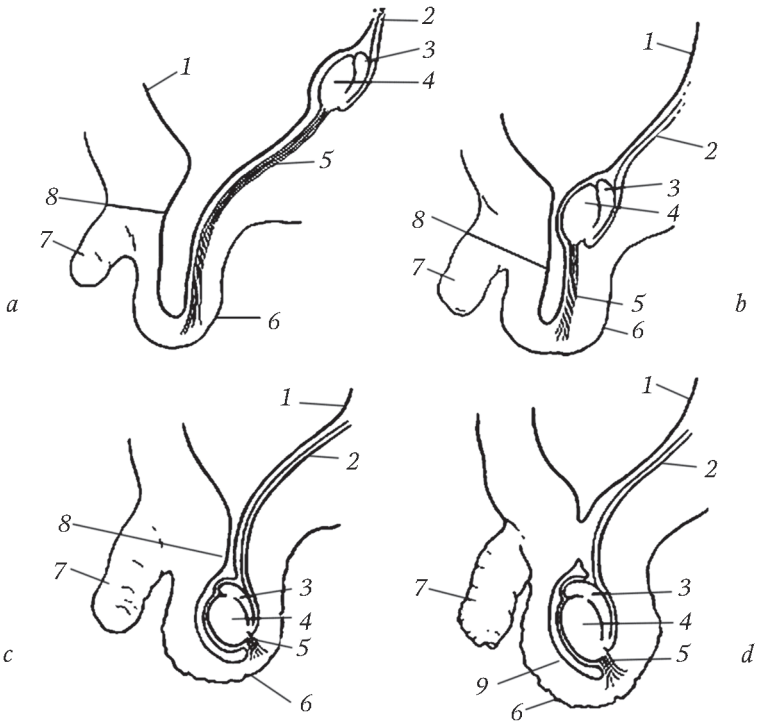


Fig. 2.11. Scheme of the descent of testis in stages:

*a* — 3 months; *b* — 7 months; *c* — 9 months; *d* — 2 months after birth;

*1* — peritoneum; *2* — deferent duct; *3* — epididymis; *4* — testis; *5* — ligamentum gubernaculums testis; *6* — scrotum; *7* — penis; *8* — processus vaginalis of peritoneum; *9* — tunica vaginalis of testis

At the end of the 7th or at the beginning of the 8th month of pregnancy the descent of the testis commences; it occurs due to the cessation of the growth of the proper gubernacilum of testis and the contraction of its smooth muscle elements. During the 8th month the testis passes through the inguinal canal. Only by the middle of the 9th month the testis descends into the scrotum ultimately.

In the scrotum the testis is behind the fascial coverings and processus vaginalis. The peritoneal fold, *mesorchium*, is attached to the posterior border of the testis. At the end of the 9th month the testis starts to penetrate into the processus vaginalis and adhere to it. The processus vaginalis forms two layers: inner, visceral, and outer, parietal. Outer layer is fused with the internal spermatic fascia, *fascia spermatica interna*. Between the visceral and parietal layers of the processus vaginalis a slit-like space, the serous cavity of the testis, remains throughout life; it contains a small amount of the serous fluid.

Shortly after birth the processus vaginalis is obliterated throughout the inguinal canal and spermatic cord and loses the connection with the peritoneal cavity. Only its lower part, forming the serous cavity of the testis, is not closed.

## 2.13. Developmental Abnormalities of Male Reproductive Organs

### *Developmental anomalies of testis*

1. Hypoplasia of testis, *hipoplasia testis*, which is accompanied first of all by the great decrease of the endocrine function. The amount of androgens is diminished that leads to the underdevelopment of the secondary sexual characteristics and external reproductive organs. In case of bilateral testicular hypoplasia eunochoidyzm occurs.

2. Retention of testis, *retentio testis*, is a failure of the testis descent, i. e. the testis does not reach the scrotum. The absence of one testis in the scrotum is called monorchism, *monorchismus*, of both testis — kryptorchism, *kryptorchismus*. Depending on the place of the stop of the testis, the following testicular positions are distinguished: abdominal retention, *retentio abdominalis*, when the testis stays in the abdominal cavity, exactly in the retroperitoneal space; inguinal retention, *retentio inguinalis*, when the testis stops in the inguinal canal; suprascrotal retention, *retentio suprascrotalis*, when the testis passes through the superficial inguinal ring but does not descend into the scrotum.

3. Ectopia of testis, *ectopia testis*, is an anomaly when the testis deviates from the usual course of the descent (located in the abdominal cavity, abdominal wall etc.).

4. Inversion of testis, *inversio testis*, is unusual position of the testis in the scrotum (superior pole is located inferiorly).

5. Synorchism, *synorchismus*, the merger of the rudiments of the right and left testes; usually is associated with the abdominal kryptorchism.

6. Polyorchism, *poliorchisnus*, the division of the rudiment of the testis resulting in the increase of the number of the testis more than two (3—4).

7. Congenital inguinal hernia, *hernia inguinalis congenita* (oblique inguinal hernia, *hernia inguinalis obliqua*), appears when the processus vaginalis is not closed. In case of the hernia formation the serous cavity which encloses the testis is freely communicated with the peritoneal cavity. Hence the parts of the viscera (intestine, omentum, urinary bladder) may descend into the serous cavity of the testis, and the serous fluid accumulates in it. Due to its genesis, the congenital inguinal hernia got one more name, the communicating hydrocele of testis.

8. Male false hermaphroditism, *hermaphroditismus spurius masculinus* (*seu externus*, *seu pseudohermaphroditismus*), the presence of both sexes, when the male genital organs have some similarities to the female organs. As usual it is combined with testicular hypoplasia and kryptorchism. An underdeveloped penis looks like a clitoris; a deformed bifurcated scrotum is like labia majora pudendi; a cleft at the root of the penis is like the vestibule of the vagina.

9. True hermaphroditism, *hermaphroditismus verus*, is the presence of the reproductive glands of both sexes. This abnormality has been established only in some cases. The development of the external genital organs may be combined differently, depending on the prevalence of the hormonal activity of male or female reproductive gland.

## Developmental anomalies of spermatic cord and seminal vesicle

1. Atresia of spermatic cord.
2. Hypoplasia of seminal vesicles.
3. Duplication of spermatic cord.
4. Cysts of seminal vesicle.
5. Cysts of spermatic cord, *hydrocele funiculi spermatici*, are the formation of the closed cavities in the connective tissue of the spermatic cord, which are lined by the serous membrane and filled with the serous fluid.

The development of such cysts is caused by the partial closure of the processus vaginalis.

## Anomalies of penis

1. Micropenis, *micropenia*, is a short penis (during erection its length does not exceed 6 cm). This anomaly is usually combined with hypoplasia of testes.

2. Macropenis, *macropenia*, is a long penis (in erectile condition its length is more than 25 cm).

3. Phimosis, *phimosis*, is an abnormality when the opening of the prepuce is narrow; because of this, the glans penis is closed, and it is impossible to open it. —Such a condition is normal in children before 3—9 years, when the prepuce is adhered to the glans by loose connective tissue. In middle degree of phimosis, when the prepuce is rolled over the glans penis, the strangulation of the glans in the area of the corona glandis may occur (paraphimosis); the strangulation is accompanied by an abrupt swelling of the glans and its further necrosis.

4. Deformation of penis.

## Developmental anomalies of male urethra

1. Epispadias, *epispadia*, is the cleft of the urethra from the superior (anterior) side of the penis, which appears because the corpora cavernosa are not fused. Depending on the localization of the cleft the following forms of epispadias are distinguished: pubic, penopubic, penile and glanular.

2. Hypospadias, *hypospadia*, is the cleft of the urethra, which appears because the genital folds are not fused. This abnormality is quite often observed. In the mildest form of hypospadias, the penis is normally developed but the external urethral orifice is larger than in normal (reaches the frenulum). Such a form of hypospadias is termed *hypospadia glandis*. The cleft may continue to the body of the penis (*hypospadia penis*). The extreme form of hypospadias is *hypospadia perinealis* when the penis is rudimentary, the urethra is absolutely not formed and the external urethral orifice is located closely to the root

of the penis. In these cases the scrotum is usually divided by a deep groove into two symmetric halves. Thus, hypospadias may be glanular, penile and perineal.

3. Duplication of urethra. The double urethra may open on the glans penis by two orifices; both canals are contained in the corpus spongiosus. More often the additional urethra has a blind end and smaller lumen.

4. Congenital constrictions of the urethra. Usually they occur at the junctions of three rudiments of the urethra with each other: posterior (prostatic-membranous), middle (flaccid urethra) and anterior (in glans penis). More often the constrictions are observed in the external urethral orifice.

5. Diverticula of urethra are the outpouchings of the urethral wall (more often the lower wall).

### *Developmental Anomalies of scrotum*

1. Splitting of scrotum.
2. Fusion of the scrotum to the penis.
3. Cysts and canals along the perineal raphe.
4. Asymmetric scrotum.

## TEST QUESTIONS

1. List the male reproductive organs.
2. Which of the male reproductive organs belong to the external organs?
3. Which of the male reproductive organs belong to the internal organs?
4. What is the function of the testis? What are the sizes of the testis? Where are testes located?
5. What borders, surfaces, poles of the testis do you know? How will you differentiate the anatomical preparation of the right testis from the left one?
6. Name the coverings of the testis in order. Describe the origin of each testicular covering.
7. Describe the structure of the testis lobule. How many lobules are there in the testis?
8. Where are spermatozoa produced?
9. Describe the pathway of the sperm, beginning from the convoluted seminiferous tubules up to the prostatic part of the urethra.
10. What is the spermatic cord? Name it components and coverings.
11. Describe the localization of the spermatic cord.
12. What is the function of the deferent duct?
13. What is the length of the deferent duct?
14. Describe the layers of the deferent duct`s wall.
15. Where does the deferent duct start and open?
16. What parts of the deferent duct do you know?
17. How is the ejaculatory duct formed?
18. What is the function of the seminal vesicles? What are their sizes? Describe their localization and syntopy.
19. What is the function of the prostate? What is its size? Describe its localization and syntopy.
20. What is the function of the bulbo-urethral glands? Describe their localization.
21. What parts of the penis are distinguished?
22. How does the penis fix to the body?

23. What part of the penis includes urethra?
24. Describe the structure and physiology of the cavernous bodies.
25. List the parts of the male urethra. Describe the localization and structure of each part. Describe the structure of the wall of the urethra.
26. Describe the sphincters of the male urethra. Which of them are voluntary (involuntary)?
27. Describe the development of the male reproductive organs.
28. Describe the descent of the testes. Which mechanisms contribute to the descent of testes?
29. What developmental anomalies of the male reproductive organs do you know?

## CLINICOANATOMICAL PROBLEMS

A patient has a congenital oblique inguinal hernia because the processus vaginalis of the peritoneum was not fused. In upright position of the body the serous fluid accumulates between the testicular coverings. Where does this fluid accumulate?

After the inflammation of the testis the production of spermatozoa ceased. Which structures of the testis were damaged?

60-years-old man complains of the delay of urination (urine is extruded by drops). The adenoma of the prostate is supposed. What part of the urethra is obstructed? What is the length of the obstruction?

A doctor has to evacuate urine with the help of the metallic catheter. What part of the urethra can be damaged in case of the careless insertion of the catheter? Which curves of the urethra should the doctor take into account during catheterization?

# 3. FEMALE REPRODUCTIVE SYSTEM

the female reproductive organs, *organa genitalia feminina*, carry out the reproductive and endocrine functions. The reproductive function includes: the maturation of oocytes; the creation of the conditions for fertilization of ova and the implantation of blastocyst; pregnancy and parturition. The endocrine part of the female reproductive system controls the development of the female reproductive organs, the formation of the secondary sexual characteristics and gender-specific behavior. According to the position, the female reproductive organs are divided into internal and external.

I. Internal female reproductive organs, *organa genitalia feminina interna*: ovaries, *ovaria*; uterus, *uterus*; uterine tubes, *tubae uterinae*; vagina, *vagina*.

II. External female reproductive organs, *organa genitalia feminina externa*: mons pubis, *mons pubis*; labia majora pudendi, *labia majora pudendi*; labia minora pudendi, *labia minora pudendi*; greater vestibular glands, *glandulae vestibulares majores*; bulb of vestibule, *bulbus vestibuli*; clitoris, *clitoris*; hymen, *hymen*.

## 3.1. Ovary

The ovary, *ovarium* (in Greek *oophoron*), is a paired female reproductive gland situated in the lesser pelvis (fig. 3.1—3.3). In the ovaries oocytes develop and mature. Also the ovaries secrete the female hormones into blood and lymph.

**External structure of ovary.** By the puberty the ovary takes the form of a flattened ellipsoid having the following sizes: the length is 3—5 cm, the breadth is 1,5—3 cm, the thickness is 0,7—1,5 cm; the weight is 5—6 g. The surface of the ovary is matte, pinkish-white, convex, with the depressions and scars. At 35—40 years the ovaries start to decrease regardless of whether a woman has given birth or not. By 50 years menstruation stops and the ovaries atrophy: they shrivel, decrease almost by two times, become denser because the follicles are replaced by connective-tissue. The ovary has two surfaces, two borders and two ends (extremities). Both surfaces are free. The medial surface, *facies medialis*, faces the uterus, while the lateral surface, *facies lateralis*, adjoins the wall of the lesser pelvis. The surfaces of the ovary are separated by two borders. One of them, the free border, *margo liber*, is convex; the other, mesovarian border, *margo mesovaricus*, is straight, directed backwards and is fused with the posterior layer of the uterine broad ligament. The mesovarian border has a depression called the hilum, *hilum ovarii*, through which the vessels and nerves pass into the ovary. The superior end of the ovary is termed the tubal extremity, *extremitas tubaria*, because it adjoins the uterine tube. The inferior, sharper, end, the uterine extremity, *extremitas uterina*, is connected to the uterus by the proper ovarian ligament, *ligamentum ovarii proprium*.

**Anatomico-topographical position of ovary.** The ovary occupies the ovarian fossa, *fossa ovarica*, situated on the lateral pelvic wall, at the place of the bifurcation of the common iliac artery. The floor of the fossa is formed by the obturator internus covered by the pelvic fascia and the parietal peritoneum; under the parietal peritoneum is the layer of fat. The superior extremity of the ovary is below the pelvic inlet; the lateral surface contacts the parietal layer of the peritoneum, lining the ovarian fossa. In nulliparous women the long axis of the ovary is almost vertical. In parous women the ligamental apparatus of the uterus and of the ovaries is overstretched, and the ovaries lie horizontally.

**Ligamental apparatus of ovary.** The ovary has two ligaments (fig. 3.2): the suspensory ligament, *ligamentum suspensorium ovarii*, and the proper ligament, *ligamentum ovarii proprium*. The ovarian suspensory ligament is a peritoneal fold arising at the level

of the pelvic inlet and descending to the tubal extremity of the ovary. It contains the ovarian vessels and nerves.

The proper ovarian ligament is a rounded cord, 3—5 mm thick, passing in the broad ligament of the uterus (fig. 3.3). It connects the uterine extremity of the ovary to the fundus of the uterus; it is attached below the entrance of the uterine tube. This ligament is of great importance because it contains the ovarian nerves and vessels which anastomose with the uterine vessels; also it contains dense connective tissue and smooth muscle fibers, due to which the ligament is able to change its length and tension.

The ovary is fixed by a short mesentery, *mesovarium*, which represents a peritoneal fold passing from the posterior layer of the uterine broad ligament to the mesovarian border of the ovary. The ovaries are rather mobile organs therefore may change the position according to the state of the uterus.

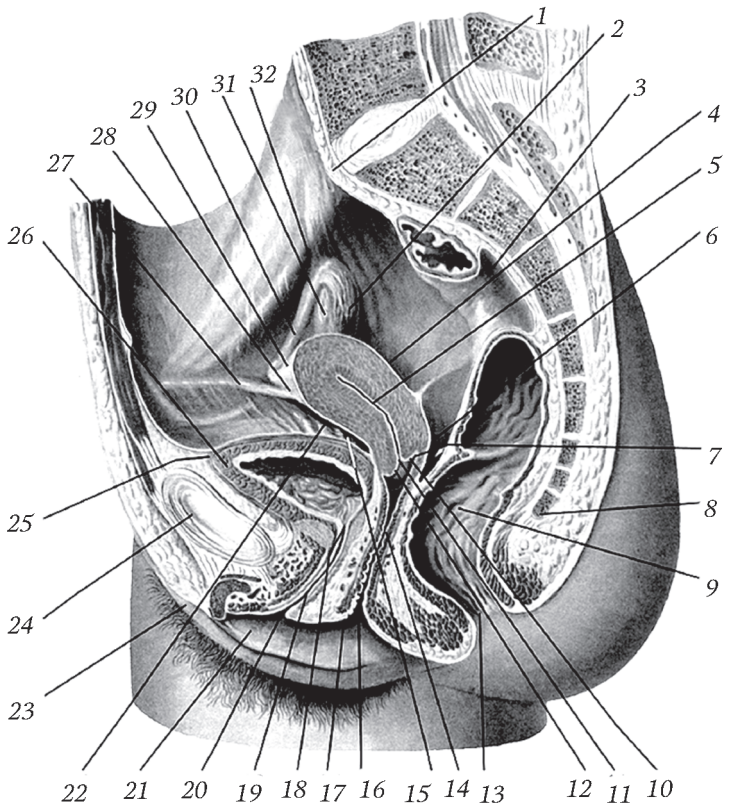


Fig. 3.1. Median section of female pelvis:

*1* — promontorium; *2* — fimbriae of uterine tube; *3* — parietal peritoneum; *4* — body of uterus (intestinal surface); *5* — uterine cavity; *6* — rectouterine pouch; *7* — posterior part of vaginal fornix; *8* — coccyx; *9* — rectum; *10* — posterior lip of uterine cervix; *11* — uterine orifice; *12* — anterior lip of uterine cervix; *13* — anus; *14* — vagina; *15* — vesicouterine pouch; *16* — hymen; *17* — vaginal orifice; *18* — internal urethral orifice; *19* — urethra; *20* — external urethral orifice; *21* — labium minus pudendi; *22* — body of uterus (vesical surface); *23* — labium majus pudendi; *24* — pubic symphysis; *25* — median umbilical ligament; *26* — apex of urinary bladder; *27* — round ligament of uterus; *28* — fundus of uterus; *29* — ampulla of uterine tube; *30* — ovary; *31* — external iliac vein; *32* — suspensory ligament of ovary

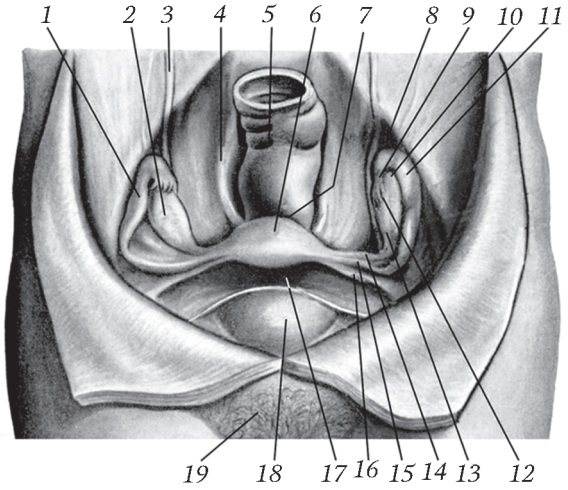


Fig. 3.2. Female pelvis (superior aspect):

*1* — uterine tube; *2* — ovary; *3* — ureter; *4* — rectouterine fold; *5* — rectum; *6* — uterus; *7* — rectouterine pouch; *8* — suspensory ligament of ovary; *9* — fimbriae of uterine tube; *10* — tubal extremity of ovary; *11* — ampulla of uterine tube; *12* — free border of ovary; *13* — uterine extremity of ovary; *14* — proper ovarian ligament; *15* — isthmus of uterine tube; *16* — round ligament of uterus; *17* — vesicouterine pouch; *18* — urinary bladder; *19* — mons pubis

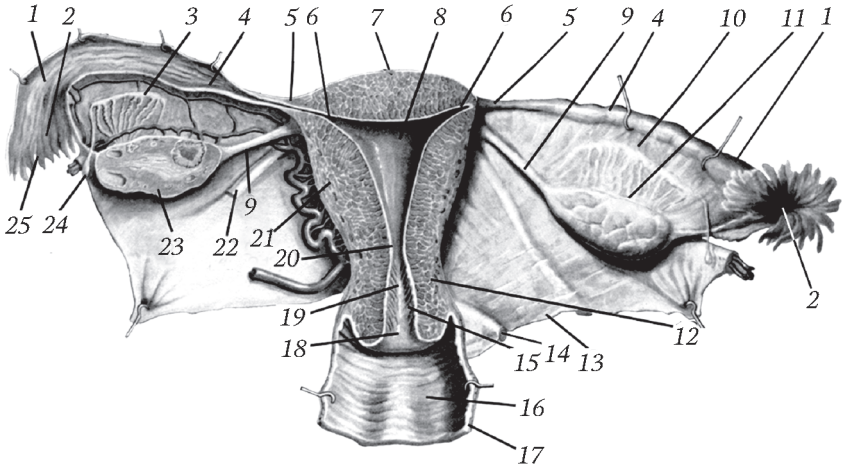


Fig. 3.3. Frontal section of internal female reproductive organs (posterior aspect):

*1* — ampulla of uterine tube; *2* — section of abdominal orifice of uterine tube; *3* — epoophoron; *4* — uterine tube; *5* — isthmus of uterine tube; *6* — uterine orifice of uterine tube; *7* — fundus of uterus; *8* — uterine cavity; *9* — proper ovarian ligament; *10* — mesosalpinx; *11* — mesovarium; *12* — cervix of uterus; *13* — broad ligament of uterus; *14* — cardinal ligament of uterus; *15* — palmate folds; *16* — vaginal rugae; *17* — vagina; *18* — uterine orifice; *19, 20* — cervical canal; *21* — body of uterus; *22* — round ligament of uterus; *23* — ovary; *24* — vesicular appendices; *25* — fimbriae of uterine tube

**Internal structure of ovary.** The surface of the ovary is covered by a layer of cuboidal cells (peritoneal mesothelium) therefore, it is not like the surface of an intraperitoneal organ: it is matte, contrasting with the shining peritoneum. Such a position of the organ is called *intra cavum peritonei*. The transition between the peritoneal covering of the mesovarium and ovarian epithelium is marked by a white line around the mesovarian border. Under the epithelium there is a connective tissue coat of the ovary, the tunica albuginea.

The connective tissue of the ovarian parenchyma forms its stroma, *stroma ovarii*, which is rich in elastic fibers. The parenchyma consists of two layers: outer, the cortical stroma, *cortex ovarii*, and inner, situated closer to the ovarian hilum, the medullary stroma, *medulla ovarii*. The cortex is denser, contains the ovarian follicles surrounded by connective tissue. The primordial, primary, secondary, tertiary and mature follicles are observed in the ovary.

In childhood the primordial and primary ovarian follicles prevail; their number is 400—500 thousands, but further the most of them atrophy, not reaching the full development. Only several hundreds of oocytes mature and become fertile (400—500 for the entire reproductive period). In adult the ovaries contain the follicles of different stages of the development. At old age the ovarian parenchyma undergoes involution and becomes sclerotic.

The primordial ovarian follicles, *folliculi ovarici primordiales*, consist of a central oogonium surrounded by a single layer of flat follicular cells. These follicles numerically prevail at all ages, disappearing only in postmenopausal period. The primary ovarian follicles, *folliculi ovarici primarii*, consist of a primary oocyte surrounded by a layer of prismatic follicular cells (compared to the primordial follicle, its volume is increased due to ooplasma). In these follicles the pellucid zone appears for the first time; these follicles are immature and exist before puberty and also at reproductive age. The secondary ovarian follicles, *folliculi ovarici secundarii*, contain a primary oocyte surrounded by a multilayered coat of the follicular cells, many of which divide mitotically. The division of the follicular cells occurs only when puberty begins and is stimulated by follicle-stimulating hormone. The tertiary (vesicular) ovarian follicles, *folliculi ovarici tertii* (*vesiculosi*), develop from the secondary follicles, in which a cavity is formed. This cavity occupies the major volume of the tertiary follicle; it contains a viscous liquid, which is rich in estrogens. The tertiary follicles are located peripherally, under the mesothelium. They increase in diameter up to 1 cm and rise above the ovarian surface.

A mature ovarian follicle is about 1 cm in diameter and has a connective tissue covering termed *theca folliculi*; this consists of an outer tunica externa, *theca externa*, composed of dense connective tissue, and an inner tunica interna, *theca interna*, containing a lot of blood and lymphatic capillaries and interstitial cells. Immediately deep to the tunica interna is the membrana granulosa, *stratum granulosum*. In the certain place the membrana granulosa thickens to form the cumulus ovaricus, *cumulus oophorus*, which contains oocyte. Inside a mature follicle there is a cavity containing the follicular liquor, *liquor follicularis*. The oocyte, surrounded by the pellucid zone, *zona pellucida*, and by the corona radiate, formed by the follicular cells, is located in the cumulus ovaricus (fig. 3.4). During the development, the follicle gradually reaches the ovarian surface. During each menstrual cycle (which lasts about 25—28 days), usually one follicle matures. The follicle ruptures, and the oocyte with the follicular liquor passes into the peritoneal cavity and then into the uterine orifice of the uterine tube. The release of the oocyte from the ovary is called the ovulation. When the follicular liquor together with oocyte and the cells of the follicular epithelium pours out from the vesicle, the cavity of the vesicle is decreased, the walls collapse and fold, and

the rest of its inner space is filled with the surviving cells of the follicular epithelium. From the tunica interna of the theca folliculi, the blood vessels grow into the empty follicle. Thus, the Graafian vesicle transforms into the corpus luteum. If fertilization does not occur, the corpus luteum has small sizes (from 1,0 to 1,5 mm), exists for a short time and called the corpus luteum of menstruation, *corpus luteum ciclicum (menstruationis)*. If fertilization occurs, the corpus luteum of pregnancy, *corpus luteum graviditatis*, develops. The size of the corpus luteum of pregnancy may reach 1,5—2,0 cm. It exists during the entire pregnancy and secrets the hormones.

When a new menstrual circle begins, the corpus luteum degenerates into the corpus atreticum. Fibrous tissue replaces its cells to transform the corpus atreticum into a scar, the corpus albicans, i. e. in the site of ovulation, the connective tissue scar remains; the scars look like depressions and folds on the surface of the ovary.

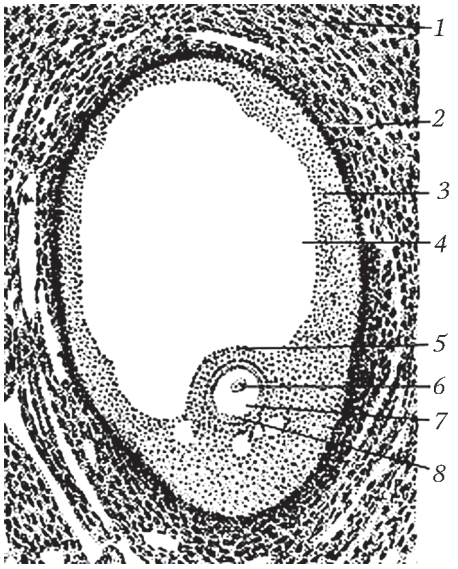


Fig. 3.4. Structure of Graafian follicle:
*1* — ovarian stroma; *2* — theca folliculi; *3* — stratum granulosum; *4* — liquor folliculi; *5* — cumulus oophorus; *6* — nucleus; *7* — ovum; *8* — zona pellucida

## 3.2. Vestigial Structures of Ovary

Near each ovary the vestigial structures are situated: epoophoron, *epoophoron*, paraoophoron, *paroophoron*, and vesicular appendices, *appendices vesiculosae*, the remnants of the Wolffian body and Wolffian duct.

The epoophoron, 2—3 cm in length and 1,5—2 cm in breadth, lies in the lateral part of the mesosalpinx. It is a flat structure consisting of several thin, slightly convoluted transverse ductules, *ductuli transversi*. Their blind ends approach the ovarian hilum, while the other ends, directed to the uterine tube, open into the longitudinal duct of epoophoron, *ductus epoophori longitudinalis*.

The paraoophoron, *paroophoron*, is a very small structure, also lying in the mesosalpinx, near the uterine end of the ovary. The paraoophoron is composed of several separate blind tubules.

The vesicular appendices, *appendices vesiculosae*, are the vesicles, which contain a transparent fluid. The vesicular appendices are lateral to the ovaries, below the infundibulum of the uterine tube.

## 3.3. Uterus

The uterus, *uterus* (in Greek *metra*, *hystera*), is an unpaired hollow muscular organ. The fertilized ovum passes into the uterus; here embryo develops and fetus is carried; during parturition due to the contraction of the uterine musculature the fetus is pushed out. The uterus is situated in the middle of the pelvic cavity between the urinary bladder and the rectum (fig. 3.1, 3.2).

**External structure of uterus.** The uterus is pear-shaped and is flattened from front to back. It has a fundus, body and cervix (fig. 3.3). The fundus, *fundus uteri*, is the upper convex part of the uterus, protruding above the entry-points of the uterine tubes. The body, *corpus uteri*, cone-shaped, is the middle, largest part of the uterus. The lower, smallest part of the organ is the cervix, *cervix uteri*, consists of two parts: 1 — inferior, projecting into the vaginal cavity, called the vaginal part, *portio vaginalis cervicis*; 2 — superior, situated above the vagina, called the supravaginal part, *portio supravaginalis cervicis*. The place where the body of the uterus narrows into the cervix is named the isthmus, *isthmus uteri*. On the vaginal part the uterine orifice, known as the external os, *ostium uteri*, is visible; it leads into the cervical canal, *canalis cervicis uteri*, and further into the uterine cavity. In nulliparous state the external os is rounded or oval, while in parous state it has the shape of a transverse slit bounded by the anterior lip, *labium anterius*, and posterior lip, *labium posterius*. The uterus has two surfaces. The anterior surface, directed to the urinary bladder, is called the vesical surface, *facies vesicalis*, while the posterior, directed to the rectum, is called the intestinal surface, *facies intestinalis*. The surfaces are separated by two borders, the right and the left, *margo uteri dexter et margo uteri sinister*. At the site where the borders are continuous with the fundus the uterine tubes traverse the uterine wall. The uterine tubes together with the round uterine ligament and the proper ovarian ligament are enclosed in the peritoneal fold termed the broad ligament of the uterus.

The uterus varies in size and weight. In an adult female the length of the uterus is about 7—8 cm, the breadth is 4 cm, the thickness is 2—3 cm. The weight of the uterus in a nulliparous woman is about 40—50 g; in a parous woman is about 80—100 g. The volume of the uterine cavity is 4—6 cm3.

**Internal structure of the uterus.** The uterine wall is thick (from 1 to 1,5 cm). On the frontal section the uterine cavity, *cavitas uteri*, has the shape of a triangle with the base directed to the uterine fundus and the apex directed down, to the uterine cervix. The uterine cavity is continuous with the cervical canal, *canalis cervicis uteri.*

The uterine wall consists of three layers: 1 — mucous layer, *tunica mucosa*, or endometrium, *endometrium*; 2 — muscular layer, *tunica muscularis*, or myometrium, *myometrium*; 3 — serous layer, *tunica serosa*, or perimetrium, *perimetrium*.

The mucosa, *tunica mucosa (endometrium)*, lines the uterine cavity from inside. The thickness of the mucosa in the uterine body is about 1—1,5 mm, in the cervix it is thicker, 2—3 mm. The surface of the mucosa is smooth, and only in the cervix it has one longitudinal fold and smaller palmate folds, *plicae palmatae*, arising from the longitudinal fold at a sharp angle and running from it to both sides. The palmate folds, being present on the anterior and posterior walls of the cervical canal, are in contact with each other that prevents the passage of the vaginal content into the uterine cavity.

The mucosa lining the uterine cavity in the body and fundus is covered by the columnar epithelium and has a proper lamina connecting with the myometrium. This mucosa contains many simple tubular uterine glands, *glandulae uterinae*, opening on the surface of the epithelium. The deepest parts of the glands reach the myometrium. The endometrium consists of two layers: the superficial thick layer called the functional layer, and the deeper basal layer. During menstruation the functional layer is detached almost entirely, while the basal layer does not change considerably because it is the foundation, from which the functional layer develops. The epithelium of the cervical canal contains many cells producing the mucosa. Near the external os, the epithelium is displaced by non-keratinized stratified squamous epithelium which lines the free surface of the uterine cervix, projecting into the vaginal cavity. The submucous layer is absent in the uterine wall.

The muscular layer, *tunica muscularis (myometrium)*, forms most of the uterine wall. The myometrium consists of the interwoven smooth muscle fascicles separated by connective tissue. According to the predominant direction, the muscular fascicles of the myometrium are divided into three layers. The external and internal layers are thin and composed of mainly longitudinal and oblique fibers. The middle, circular, layer is the thickest and especially well-developed in the cervix. The middle layer is also called the vascular layer, *stratum vasculosum*, because the large vessels pass here.

The serosa, *tunica serosa (perimetrium)*, is a visceral peritoneum covering the uterus. It is firmly fused with the myometrium. The subserous layer, *tela subserosa*, is present only in the uterine cervix and along the borders of the uterine body, where the peritoneal covering of the uterus is continuous with the right and left broad ligaments. On the sides of the uterine isthmus and the body, between the layers of the broad ligament there is loose connective tissue termed the parametrium, *parametrium*, containing a well-developed venous plexus.

**Relation of uterus to peritoneum.** The most part of the uterus is covered by the peritoneum from three sides (mesoperitonaeally). The vaginal part of the cervix, the anterior surface of the supravaginal part and also the right and left borders of the uterine body are free from the peritoneal covering. The peritoneum, which covers the posterior surface of the uterus, reaches the posterior wall of the vagina and then ascends to cover the anterior wall of the rectum. Thus, between the rectum and uterus a depression, termed the rectouterine pouch (of Douglas), is formed. On the right and on the left the Douglas pouch is limited by the rectouterine peritoneal folds running from the uterine cervix to the rectum. Each rectouterine fold contains the rectouterine muscle, *m. rectouterinus*, and the fibrous fascicles. The muscle arises from the posterior surface of the uterine cervix, passes in the mentioned folds lateral to the rectum and is attached to the periosteum of the sacrum. The peritoneum, which covers the vesical surface of the uterus, reaches the supravaginal part of the cervix and then reflexes on to the urinary bladder to form the vesicouterine pouch, *excavatio vesicouterina*, less deep then the Douglas pouch.

**Ligaments of uterus.** The visceral layers of the peritoneum, that cover the vesical and intestinal surfaces of the uterus, converge along the uterine borders, forming the broad ligaments of the uterus. The broad ligament, *ligamentum latum uteri*, is a double layer of the peritoneum; it plays the role of a mesentery because between its layers the vessels and nerves surrounded by connective tissue pass. The broad ligament has the shape of an irregular quadrangle arranged in the frontal plane. Its medial border reaches the uterus where is continuous with the perimetrium. Almost at a right angle the medial border of the ligament is continuous upwards with a free upper border which encloses the uterine tube. Below, the layers of the broad ligament diverge and prolong to the peritoneal peritoneum of the lesser pelvis. The lateral border of the broad ligament is attached to the lateral pelvic wall along the internal iliac artery. The broad ligament lies in the pelvis freely and easily follows each movement of the uterus.

Besides the uterine tube, the broad ligament encloses the proper ovarian ligament and the round ligament of the uterus; they arise a little below the uterine tube. The ovary is fused with the posterior surface of the broad ligament. The broad ligament can be functionally divided into three parts: 1 — the mesosalpinx (the uppermost part), which is limited below by the ovary and the proper ovarian ligament, and above by the uterine tube; the mesosalpinx encloses the epoophoron, paroophoron and vesicular appendices; 2 — the mesovarium (the part of the posterior layer, which continues to the mesovarian border of the ovary); 3 — the mesometrium (the uterine mesentery proper, which forms

the most part of the broad ligament). The structure and strength of the parts of the broad ligament are different: between the layers of the mesosalpinx and mesovarium the connective tissue is almost absent; the mesometrium contains cellular connective tissue (parametrium), more expressed in front of and on the sides of the uterine isthmus. The parametrium is gradually continuous with the paracervical connective tissue, paracervix, and with the connective tissue of the neighboring regions: anteriorly it is continuous with the paravesical connective tissue, posteriorly with the pararectal connective tissue and inferiorly with the connective tissue surrounding the vagina. The connective tissue of these areas is a potential site of pathological processes.

The round ligament of the uterus, *ligamentum teres uteri*, arises from the lateral border of the uterus, below the uterine tubes. Firstly it lies almost horizontally between the layers of the broad ligament, rising it anterior layer. Further it descends forward and, turning up, reaches the lateral pelvic wall; it then runs along the pelvic wall forwards and laterally across the obturator vessels and nerve, median umbilical ligament and external iliac vein and enters the deep inguinal ring. In the inguinal canal the round ligament contains thin striated muscle fascicles (the homologue of the cremaster) arising from the obliquus abdominis internus and transversus abdominis. After leaving the superficial inguinal ring the round ligament divides into the separate fibrous bundles, which end in the labium majus pudendi. The total length of the ligament is 12—14 cm. After childbirth the thickness and length of the ligament increase.

The cardinal uterine ligament, *ligamentum cardinale uteri*, is a paired ligament situated in the bases of the broad ligaments in the frontal plane; this is a fibrous cord containing smooth muscle fibers, which stretches between the uterine cervix and the lateral pelvic wall. The lower edge of the ligament is continuous with the proper pelvic fascia thus plays a part in stabilizing the uterus, preventing its lateral displacements.

**Position and fixation of uterus.** The position of the uterus in the lesser pelvis depends on the distension of the urinary bladder and rectum. In the upright position and empty neighboring organs the long axis of the uterus is bent forwards, forming an angle called anteflexio, *anteflexio uteri*. The whole uterus is turned anteriorly or anteverted, *anteversio uteri*. The uterine fundus adjoins the urinary bladder. The rectouterine pouch situated behind the uterus is filled with the small amount of the serous fluid. The main mechanisms providing the normal position of the uterus are: 1 — the structural features of the perimetrium: it contains a lot of the elastic fibers and firmly fused with the myometrium; 2 — the presence of the ligamental apparatus (the paired round ligament provides the bend of the uterus forwards; the paired cardinal ligament prevents the lateral displacements); 3 — the connection of the uterus with the vagina and the perineal tissues; 4 — the fixation of the uterus to the rectum by means of the rectouterine ligaments and muscles; 5 — the fusion of the uterine cervix with the urinary bladder by means of the fibrous tissue, the vesicocervical ligament. However, the uterine body may change the position relatively to the cervix, and the whole uterus is also moveable. Occasionally, the uterus may be bent backwards (*retroversio uteri*) or curved backwards (*retroflexio uteri*).

**Age changes of uterus.** In newborns the uterus, as well as the urinary bladder, is situated highly in the lesser pelvis. Its body is rudimentary, while the cervix is rather well-developed. Before 9—10 years of age the uterus almost does not change. By the puberty the length of the uterine body is almost equal to the length of the cervix; the vaginal part of the cervix becomes longer. The uterus of an adult nulliparous woman does not differ from the uterus of a girl. The uterus of a parous woman is larger than the uterus of a nulliparous woman and has a larger cavity; in nulliparous state the uterine

cavity is triangular and in parous state it is oval. After childbirth the external os looks like a transverse slit dividing the cervix into the lips which may have tears. In menopause the uterus undergoes involution: it decreases in sizes (especially the cervix atrophies), the uterine walls become thinner and the uterine glands reduce.

**Functional changes in uterus.** During the menstrual cycle the endometrium undergoes the functional changes. In each cycle, which lasts about 25—28 days, the endometrium passes through the following phases: menstrual, postmenstrual and premenstrual.

The menstrual phase (phase of desquamation) occurs, if ovum is not fertilized. In this phase the superficial layer of the endometrium is shed that is marked by a discharge of blood from the uterus through the vagina. The menstrual phase lasts 3—5 days. The first day corresponds to the death of the corpus luteum in the ovary and to the beginning of the maturation of a new follicle. The postmenstrual phase (phase of proliferation) lasts 11—18 days. The growth (proliferation) of the endometrium is stimulated by oestrogen which is secreted by the ovaries, while a new follicle is maturing in the ovary. The beginning of the premenstrual phase (phase of secretion) (2—3 days) is described as the period of relative rest, the start of the development of the corpus luteum. Further growth of the endometrium and preparing of the endometrium to the embedding of a blastocyst is controlled by progesterone, secreted by the corpus luteum.

If oocyte fertilized, a blastocyst forms; it embeds in the uterine mucosa. During pregnancy the sizes of the uterus increase due to the hypertrophy of the myometrium, and the form of the uterus is changed (it becomes ovoid). After parturition the uterus returns almost to its former condition.

## 3.4. Uterine tube

The uterine (Fallopian) tube, *tuba uterina* (in Greek *salpinx*), is a paired hollow organ, which carries ovum from the ovary into the uterine cavity. The length of the uterine tube is about 10—12 cm, the lumen is from 2 to 4 mm. The uterine tubes lie in the lesser pelvis, being enclosed in the upper borders of the broad ligaments. At the commencement the tube passes horizontally, then it ascends along the mesovarian border, archs over the ovary and ends near the ovary`s medial surface. The uterine tube is divided into the following parts: 1 — the uterine part, *pars uterina*, is the intramural part, enclosed in the uterine wall; 2 — the isthmus, *isthmus tubae uterinae*, is the narrowest, shortest and thick-walled part located near the uterus; 3 — the ampulla, *ampulla tubae uterinae*, is next to the isthmus, the longest and expanded part, whose length is about 8 cm and the lumen is 4—6 mm; 4 — the infundibulum, *infundibulum tubae uterinae*, is an expansion of the uterine tube, situated after the ampulla. The circumference of the infundibulum is prolonged by the fimbriae, *fimbriae tubae uterinae*. One of them, termed the ovarian fimbria, *fimbria ovarica*, is longer than the others (2—3 cm) and reaches the ovary. The fimbriae direct the ovum from the peritoneal cavity into the infundibulum of the uterine tube. Within the floor of the infundibulum there is an abdominal ostium of the uterine tube, *ostium abdominale tubae uterinae*, which communicates the lumen of the uterine tube with the peritoneal cavity. Moving through the lumen of the utrine tube, the ovum passes into the uterine cavity through the uterine ostium of the uterine tube, *ostium uterinum tubae uterinae*.

**Structure of wall of uterine tube.** The wall of the uterine tube is composed of three layers: mucous, muscular and serous (fig. 3.5).

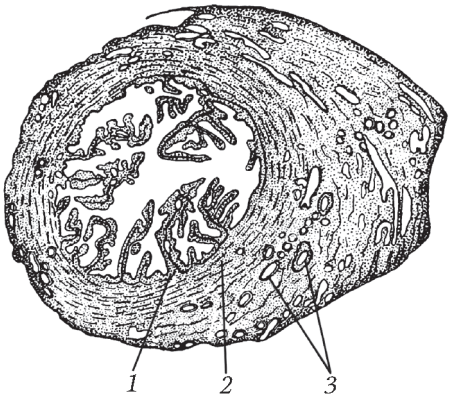


Fig. 3.5. Uterine tube (transverse section):
*1* — tunica mucosa; *2* — tunica muscularis; *3* — blood vessels

The epithelium of the mucosa consists of one layer of two types of the columnar cells: ciliated and secretory. The cilia move towards the uterus, facilitating the transport of ovum. The lamina propria of the mucosa is formed by loose connective tissue, which is able to undergo the cyclical change, like the endometrium. Therefore, a fertilized oocyte may implant into the mucosa of the uterine tube and cause the development of the ectopic (tubal) pregnancy. The tubal mucosa forms the longitudinal tubal folds, *plicae tubariae*. In the ampulla they are especially tall and form the secondary and tertiary folds. The folds of the isthmus are low.

The muscular stratum consists of two layers of smooth muscle fibers: internal, circular, more distinct, and external, longitudinal. The thickness of the muscular layer of the tube increases towards the uterus that determines the peristalsis of the tube and the passage of ovum. The tone and contraction of the muscular stratum of the tube are controlled by the reproductive hormones. The serosa entirely covers the uterine tube and is continuous down with the mesentery, the mesosalpinx, which is a part of the broad ligament.

## 3.5. Vagina

The vagina, *vagina* (in Greek *colpos*), is an unpaired hollow organ connecting the uterus with the external reproductive organs; it is a copulatory organ, also evacuating the menstrual blood and fetus. The vagina is a tube, 8—10 cm long; the thickness of its wall is 3 mm. The lumen of the vagina is normally collapsed and looks like a slit on the frontal section. The vagina has an anterior wall, *paries anterior*, and posterior wall, *paries posterior*, 1,5—2 cm longer than the anterior wall. The vaginal part of the uterine cervix projects into the upper portion of the vagina. Between the vaginal wall and the uterine cervix a narrow slit is formed, the vaginal fornix, *fornix vaginae*, having four parts: anterior, *pars anterior*, posterior, *pars posterior*, and two laterals, *partes laterales* (fig. 3.6). The posterior vaginal wall is attached to the cervix higher than the anterior wall thus the anterior part of the vaginal fornix is deeper than other parts. Only this area of the

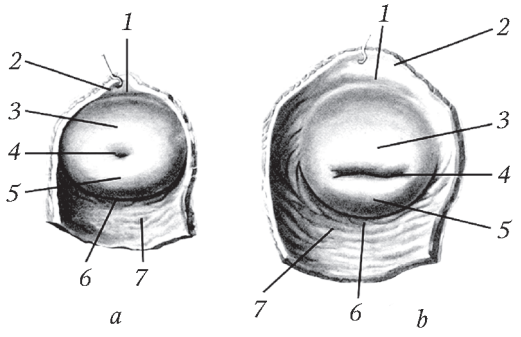


Fig. 3.6. Vaginal portion of uterine cervix (inferior aspect):
*a* — in nulliparous female; *b* — in parous female;
*1* — anterior part of vaginal fornix; *2* — anterior wall of vagina; *3* — anterior lip; *4* — external os; *5* — posterior lip; *6* — posterior part of vaginal fornix; *7* — posterior wall of vagina

vaginal wall is covered by the peritoneum within the rectouterine pouch. It should be noted that the external os of the uterus opens in the area of the posterior part of the fornix because the posterior lip of the uterine cervix is thicker. The vagina is slightly curved backwards, forming an obtuse angle opened forwards with the uterine long axis. Inferiorly the vagina becomes narrow and opens into the vestibule by the vaginal orifice, *ostium vaginae*, which is limited in virgins by the mucosal fold, the hymen, separating the vestibule from the vagina. After rupture of the hymen, the small elevations of mucosa, called *carunculae hymenales*, remain and encircle the vaginal orifice.

**Topography of vagina.** The vagina is situated in the center of the lower part of the lesser pelvis. The position of the vagina is of great importance in the gynecological practice because the inflammation may spread from the vagina to the neighboring organs and from the organs to the vagina. Also the elastic wall of the vagina allows to examine the adjacent organs through the vagina, *per vaginae*. The posterior vaginal wall is connected to the rectum by loose connective tissue (more abundant below), which contains the venous plexuses. The upper quarter of the vaginal posterior wall is covered by the peritoneum. The anterior vaginal wall is related to the urethra and the fundus of the urinary bladder. The vagina is connected to the bladder by loose connective tissue containing the venous plexus. The anterior vaginal wall is firmly linked with the urethra by dense connective tissue; the thickness of the anterior vaginal wall and urethra wall together is around 10 mm. Lateral to the vagina there is a large venous plexus and the pelvic part of the ureter. Below, the vagina passes through the perineum, firmly connecting to the pubic bones by the transverse perineal ligament, *ligamentum transversum perinei*. This part of the vagina is the least mobile.

**Structure of vaginal wall.** The vaginal wall is rather dense but at the same time very extensile. From inside the vagina is lined by the mucosa, *tunica mucosa*, which has greyish-pink color and becomes brighter during menstruation. During pregnancy the mucosa has cyanotic shade (the sign of the venous hyperemia). The mucosa is thick (about 2 mm), covered by non-keratinized stratified squamous epithelium and does not have the glands. The mucosa is comprised of dense connective tissue containing a lot of elastic fibers. On the anterior and posterior vaginal walls there are numerous longitudinal folds (vaginal rugae, *rugae vaginales*), which become taller closer to the midline and form the longitudinal ridges, the vaginal columns, *columnae rugarum*. The anterior column, *columna rugarum anterior*, is especially well developed. Inferiorly it forms the longitudinal projection, the urethral carina of vagina, *carina urethralis vaginae*, corresponding to the urethra which parallels the vagina indenting the wall here. The anterior and posterior columns are located on different sides of the median plane therefore, in usual (collapsed) condition they are not in contact. The vaginal columns are rather dense; they comprise the mucosa, which is especially thick here, and also the smooth muscle fascicles and venous plexuses. The mucosa adheres to the muscular layer; the submucous layer is absent.

The muscular layer, *tunica muscularis*, is composed of smooth muscle tissue, which is continuous with the musculature of the uterus above and becomes stronger below, connecting with the perineal muscles. Near the vaginal orifice there is an aggregation of the striated circular fibers, 4—7 mm thick, which envelop the lower ends of the vagina and urethra, forming a muscular sphincter. The external layer, adventitia, is constructed from loose connective tissue containing a lot of elastic fibers and smooth muscle fascicles.

The hymen, *hymen*, is between the vagina and vestibule, near the vaginal orifice. According to the development, the hymen is the remnant of the urogenital septum, *membrana urogenitalis*. The opening of the hymen is usually semilunar, *hymen semilunaris*.

A free thin edge of the hymen surrounds the vaginal orifice; its opposite thicker edge is attached to the posterior and lateral vaginal walls. The hymen is a connective tissue lamina covered by stratified squamous epithelium from both sides. In collapsed vagina the hymen forms the folds and is closed by labia majora pudendi. Very rarely the hymen has no opening (*hymen imperforatus (atresia hymenalis)*); this abnormality occurs because the urogenital septum remains complete. In this case the hymen obstructs the vaginal orifice and during the first menstruation the hymen needs to be surgically opened. If the urogenital septum reduces considerably, the hymen looks like a low fold surrounding the vaginal orifice. In this case during the first coitus the defloration may not be accompanied by bleeding.

## 3.6. External Reproductive Organs

The external genital organs comprise: the mons pubis, labia majora and minora pudendi, greater vestibular glands and the bulb of the vestibule (fig. 3.7).

**Mons pubis**, *mons pubis*, is a skin-covered pad of fat, having the shape of a triangle, the base of which is directed up and separated from the abdominal region by the pubic groove, *sulcus pubicus*, and the lateral sides of which are formed by the pelvicofemoral grooves, *sulcus pelvicofemoralis*; they separate the mons pubis and labia majora pudendi from the femoral region. The mons pubis is covered by hairs, which normally do not spread above the pubic groove in females. Below, the hairs spread to the external surface of the labia majora. The fatty tissue of the mons pubis is 2—3 cm thick; in overweight women it is much thicker.

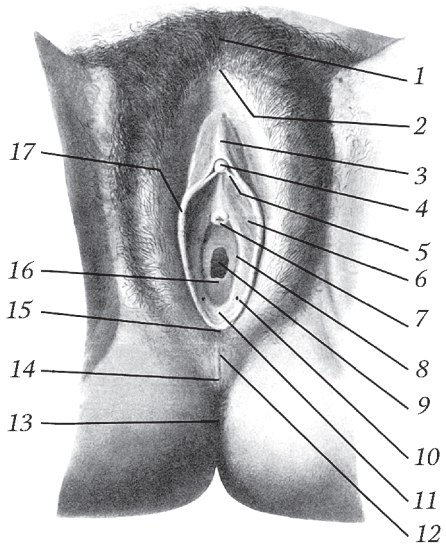


Fig. 3.7. External female reproductive organs: *1* — mons pubis; *2* — anterior commissure of labia majora; *3* — prepuce of clitoris; *4* — glans clitoridis; *5* — frenulum of clitoris; *6* — labium minus pudendi; *7* — external urethral orifice; *8* — vaginal vestibule; *9* — vaginal orifice; *10* — opening of greater vestibular gland; *11* — fossa of vaginal vestibule; *12* — posterior commissure of labia majora; *13* — anus; *14* — raphe of perineum; *15* — frenulum of labia minora; *16* — hymen; *17* — labium majus pudendi

**Labium majus pudendi**, *labium majus pudendi,* is a paired rounded elastic fold, 7—8 cm long and 2—3 cm thick. The two labia majora limit the pudendal cleft, *rima pudenda*, from the lateral sides. They are connected together by the commissures: wider anterior commissure, *comissura labiorum anterior*, and narrow posterior commissure, *comissura labiorum posterior*. The skin of the external surface of the labia is covered by hairs, contains the numerous sweat and sebaceous glands and is pigmented like the scrotum. The labia majora are formed by the accumulation of the subcutaneous adipose tissue which contains the venous plexuses and connective tissue septa connecting to the periosteum of the pubic bones and to the corpora cavernosa of the clitoris, that lie in the base of the labia. In usual position of the labia majora their medial surfaces closely contact, covering the clitoris and the edges

of labia minora. The inner surfaces of the labia majora have pink color and resemble a mucous membrane.

**Labium minus pudendi**, *labium minus pudendi* (in Greek *nympha*), is a paired longitudinal thin skin fold limiting the vaginal vestibule. The labia minora are inward to the labia majora. Each has a free sharp edge and two surfaces: lateral surface, which is separated by the groove from the labium majus and adjoins its medial surface; and medial surface, which contacts the same surface of the opposite labium minus. The posterior edges of the labia minora converge along the midline to form a fold, the frenulum of labia minora, *frenulum labiorum pudendi*. It bounds a shallow depression, the fossa of the vaginal vestibule, *fossa vestibuli vaginae*. The anterior end of each labium minus splits into two folds, which pass to the clitoris. The lateral folds of both labia join to form the prepuce, *preputium clitoridis*, overhanging the glans clitoridis. The medial, smaller, folds are attached to the crura clitoridis and form by their meeting the frenulum clitoridis, *frenulum clitoridis*.

The labia minora are formed by connective tissue without fat, containing a lot of elastic fibers, smooth muscle fibers and venous plexuses. The surfaces of the labia minora are pink, they are covered by a very delicate epidermis, which has no hairs but contains numerous sebaceous glands and nerve endings.

**Vestibule of vagina**, *vestibulum vaginae*, is unpaired oval space, limited by the medial surface of the labia minora pudendi laterally, by the fossa of the vaginal vestibule inferiorly and by the clitoris superiorly. Within the vaginal vestibule there is a vaginal orifice, *ostium vaginae*, bordered by the hymen. The external urethral orifice opens in the vaginal vestibule, on the summit of the urethral carina, which is between the vaginal orifice and clitoris. The entire inner surface of the labia minora contains the numerous lesser vestibular glands, *glandulae vestibulares minores*; at the junction of their middle and lower thirds the ducts of the greater vestibular glands open.

**Greater vestibular glands (of Bartolini)**, *glandulae vestibulares majores*, are homologues of the male bulbo-urethral glands. They are acinotubular glands, each the size of pea. The glands elaborate a mucus-like fluid moistening the walls of the entrance to the vagina. The glands lie in the base of the labia minora pudendi, flanking the vaginal orifice, in the posterior third of the vaginal vestibule, 1 cm deep to the mucosa. The excretory duct opens on the inner surface of the labium minus, in the groove between the labium and hymen, approximately at the junction between the posterior and middle thirds of the labium minus.

**Bulb of vestibule**, *bulbus vestibuli*, is homologous to the corpus spongiosum of the penis; it has the form of a horseshoe (fig. 3.8). A very thin middle part of the

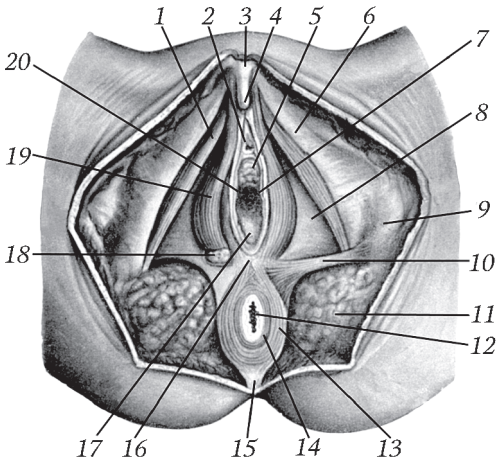


Fig. 3.8. Female perineum. Skin and subcutaneous adipose tissue have been removed:

*1* — ischiocavernosus; *2* — external urethral orifice; *3* — pubic symphysis; *4* — clitoris; *5* — vaginal rugae; *6* — inferior pubic ramus; *7* — vagina; *8* — inferior fascia of urogenital diaphragm; *9* — ischial tuberosity; *10* — transversus perinei superficialis; *11* — ischiorectal fat pad; *12* — anus; *13* — sphincter ani externus; *14* — sphincter ani internus; *15* — anococcygeal ligament; *16* — central tendon of perineum; *17* — posterior vaginal wall; *18* — greater vestibular gland; *19* — bulbospongiosus; *20* — vaginal vestibule

bulb is between the external urethral orifice and clitoris, joining the veins of the clitoris. The lateral part of the bulb is paired, slightly flattened and situated in the base of the labia majora pudendi; the posterior ends of the lateral parts adjoin the greater vestibular glands. The bulb is surrounded by the fascicles of the bulbospongiosus. The bulb consists of the thick plexus of the veins which are somewhere expanded to form cavernae. These veins are surrounded by connective tissue and smooth muscle fascicles.

**Clitoris**, *clitoris*, corresponds to the corpora cavernosa of the penis in the structure, form and position. It consists of a paired corpus cavernosum, *corpus cavernosum clitoridis*; each corpus cavernosum is connected to the periosteum of the inferior pubic ramus by the crus, *crus clitoridis*. The crura have cylindrical form and are united below the pubic symphysis to form the corpus clitoridis, *corpus clitoridis*, 2,5—3,5 cm long; the anterior free end of the clitoris is called the glans clitoridis, *glans clitoridis*. Like the corpora cavernosa of the penis, those of the clitoris are composed of the cavernous tissue with small cavernae, enclosed in the tunica albuginea. The corpus clitoridis is covered by the proper fascia, *fascia clitoridis*, and has a suspensory ligament, *ligamentum suspensorium clitoridis*. The crura of the corpora cavernosa are enveloped by the ischiocavernosus. Above, the clitoris is covered by the fold of the labia minora, the prepuce; below it, there is a frenulum clitoridis. The glans clitoridis has a lot of nerve endings.

## 3.7. Female Urethra

The female urethra, *urethra feminina*, begins at the internal urethral orifice, *ostium urethrae internum*, in the fundus of the urinary bladder, and ends at the external urethral orifice, *ostium urethrae externum*, which opens in the vaginal vestibule, 2 cm behind the clitoris. The female urethra is an unpaired tube, curved backwards, 2,5—3,5 cm long and 8—12 mm in diameter. The anterior wall of the urethra is behind the pubic symphysis and in contact with the vesical venous plexus. The posterior wall is fused with the anterior vaginal wall. The urethra passes down, traversing the perineal diaphragm; here it is surrounded by the muscle fibers that form a voluntary external urethral sphincter, *m. sphincter urethrae externus*. The wall of the female urethra consists of the mucous, muscular and adventitial layers.

The mucosa, *tunica mucosa*, is thick (2 mm) and forms longitudinal folds. One of them, located on the posterior wall of the urethra, is especially well developed and looks like a ridge; it is called the urethral crest, *crista urethralis*. The epithelium of the mucosa forms minute depressions, the urethral lacunae, *lacunae urethrales*, into which the branched urethral glands, *glandulae urethrales*, open. The lamina propria of the mucosa contains numerous elastic fibers and venous plexuses; the venous plexuses are well developed therefore, the deep layer of the lamina propria resembles the erectile tissue and is named the tunica spongiosa. The muscular coat of the urethra has two layers of smooth muscles: inner, longitudinal, and outer, circular. The circular layer is linked with the musculature of the urinary bladder and forms an involuntary internal urethral sphincter, *m. sphincter urethrae internus*, around the internal urethral orifice.

## 3.8. Development of Female Reproductive Organs. Developmental Abnormalities

### *Development of internal female reproductive organs*

The rudiment of the female reproductive gland appears in embryo during the 4th week of the development as a thickening of the genital folds, *plicae genitales*, extending between the dorsal mesentery and mesonephridic fold, *plica mesonephridica*, which

contains the mesonephros together with Wolffian and Mullerian ducts. In the site of the future ovary the primordial epithelium is thickened by means of the connective tissue zone which forms the cords.

Starting at 7—8th week of embryogenesis, the primordial germ cells appear between the cords. It is known that these cells originate from entoderm of the yolk sac, whence they migrate into the developing ovary approximately to the moment of the forrmation of the cords in the ovarian cortex. The female germ cells, migrating into the ovary, divide by meyosis, and their number considerably increases. However, the majority of primordial germ cells die in prenatal period. By the time of birth their number reaches about 2 millions in both ovaries. By puberty most of them degenerate, and 40 000 of germ cells remain in the ovaries. Further the cortex and medulla are formed in the ovary. The vessels and nerves grow into the medulla. During the development the ovaries together with the uterine tubes displace into the lesser pelvis. The descent of the ovaries is accompanied by the change of the direction of the tubes from vertical to horizontal. During the development of the female reproductive gland the mesonephric duct reduces; it remains as the epoophoron and paroophoron. Extremely rarely the Wolffian duct may remain as a cord passing lateral to the uterus and vagina, so-called longitudinal epoophorontic duct, *ductus epoophori longitudinalis*, (duct of Gartner).

Starting from puberty, approximately every 28 days one of germ cells leaves the ovary (ovulation). If pregnancy occurs, the ovulation is interrupted. The complete cessation of the ovulation occurs in menopause.

The paramesonephric ducts give rise to the uterine tubes. The uterus and vagina develop from the fused middle and caudal parts of the Mullerian duct and surrounding mesenchyme. The lower ends of the Mullerian ducts reach the urogenital sinus in the region of its dorsal wall. Further the urogenital sinus transforms into the vaginal vestibule. In the site of the septum separating the vagina and vestibule the hymen remains.

## *Development of external female reproductive organs*

The sources of the development of the external female reproductive organs are similar to male: genital tubercle, genital ridge and genital folds. If embryo is female, the growth of the genital tubercle slows, and the clitoris with the corpora cavernosa and preputium develop. A shallow urogenital sinus transforms into the vaginal vestibule. The ostium urogenitalis primitivum considerably elongates in the sagittal direction, and the pudendal cleft is formed. The genital folds, which limit the pudendal cleft, grow to become the labia minora pudendi. The genital ridge gives rise to the labia majora pudendi and mons pubis and accumulates a lot of adipose tissue.

## *Developmental anomalies of internal female reproductive organs*

1. Ectopia of ovary, *ectopia ovariorum*. In this anomaly of the ovarian development the ovaries displace from the lateral wall of the lesser pelvis (from the ovarian fossa) to the deep inguinal ring or they enter the inguinal canal and lie under the skin of labia majora.

2. Accessory ovary, *ovarium accessorium*, is observed in 4 % of cases and appears because of the formation of the accessory rudiment of the reproductive gland in the genital folds. More rarely, the underdevelopment of one (sometimes both) ovaries, *hypoplasia ovarii*, which is accompanied by the decrease of the endocrine activity, is observed.

3. The failure of the fusion of the paramesonephric (Mullerian) ducts leads to the duplication of the organs: double uterus, *uterus duplex*, and double vagina, *vagina duplex*.

4. The incomplete merger of the Mullerian ducts causes the development of the bicornuate uterus, *uterus bicornus*. Such a uterus has a bifurcated fundus, or the uterus and vagina have the septa inside (*uterus septus*, *vagina septa*).

5. Unicornuate uterus, *uterus unicornus*, has an irregular-shaped fundus which is continuous with a single uterine tube. This malformation appears in the case of the unilateral atrophy of the mesonephric duct.

6. The absence of the uterine tubes, uterus and vagina, *aplasia tubae uterinae*, *uterus*, *vaginae*; it is observed extremely rarely, in the case of full reduction of both Mullerian ducts, and is associated with the defects of the other vital organs. More often the uterus and vagina are partially deformed: the uterine fundus remains flat, as in the embryonic period; the uterus and vagina may be not communicated; the vagina may be underdeveloped or even may be absent (*aplasia vaginae*); the uterus may be rudimentary (*uterus fetalis*), or infantile (*uterus infantilis*), which has failed to attain adult characteristics.

## *Developmental anomalies of external female reproductive organs*

The female false hermaphroditism, *pseudohermaphroditismus femininus,* is observed more rarely than male. In this abnormality the reproductive glands develop as the ovaries, pass through the inguinal canal into the labia majora which approach each other, resembling the scrotum; the vaginal orifice is significantly narrowed. The genital tubercle considerably grows; the clitoris resembles the penis in form and size.

## TEST QUESTIONS

1. List the female reproductive organs.
2. Which of the female reproductive organs belong to external organs?
3. Which of the female reproductive organs belong to internal organs?
4. Describe the localization and syntopy of the uterus.
5. How are the different parts of the uterus covered by the peritoneum? What are the vesicouterine recess and recrouterine recess?
6. Describe the ligaments of the uterus.
7. Describe the normal position of the uterus. How does the state of the urinary bladder and rectum effect the position of the uterus? What is anteflexio and anteversio (retroflexio and retroversio)?
8. What sizes can the uterus have, depending on the state? Describe the parts and the surfaces of the uterus.
9. How will you differentiate the uterine anterior surface from the posterior surface on the anatomical preparation of the uterus?
10. Describe the relations between the uterine cervix and vagina. What are the supravaginal and vaginal portions of the cervix?
11. What canal is the continuation of the uterine cavity?
12. Where can the uterine orifice be found? Where is it opened? What are the differences between the shape of the uterine orifice in nulliparous and parous women?
13. Which organs open into the uterine cavity?
14. Describe the layers of the uterine wall. What layers does the endometrium consist of? How many layers compose the myometrium? What is the perimetrium and parametrium?
15. What is the function of the uterine tube?
16. What openings does the uterine tube have? Where do they open?
17. What is the length and diameter of the uterine tube? Describe the parts of the uterine tube. In which part of the uterine tube does fertilization occur?

18. Describe the layers of the uterine tube`s wall.
19. How is the uterine tube covered by the peritoneum? What is the mesosalpinx?
20. Describe the position of the ovaries (relatively to the uterine tube and to the uterus). What sizes does the ovary have?
21. What surfaces, borders, extremities are distinguished in the ovary? How will you differentiate the ovarian medial surface from the lateral one on the anatomical preparation of the ovary?
22. Describe the relations between the ovary and peritoneum. What is the mesovarium?
23. Describe the internal structure of the ovary. What types of the ovarian follicles do you know? When the different types of the follicles appear? Describe the stages of the maturation of the follicles.
24. What is the ovulation? When does it occur? What happens with the follicle after the ovulation?
25. What is the corpus luteum and albicans? What is the function of the corpus luteum?
26. Describe the phases of the menstrual cycle (their length and the processes happening in each phase).
27. Describe the position of the vagina. What is the length of the vagina?
28. What are the vaginal fornices? Where are they formed? What is their clinical importance?
29. Describe the layers of the vaginal walls. Describe the features of the vaginal mucosa (glands, folds).
30. Where is the vaginal orifice located? What are the relations between the urethra and vagina; between the external urethral orifice and vaginal orifice?
31. Where is the hymen located? Describe its structure and shape. What is the distance between the hymen and vaginal orifice?
32. What is the length and diameter of the female urethra? Describe its position.
33. Where are the internal and external orifices of the female urethra situated?
34. Describe the layers of the urethra.
35. Describe the structure of the labia majores and minores pudendi. What is the vaginal vestibule? How are the prepuce and frenulum of the clitoris formed?
36. Describe the parts and fixation of the clitoris. What part of the penis does it correspond to?
37. What is the vestibular bulb? Describe its localization and structure. What part of the penis does it correspond to?
38. Where are the major vestibular glands located? What is their function?
39. Describe the development of the female reproductive organs.
40. What developmental anomalies of the female reproductive organs do you know?

## CLINICOANATOMICAL PROBLEMS

1. A gynecologist has to examine the uterine cervix in a nulliparous woman with the help of the vaginal speculum. What length should the speculum have?
2. In ectopic pregnancy the uterine tube is ruptured. A diagnostic puncture through the posterior vaginal fornix needs to be performed. What pouch of the peritoneal cavity will the needle enter?
3. A doctor has to evacuate urine in elderly women with the help of the catheter. Where is the external urethral orifice located? At what depth should the doctor insert the catheter?
4. A doctor observed a solid hymen in a 10-years-old girl. What recommendations should the doctor give?

## 4. MAMMARY GLAND

The mammary gland, *mamma — glandula mammaria* (in Greek *mastos*), is the biggest glandular organ in females. As the organ of external secretion, it produces milk in the period of lactation; as the organ of internal secretion, it produces the hormone called the mammin. In males the mammary glands are rudimentary throughout life. In females after puberty the glandular and endocrine tissues of the mammary glands grow considerably.

The form and sizes of the mammae vary in individuals and at different age, depend on the functional condition of the female body (phase of menstrual cycle, pregnancy, period of lactation) and the number of parturitions. The functioning of the mammary gland is closely associated with the activity of the reproductive glands.

In girls the mamma is conical or ovoid; in pregnant and lactating women it is spherical. In adult women after lactation and in elderly women the shape of the mamma may be variably pendulous, piriform, spherical or flattened. The average sizes of the mamma in adult female are $10 \times 10 \times 5$ cm.

The mammary gland lies within the superficial pectoral fascia anterior to the thorax, extending from the level of the III to the V ribs and occupying the interval between the parasternal and anterior axillary lines. The superficial pectoral fascia envelops the mamma as a capsule. Between the capsule and the superficial layer of the proper pectoral fascia, covering the pectoralis major, there is a loose connective tissue, the retromammary space, which allows the mamma some degree of movements on the deep layer of the proper pectoral fascia.

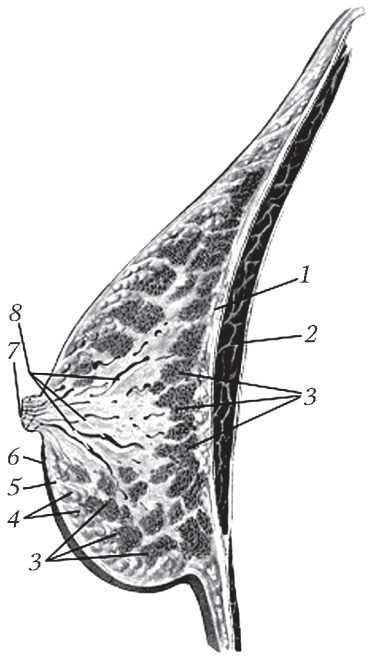


Fig. 4.1. Mammary gland (sagittal section):
*1* — proper pectoral fascia; *2* — pectoralis major; *3* — body of mamma; *4* — lobes of mammary gland; *5* — panniculus adiposus; *6* — skin; *7* — mammary papilla; *8* — lactiferous duct

Approximately in the center of the mammary gland there is a mammary papilla (nipple), papilla *mammaria* (fig. 4.1). It is traversed by 10–15 lactiferous ducts, *ductus lactiferi*. The average sizes of the papilla are $1 \times 1 \times 0{,}7$ cm; the shape is conical or cylindrical, more rarely is flattened or retracted. The papilla is surrounded by a cutaneous discoidal area, about 1,5 cm in breadth, called the areola, *areola mammae*. The papilla and areola are pigmented: pink in young and dark brown in adult females. The skin of the areola contains the areolar glands, *glandulae areolares*, whose minute ducts open on the surfaces of 15—20 areolar tubercles, *tuberculae* areolae, having about 1 mm in size. Near the areolar glands there are the sebaceous glands.

The papilla and areola contain non-striated myocytes which are arranged circularly and longitudinally. The collection of these myocytes forms the muscle of the nipple, the contraction of which erects the papilla.

The body of the mamma, *corpus mammae*, has the shape of a disc with a smooth posterior surface and uneven anterior surface. It consists of 15–20 lobes, *lobi glandulae mammariae*, ar-

ranged radially. The lobes are separated from each other by adipose tissue and connective tissue septa called the suspensory ligaments, *ligamenta suspensoria mammaria*. The body of the mamma itself is much less than the total size of the mammary gland because it is surrounded by adipose tissue. In asthenic women the mamma has few adipose tissue.

The mammary gland`s lobes are the compound acinotubular glands in structure. The structural and functional unit of the lobe is an alveola surrounded by capillary plexuses and smooth muscle capsule. The contraction of the capsule expels the milk in suckling. From the alveoli the alveolar ducts arise; they open into the collecting duct. Each lobe has own collecting lactiferous duct, *ductus lactiferi colligens*. The collecting duct passes to the mammary papilla, forming beneath it an expansion, the lactiferous sinus, *sinus lactiferi*. The latter is drained by a short lactiferous duct, *ductus lactiferi*. The lactiferous ducts are partially united at the lactiferous sinuses therefore, only 10—15 orifices open on the summit of the mammary papilla.

In accordance with origin, the mamma is a modified apocrine sweat gland which matures at and after puberty. The mamma especially grows during pregnancy: it increase in size, the papilla and areola become strongly pigmented. The expanded veins are visible through thin skin of the mamma. After lactation the sizes of the mammary gland decrease. In menopause the gland undergoes partial involution.

The following developmental anomalies of the mamma are observed:

1) the underdevelopment (hypoplasia) of one or both glands;
2) the appearance of accessory glands (4—6) (polymastia);
3) the appearance of accessory papillae (3—4) on one or both glands;
4) the strong increase of the mammary glands in males, and the development of the glands like in females (gynecomastia).

## TEST QUESTIONS

1. Describe the function of the mammary gland. What hormone does it produce as an endocrine gland?
2. What are the sizes of the mammary gland?
3. Describe the topography of the mammary gland (relatively to the ribs, to the pectoralis major and fasciae of the chest). How is the capsule of the gland formed?
4. Describe the walls of the retromammary space. What is its clinical importance?
5. Describe the structure of the mammary papilla.
6. Describe the structure of the body of mamma.
7. Describe the structure of the lobe of the mammary gland. How is the lactiferous duct formed? How many orifices of the ducts open on the summit of the mammary papilla?
8. Describe the genesis of the mammary gland. What changes does the gland undergo throughout life?
9. What developmental abnormalities of the mammary gland do you know?

## CLINICOANATOMICAL PROBLEMS

1. A doctor has to open the intramammary abscess of the mammary gland. He should do the radial incision, the anterior end of which must not reach the mammary areola. What anatomical features of the mammary gland structure determine the use of such an incision?
2. A woman has a purulent retromammary mastitis. In which anatomico-topographical layer is the pus located? What incision should be used to open the phlegmon of such localization?

## 5. PERINEUM

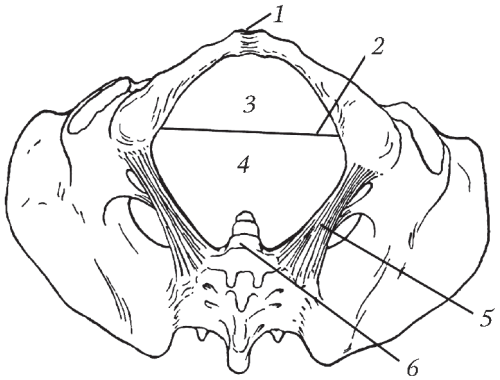


Fig. 5.1. Male pelvis (superior aspect):
*1* — pubic symphysis; *2* — linea biischiadica; *3* — urogenital region; *4* — anal region; *5* — sacrotuberous ligament; *6* — coccyx

The perineum, *perineum*, is composed of the soft tissues that close the pelvic outlet. Its skeletal boundaries are: anteriorly the inferior edge of the pubic symphysis; posteriorly the tip of the coccyx; laterally the conjoined inferior pubic and ischial rami, the sacrotuberous ligaments and ischial tuberosities which are the most distant points (fig. 5.1). Taking into account the disposition of the extreme points, it can be noted that the perineum has a rhomboid shape.

The line connecting the ischial tuberosities, *linea biischiadica*, divides the perineum into two triangular regions: anterior and posterior. The anterior region lies in almost frontal plane, while the posterior region is in horizontal plane; the regions meet each other at an obtuse angle.

The anterior region, called the urogenital region, *regio urogenitalis*, contains the root of the penis in males and the pudendal cleft with surrounding external reproductive organs. The posterior region contains the anus hence it is called the anal region, *regio analis*. A pigmented ridge, the perineal raphe, *raphe perinei*, passes along the midline of the perineum; in males it is continued forwards as the scrotal raphe.

The part of the perineum situated between the external reproductive organs anteriorly and the anus posteriorly corresponds to the perineal body (central tendon of the perineum, *centrum tendineum perinei*). In males this part extends from the posterior edge of the scrotum to the anterior edge of the anus; in females from the posterior edge of the pudendal cleft (posterior labial commissure) to the anterior edge of the anus.

The soft tissues of the perineum include the skin, subcutaneous adipose tissue, muscles, fasciae and the peritoneum with the anteperitoneal fat and connective tissue. The muscles form the most important part of the peritoneum. They close the abdominal cavity from below. In upright position the muscles play the great role in the fixation of the pelvic organs and in the maintaining of the intra-abdominal pressure. Besides, the perineal muscles form the sphincters around the rectum and urethra. It should be noted that these sphincters are voluntary because they are composed of striated skeletal muscle fibers. In males the perineal muscles maintain penile erection.

According to origin, the perineal muscles can be divided into two groups: 1) the muscles of the caudal part of the trunk; 2) the muscles derived from the *sphincter cloacae*.

The first group comprises the levator ani, *m. levator ani*, and the coccygeus, *m. coccygeus*. The second group includes all the muscles developed after the division of the cloaca into the urogenital sinus and anus. The cloacal membrane in region of the urogenital sinus gives rise to the transversus perinei superficialis, *m. transversus perinei superficialis*; ischiocavernosus, *m. ischiocavernosus*; bulbospongiosus, *m. bulbospongiosus*; transversus perinei profundus, *m. transversus perinei profundus*; and sphincter urethrae externus, *m. sphincter urethrae externus*. In the region of the anal canal the sphincter ani externus, *m. sphincter ani externus*, develops.

The muscles of the urogenital region are divided into superficial and deep. The superficial muscles are: transversus perinei superficialis, ischiocavernosus and bulbospongiosus (fig. 5.2).

**Transverus perinei superficialis**, *m. transversus perinei superficialis*, paired, lies in the deep layer of the subcutaneous adipose tissue. It arises from the ischial ramus near the ischial tuberosity, runs transversely to the perineal body and joins its antimere. This muscle partly blends with the sphincter ani externus and ischiocavernosus of opposite side. Both transversi perinei superficialis assist in the strengthening of the perineal body.

**Ischiocavernosus**, *m. ischiocavernosus*, paired, arises from the ischial ramus, adjoins the penile root (in males) from the lateral side and end in the tunica albuginea of the penis or clitoris. The muscles compress the crura of the penis, maintaining the penile erection.

**Bulbospongiosus**, *m. bulbospongiosus*, paired, is composed of two symmetrical parts arising from the raphe on the inferior surface of the penile bulb. They embrace the bulb and corpus spongiosum of the penis from the right and from the left and are attached to the tunica albuginea and superficial penile fascia on the dorsum of the penis. The muscles assist in erection by compressing of the bulb, corpora cavernosa and dorsal vein of the penis; they also compress the bulbo-urethral glands.

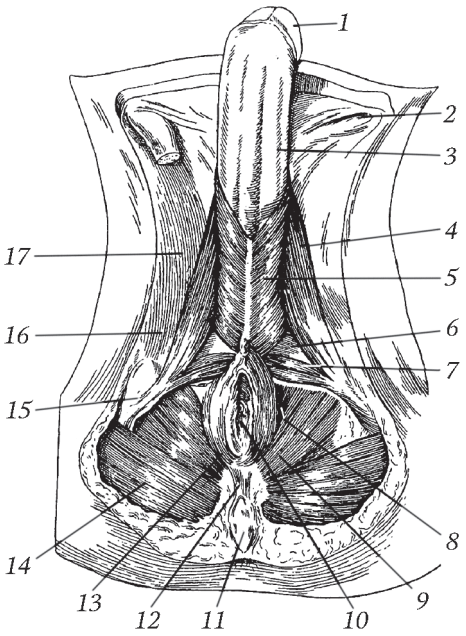


Fig. 5.2. Muscles of male perineum:

*1* — glans penis; *2* — annulus inguinalis superficialis; *3* — penis; *4* — m. ischiocavernosus; *5* — m. bulbospongiosus; *6* — m. transversus perinei profundus; *7* — m. transversus perinei superficialis; *8* — fossa ischiorectalis; *9* — m. levator ani; *10* — anus; *11* — os coccygis; *12* — lig. anococcygeum; *13* — sphincter ani externus; *14* — gluteus maximus; *15* — tuber ischiadicum; *16* — f. lata; *17* — funiculus spermaticus

In females the bulbospongiosi, *mm. bulbospongiosi (m. constrictor cunni seu m. sphincter vaginae)*, encircle the vaginal orifice. They arise from the perineal body and sphincter ani externus and are attached to the dorsal surface of the clitoris, blending with its tunica albuginea. The muscles adjoin the greater vestibular glands from below. The muscles narrow the vaginal orifice, compress the bulb of the vestibule and the veins which drain the bulb.

The deep muscles of the urogenital region are: the transversus perinei profundus and sphincter urethrae externus (fig. 5.3).

**Transversus perinei profundus**, *m. transversus perinei profundus*, paired, is a narrow muscular sheet. It extends from the ischial and pubic rami to end in the perineal body, joining its antimere by the flat tendon along the midline.

**Sphincter urethrae externus**, *m. sphincter urethrae externus*, is an unpaired muscle. Its fibers are arranged mainly circularly; they surround the membranous part of the male urethra and the female urethra, arising partially from the inferior pubic rami. In males the fibers of this muscle join the prostate; in females they blend with the vaginal wall. The muscle is the voluntary sphincter of the urethra.

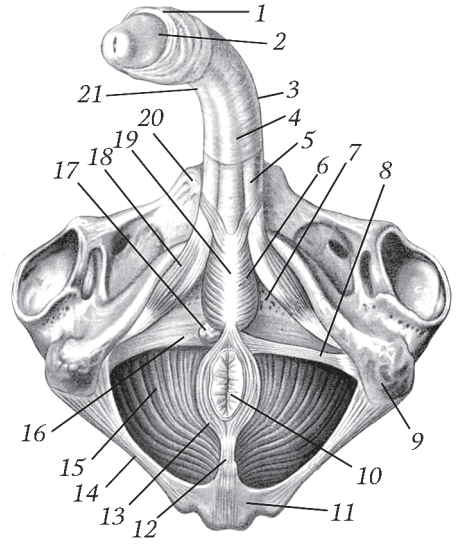


Fig. 5.3. Muscles of male perineum:

*1* — prepuce; *2* — glans penis; *3* — corpus penis; *4* — corpus spongiosum penis; *5* — corpus cavernosum penis; *6* — bulbospongiosus; *7* — inferior fascia of urogenital diaphragm; *8* — transversus perinei superficialis; *9* — ischial tuberosity; *10* — anus; *11* — sacrum; *12* — anococcygeal ligament; *13* — sphincter ani externus; *14* — sacrotuberous ligament; *15* — levator ani; *16* — transversus perinei profundus; *17* — bulbo-urethral gland; *18* — ischiocavernosus; *19* — raphe of bulbospongiosi; *20* — pubis; *21* — proper fascia of penis

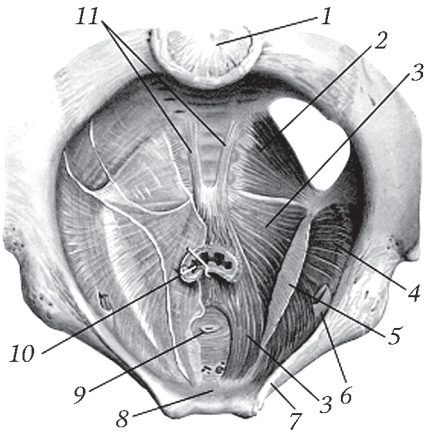


Fig. 5.4. Floor of pelvis (superior aspect). Sacrum, pelvic bone and pelvic fasciae have been partially removed:

*1* — sacrum; *2* — coccygeus; *3* — levator ani; *4* — obturator internus; *5* — tendinous arch of pelvic fasciae; *6* — obturator canal; *7* — superior pubic ramus; *8* — pubic symphysis; *9* — urethra; *10* — rectum; *11* — ventral sacrococcygeal ligament

The muscles of the anal region are also divided into superficial and deep. The superficial layer is composed of only one unpaired muscle, the sphincter ani externus, surrounding the end of the anal canal.

**Sphincter ani externus**, *m. sphincter ani externus,* consists of several fascicles, the most superficial of them end in subcutaneous adipose tissue. The fascicles arising from the tip of the coccyx encircle the anus and end in the perineal body. The deepest fascicles surround the lowest part of the rectum and adjoin the levator ani. All the fascicles of the sphincter ani externus compress (close) the anal canal.

The deep muscles of the anal region include two muscles that form the posterior part of the pelvic floor: the levator ani and coccygeus (fig. 5.4).

**Levator ani**, *m. levator ani*, paired, is a broad triangular sheet. It unites with its fellow to form a funnel, directed upwards by its wide part.

The lower parts of both muscles narrow downwards to envelop the rectum like a loop. The levator ani springs by several fascicles from the lateral wall of the lesser pelvis. The anterior fascicles, the strongest, arise from the inner surface of the inferior pubic ramus. Near the symphysis they are absent; only this area is not occupied by the levator ani. The lateral fascicles are attached to the tendinous arch of the levator ani, *arcus ten-*

*dineus musculi levatoris ani*. The latter is an arch-shaped thickened fusion of the proper pelvic fascia and obturator fascia. The fascicles of the right and left levatores ani join to envelop the rectum and then run down and medially. The most anterior muscle`s fibers blend with the prostate in males, with the vaginal wall in females and also with the urinary bladder and the rectum. Besides, the muscle is closely linked with the walls of these organs by fibro-elastic connective tissue.

The levatores ani end behind the rectum at the tip of the coccyx by means of the anococcygeal ligament, *ligamentum anococcygeum*.

The levator ani strengthens and elevates the pelvic floor, pulls the lower part of the rectum forwards and up, compressing it. In females this muscle constricts the vagina, bringing its posterior and anterior walls together.

**Coccygeus**, *m. coccygeus*, paired, arises from the ischial spine and sacrospinous ligament, passes medially and backwards and is attached to the lateral edge of the coccyx and to the apex of the sacrum. The muscle`s fascicles adjoin the sacrospinous ligament from the medial side and partially blend with it, assisting in the strengthening of the pelvic floor.

**Perineal fasciae.** The following fasciae are distinguished in the perineum: the superficial fascia, the superior and inferior fasciae of the pelvic diaphragm and also the superior and inferior fasciae of the urogenital diaphragm.

The superficial (subcutaneous) perineal facsia, *fascia superficialis perinei*, poorly distinct, is the continuation of the superficial fascia covering the neighboring parts of the body. This fascia covers the superficial muscles of the urogenital diaphragm (transversi perinei superficiales, ischiocavernosi and bulbospongiosi) from below, loosely connecting to their proper fasciae. In males the superficial fascia is continuous forwards with the superficial penile fascia. On the sides it is attached to the ischial tuberosities.

Above the superficial perineal fascia, in the posterior part of the perineum, there is a proper fascia of the perineum, the inferior fascia of the pelvic diaphragm, *fascia diaphragmatis pelvis inferior*. Posteriorly it is fused with the fascia of the gluteus maximus. The inferior fascia of the pelvic diaphragm lines the ischiorectal fossa, covering the outer surface of the obturator internus and reaching the top of the fossa. Then it passes to the outer surface of the levator ani. Near the rectum the inferior fascia of the pelvic diaphragm covers the outer surface of the sphincter ani externus and ends in the areolar tissue surrounding the anus. Anteriorly it reaches the posterior edge of the urogenital diaphragm, where divides into three layers: superficial, middle and deep.

Above (from the side of the pelvis) the levator ani is covered by the fascia called the superior fascia of the pelvic diaphragm, *fascia diaphragmatis pelvis superior*, which is a part of the endoabdominal fascia, *fascia endoabdominalis*.

Thus, the levator ani, coccygeus and sphincter ani externus together with the superior and inferior fasciae of the pelvic diaphragm form the muscular-fibrous sheet, the pelvic diaphragm.

In the urogenital region the superficial layer of the inferior fascia of the pelvic diaphragm covers the superficial muscles (bulbospongiosi, ishiocavernosi and transversi perinei superficiales), being their proper fascia. The superficial and deep muscles are separated by the middle layer of the inferior fascia of the pelvic diaphragm, which is called the inferior fascia of the urogenital diaphragm, *fascia diaphragmatis urogenitalis inferior* (perineal membrane, *membrana perinei*); it covers the transversi perinei profundi and sphincter urethrae externus from below (from outside). Above the transversi perinei profundi and sphincter urethrae there is a deep layer of the inferior fascia of the pelvic diaphragm, which is also called the superior fascia of the urogenital diaphragm, *fascia*

*diaphragmatis urogenitalis superior*. Besides the mentioned muscles, the bulbo-urethral glands in males or the greater vestibular glands in females lie between the superior and inferior fasciae of the urogenital diaphragm.

The superior and inferior fasciae of the urogenital diaphragm are fused with the periosteum of the ischial and pubic rami. Also the both fasciae are fused together under the pubic symphysis, forming the transverse perineal ligament, *ligamentum transversum perinei*. The latter is in front of the membranous part of the urethra and does not reach the inferior pubic ligament; thus, between these two ligaments there is a narrow space which transmit the dorsal vessels of the penis or clitoris.

As mentioned above, the superior fascia of the pelvic diaphragm is a part of the endoabdominal facsia, or the parietal pelvic fascia, *lamina parietalis (fascia pelvis)*. The part of the pelvic fascia, which forms the septa between the pelvic viscera, is called the visceral pelvic fascia, *fascia pelvis visceralis*. The latter forms paired pubovesical (puboprostatic) ligaments, *ligamenta pubovesicalia*, *puboprostatica*, between the pubic symphysis and the lower part of the urinary bladder. Between the urinary bladder and the rectum in males the visceral pelvic fascia forms a plate, arranged in the frontal plane, so-called rectovesical septum, *septum rectovesicale*. In females between the rectum and vagina the visceral pelvic fascia forms the rectovaginal septum, *septum rectovaginale*, arranged transversely.

The urogenital diaphragm is within the urogenital region; the pelvic diaphragm is within the anal region. Both diaphragms are the muscular-fascial sheets.

The pelvis diaphragm comprises:

1) the levator ani; 2) the coccygeus; 3) the sphincter ani externus.

These muscles are covered by the inferior fascia of the pelvic diaphragm from below, and by the superior fascia of the pelvic diaphragm from above.

The urogenital diaphragm includes:

1) the transversus perinei profundus; 2) the sphincter urethrae externus.

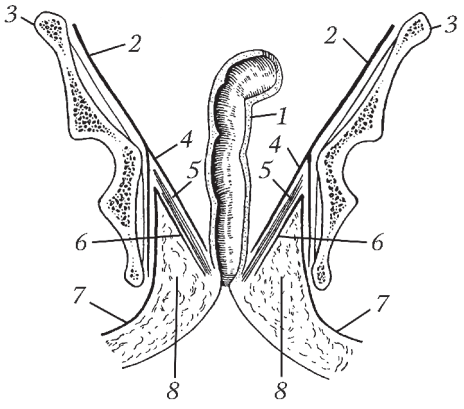


Fig. 5.5. Ischiorectal fossa (frontal section of pelvis):

*1* — rectum; *2* — pelvic fascia; *3* — ilium; *4* — superior fascia of pelvic diaphragm; *5* — levator ani; *6* — inferior fascia of pelvic diaphragm; *7* — gluteal fascia; *8* — ischiorectal fossa

These muscles are covered by the inferior fascia of the urogenital diaphragm from below, and by the superior fascia of the urogenital diaphragm from above.

**Ischiorectal fossa**, *fossa ischiorectalis*, (ischioanal fossa, *fossa ischioanalis*) is a paired depression in the perineal region, situated between the rectum and the ischial tuberosities, filled with pararectal fat, vessels, nerves and lymph nodes.

On the frontal section the fossa looks like a triangle with the apex directed to the lesser pelvis (fig. 5.5).

The ischiorectal fossa has the shape of a tetrahedral pyramid. It is limited: laterally by the ischial tuberosity and the obturator internus covered by its proper fascia; medially by the levator ani and sphincter ani externus, covered by the inferior fascia of the pelvic diaphragm; posteriorly by the coccygeus and the posterior fascicles of the levator ani; anteriorly by the posterior edges of the

transversi perinei superficiales and profundi. The ischiorectal fossa opens to the surface of the perineum by the wide base.

The adipose tissue which fills the ischiorectal fossa is called the ischiorectal fat pad, *corpus adiposum fossae ischiorectalis* (in Greek *paroproctos*); it plays the role of the elastic cushion.

## Features of Female Perineum

The features of the female perineum relate to only urogenital region which is wider and traversed not only by the urethra but also by the vagina (fig. 5.6). Near the vaginal vestibule is the bulb of the vestibule, the lateral parts of which lie in the base of the labia majora pudendi, and its thin middle part lies between the external urethral orifice and clitoris. Like corpus cavernosus, the bulb of the vestibule is composed of thin fibro-elastic tissue surrounded by the venous plexuses. The bulb is encircled by the bulbospongiosus (m. sphincter cunni). The latter also surrounds the clitoris, urethra and vaginal orifice. The inner surface of the bulb is fused with the inferior layer of the inferior fascia of the urogenital diaphragm. Behind the bulb, in the base of the labia minora pudendi there are the greater vestibular glands. More posteriorly, the two transversi perinei superficiales run in the transverse direction. In females these muscles are less distinct than in males, and sometimes are absolutely absent. The transversus perinei profundus is also weakly developed. The fibers of the sphincter urethrae externus encircle the vagina, blending with its wall.

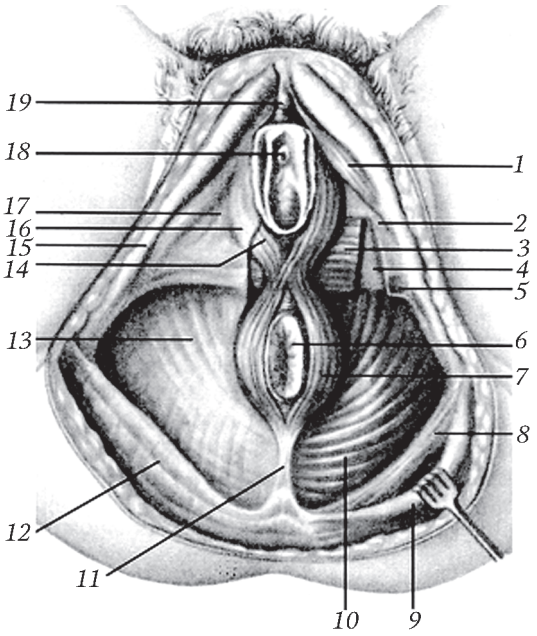


Fig. 5.6. Muscles and fasciae of female perineum:
*1* — ischiocavernosus; *2* — inferior fascia of urogenital diaphragm; *3* — transversus perinei profundus; *4* — superior fascia of urogenital diaphragm; *5* — transversus perinei superficialis; *6* — anus; *7* — sphincter ani externus; *8* — sacrotuberous ligament; *9* — gluteus maximus; *10* — levator ani; *11* — anococcygeal ligament; *12* — gluteal fascia; *13* — inferior fascia of pelvic diaphragm; *14* — bulbospongiosus; *15* — ischium; *16* — superficial perineal fascia; *17* — urogenital diaphragm; *18* — external urethral orifice; *19* — glans clitoridis

The inferior and superior fasciae of the urogenital diaphragm are well developed in females; they represent strong fibrous plates. The fasciae are especially thickened at the perineal body which projects to the intersection of the midline of the perineum with *linea biishiadica*. The aponeuroses of the muscles of the urogenital region (bulbospongiosus, sphincter ani externus, transversi perinei superficialis and profundus) meet at the perineal body. The perineal body consists of the interwoven tendinous and elastic fibers, is situated between the anus and vagina and plays the great role in the support of the vagina. The structure of the anal region in females and males do not have significant differences.

## TEST QUESTIONS

1. Give the definition of the perineum.
2. What structures bound the perineum?
3. What regions are distinguished in the perineum?
4. What organs pass through the perineum in females (males)?
5. Name the muscles of the urogenital diaphragm.
6. Name the muscles of the pelvic diaphragm.
7. Describe the origin, insertion and action of the transversus perinei superficialis.
8. Describe the origin, insertion and action (in males and females) of the ischiocavernosus.
9. Describe the origin, insertion and action (in males and females) of the bulbospongiosus.
10. Describe the origin, insertion and action of the transversus perinei profundus.

How is the external urethral sphincter formed?
Describe the origin, insertion and action of the levator ani.
Describe the origin, insertion and action of the sphincter ani externus.
Describe the origin, insertion and action of the coccygeus.
Describe the fasciae of the urogenital diaphragm.
Describe the fasciae of the pelvic diaphragm.
Describe the borders of the ischiorectal fossa.
What is the clinical importance of the ischiorectal fossa?
Describe the features of the female perineum.

## CLINICOANATOMICAL PROBLEMS

A patient complains of rectal prolapse during defecation. The actions of which perineal muscles are disordered?

A doctor has to perform a surgical operation to a patient with paraproctitis. Which layers within the ischiorectal fossa will the doctor dissect?

During the delivery, the muscles of the urogenital diaphragm were damaged, which caused the disorder of the voluntary retention of urine. What muscle was damaged?

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