Anatomy and Function of the Male Urogenital System

Understanding male anatomy: here we present key information on the structure and the functions of the male inner and outer genital organs and exam-relevant facts on spermatogenesis.

The Human Urogenital System

The urogenital system, as the name suggests, comprises of two main parts: the urinary tract, including the urine production part, the kidney and the urinary organs (the ureter, bladder, and urethra); and the genitals.

Although both parts have different functions, they are topographically and functionally closely related (on developmental grounds). The male and female genital organs are additionally divided into internal and external genitals.

Classification of Male Genital Organs

As is the case with female genitals, male genitals can be divided into internal and external genital organs. This classification is based on embryonic organ development. That is for example, why the testicle is considered as an internal genital, even
though it leaves the abdominal cavity during its development. In contrast, the male urethra (the urethral-spermatic duct) is considered to be a part of the external genitals, due to its location within the penis.

The Internal Male Genital Organs

The internal male genitals (organa genitalia masculine interna) include:

- the testis (testicle), paired
- the epididymis, paired
- the ductus deferens (vas deferens),
- the accessory sexual glands: the vesicula seminalis (the seminal vesicle), paired; the glandula bulbourethralis (Cowper´s gland), paired; the prostate (the prostate gland).
Function of the testis

The testicle (testis) contributes to the synthesis of sex hormones (androgens such as testosterone) and is the production site of male gametes (sperm). The sperm cells produced in the testis are stored in the epididymis. During ejaculation, they are released through the urethra via the vas deferens together with a secretion from the prostate and the glandula vesiculosa.

The production of sperm and hormones continues into old age.

The Location of the Testis

The plum-shaped, firm, resilient testis is about four to five centimeters long. It is located outside the abdominal cavity in the scrotum, a skin pocket formed from the abdominal skin. Below the scrotal skin is the tunica dartos, a layer of smooth muscles. The testis is then surrounded by a fibrous capsule, the tunica albuginea.

The testis rests on the epididymis and lies in a dorsal and cranial direction. Vessels and nerves enter and leave the dorsomedial-located mediastinum testis.

The tunica vaginalis

The testis is surrounded by several coverings. They have derived from muscles and fascia of the abdominal wall as well as the peritoneum. What follows is the sequence of the tunica vaginalis from the outer to the inner regions:

- the external spermatic fascia (fascia spermatica externa)
- the cremasteric fascia (fascia cremasterica)
- the cremaster muscle (m. cremaster)
- the internal spermatic fascia (fascia spermatica interna)
- the tunica vaginalis testis including epiorchium and periorchium

The epiorchium represents the visceral lamina of the tunica vaginalis. At the mediastinum it becomes the parietal lamina, namely the periorchium. Both laminas encase the scrotal cavity.

The epiorchium and periorchium are former lamina of the peritoneum that reached the scrotum via the inguinal canal during the migration of the testicle. They continue on to
the spermatic cord in the form of tunicae funiculi spermatici.

The structure of the testis

The testis is divided into small lobules by connective tissue, the septa. Inside the lobules are many convoluted tubules, the tubuli seminiferi contorti (seminiferous tubules). A straight channel system connects the seminiferous tubules with the rete testis, located in the mediastinum. This is a network of small tubules, leading to the epididymis via the ductuli efferentes testis.

The seminiferous tubules are the site of germ cell production (spermatogenesis). This is where the germ cells and the Sertoli cells are located. Within the testicle interstitium are found hormone-producing Leydig cells, along with other cells.

Vessels and nerves of the testis

Arterial supply to the testis is via the aortal a. testicularis, which reaches the testis via the inguinal canal. The plexus pampiniformis collects the venous blood and passes it to the right, into the inferior v. cava, via the v. testicularis. It is then taken to the left, into the v. renalis sinistra. Vegetative innervation occurs via the plexus coeliacus, whose fibers lead to the testis via the a. testicularis.

The structure and function of the epididymis

The epididymis is the place where sperm undergoes storage and maturation. It consists of the caput (head), corpus (body) and cauda (tail) epididymis.

The caput is located on the upper pole of the testis and it contains the ductuli efferentes (efferent ducts) that are connected to the rete testis of the testis. The corpus and the cauda are dorsal to the testis.

The ductuli efferentes continue into the ductus epididymis, which leads into the ductus deferens (vas deferens) of the cauda. Arterial supply to the epididymis occurs via a terminal branch of the a. testicularis and via a branch of the arteria deferentialis (a. ductus deferentis).

The vas deferens, the vessels and nerves, the connective tissue, and the coverings of both the testis and the epididymis comprise the funiculus spermaticus (the spermatic cord), which reaches the abdominal cavity via the inguinal canal.
The course of the ductus deferens (vas deferens)

The ductus deferens is about 40-50 cm long and it serves to transport sperm from the epididymis to the male urethral-spermatiduct. It starts as a continuation of the ductus epididymis on the lower part of the epididymis, and, within the spermatiduct (funiculus spermaticus), it reaches the abdominal cavity via the inguinal canal. There, it leads subperitoneally along the wall of the pelvis minor, to then be placed dorsal to the bladder.

Towards the end is an extension, the ampulla ductus deferentis. The ductus deferens continues as the ductus ejaculatoris, which leads to the urethra.

The substance and coverings of the spermatiduct cord

Like the ductus deferens, the spermatiduct cord (funiculus spermaticus) contains the artery and vein to the ductus deferens; the testicular artery and vein and the cremasteric artery; the pampiniform venous plexus; the lymph vessels; the autonomic nerves (plexus testicularis); and the r. genitalis n. genitofemoralis. These structures, together with their coverings (which correspond with the coverings of the testis), pass via the inguinal canal to the spermatiduct cord.

The substance and the coverings of the spermatiduct cord are always a popular exam topic. Whoever is familiar with this will be able to gain important points – with minimum effort.
These coverings correspond with the layers of the abdominal wall which migrated together with the testis through the inguinal canal into the scrotum (descensus testis), during the seventh month of gestation.

The following are the coverings of the spermatic cord, from the outer part to the inner part (with their analogous layers of the abdominal wall):

- the fascia spermatica externa (Fascia abdominis superficialis)
- the fascia cremasterica
- the m. cremaster (M. obliquus internus abdominis with is fascia)
- the fascia spermatica interna (fascia transversalis)

The location and function of the Glandula vesiculosa (seminal vesicle)

The **glandula vesiculosa** is a sack about 10-15 cm long, which is attached to the posterior wall of the bladder, in pairs. Dorsal of the posterior wall of the bladder is the seminal vesicles – lateral to the **ampullae ductus deferentis**, but medial to the ureters.

The seminal vesicles are extraperitoneal, with their fundus being in contact with the peritoneum of the **excavatio rectovesicalis**.

The excretory duct of the **glandula vesiculosa**, the **ductus excretorius**, leads into the **ductus deferentis**, within the prostate.

The viscous secretion of the **glandula vesiculosae** contains fructose, which is important for sperm motility. Approximately 70% of the ejaculation is secreted by the seminal vesicle.

The structure of the prostate

The prostate (**glandula prostatica**) is firm and resilient, it’s size is comparable to that of a chestnut. It is located between the base of the bladder and the urogenital diaphragm. It encases the prostatic part of the urethra. It is surrounded by a capsule of rough connective tissue.

The prostate consists of five lobes: an anterior lobe, a posterior lobe, two lateral lobes, and a median lobe. The anterior lobe, or isthmus, lies anterior to the urethra while the posterior lobe lies posterior to the urethra and inferior to the ejaculatory ducts. The lateral lobes lie on either side of the urethra and are a large portion of the prostate. The median lobe lies between the urethra and the ejaculatory ducts.

The posterior lobe is palpated during the digital rectal examination. The prostate is best examined when the bladder is full which provides adequate pressure to hold the prostate in place.

The prostate can also be divided into three zones: the periurethral zone around the urethra, the inner zone, and the outer zone. Benign prostatic hyperplasia involves an enlargement of the periurethral zone. This is a common finding in the case of elderly patients. Prostate carcinoma, on the other hand, usually starts from the outer zone of the prostate.
The function of the prostate

The prostate is an **exocrine** gland that produces a weakly acidic secretion (pH: 6.4). Spermine, included in the secretion, affects sperm motility.

The location and function of Cowper’s glands

Cowper’s glands (*glandula bulbourethrales*) with their viscous secretions ensure the lubricity of the urethra for the ejaculate. These round, pea-sized glands are on the posterior end of the bulbus penis in the pelvic base area. Their excretory duct is about five centimeters long and leads into the **spongy part of the urethra**.

The final common pathway in the ejaculatory duct

The **ejaculatory duct** (*ductus ejaculatorius*) is the end section shared by the **ductus deferens** and the **ductus excretorius** belonging to the seminal vesicle. This ductus ejaculatorius runs through the prostate and passes within the prostate on the seminal hillock (*colliculus seminalis*). This opening is located on both sites of the **prostatic utricle**, a blind sack which represents a rudiment of the Mullerian duct, and which is approximately one centimeter long.

The prostate is supplied via the **inferior vesical artery** and drained via the **prostatic venous plexus**, which drains into the **iliac vein**. Neural supply to the prostate is via the sympathetic fibers of the **lumbar splanchnic nerves** and by means of parasympathetic fibers from the **pelvic splanchnic nerves**.

The Formation of Male Germ Cells

(Spermatogenesis)

Spermatogenesis is the formation of male gametes. It starts before birth and from puberty onwards, this takes place in the testis. In contrast to what happens in the case of women, in men, this involves a continuous formation process.

Through mitoses of spermatogonia, the original germ cells of the testis, men have a stem cell reserve, from which sperm can constantly be produced. In the case of women, however, the maximum number of oocytes is reached in the seventh embryonic month and decreases thereafter.

Histologically the testis is a tubular organ. The **seminiferous tubules** lead to a common network, the rete testis, which in turn leads to the **efferent ducts** of the epididymis. From this point, there is a connection to the **ductus deferens** (sperm duct), via the **ductus epididymis**.

The Sertoli cells are located in the tubuli seminiferi, and in their role as supporting cells and nutrition provided to the cells they support the process of spermatogenesis. They also support the germ cells themselves-spermatogonia. The cells rest on the basal membrane.

During the development of sperm, which lasts approximately 70 days, the cells migrate from the basal membrane to the lumen of the **seminiferous tubules**.
Maturation of the spermatogonia

The spermatogonia, designed for reproduction, develop into first-order spermatocytes. These perform the first meiotic division (meiosis) and thus become second-order spermatocytes. These, in turn, perform the second meiotic division and become spermatids.

During meiosis recombination of the genetic material occurs. The spermatids have a haploid set of chromosomes (23X or 23Y). They must further maturate while in the testis and eventually reach the final stage of spermatozoa (sperm). This last stage of development is called spermiogenesis (spermatids → spermatozoa).

Through additional maturation in the epididymis, the sperm finally obtains their full mobility.

Breakdown of spermatogenesis

Spermatogenesis requires a temperature of 32 °C, and storage within the scrotum ensures this is the case. If the testis is kept too warm, for instance by wearing tight clothing or taking a hot bath, this can result in decreased sperm production and even to temporary infertility.

In case of undescended testis (also called cryptorchidism or inguinal testicle), migration (descensus) of the testis from the abdomen into the scrotum fails to occur in the third to the tenth embryonic month. An inguinal testicle occurs in approximately 3—5% of newborns and should be remedied hormonally or surgically by the end of the first year of life in order to prevent damage to the testicle.
The External Male Genitals

The external male genitals consist of:

- the penis (member)
- the scrotum (scrotum sac)
- the male urethra/urethra masculina (male urethral-spermatic duct)

The structure of the penis

The penis (member) contains the urethra (urethral-spermatic duct) and has several cavernous bodies, which are responsible for the erection. The paired roots of the penis (radix penis) is attached to the pubic branches and the pelvic base. The freely moveable corpus penis (shaft) terminates distally in the glans penis (glans).

The penis shaft is covered by a thin, movable skin, which forms on the preputium (prepuce) at the glans. This, along with the frenulum of prepuce of the penis (or simply frenulum), is attached at the bottom of the glans.

The cavernous bodies of the penis

The cavernous bodies of the penis include the paired corpora cavernosa (the cavernous bodies of the penis) and the unpaired corpus spongiosum penis (the erectile tissue of the penis).

The two cavernous bodies of the penis are connected by the deep penis fascia and form the penis shaft. The corpora cavernosa penis then each continue into a crus penis (the crus of the penis), which is attached to the pubic branch and encased by the ischiocavernosus muscle. The tunica albuginea encases the two corpora cavernosa that are separated by the septum penis in the middle.

The urethral-spermatic duct is located in the corpus spongiosum penis, on the bottom of the corpora cavernosa. The erectile tissue of the penis starts with the bulbus penis at the diaphragm urogenitale, and this bulbus penis is surrounded by the bulbospongiosus muscle, and it continues distally into the cavernous bodies of the glans.

Vessels of the penis

Arterial supply to the penis occurs via branches of the internal pudendal artery and the internal iliac artery. The a. profunda penis reaches the penis tip through the corpus cavernosum. It releases the helicine arteries of the penis, which expand upon sexual arousal and fill the cavities of the corpora cavernosa with blood. This provides enlargement and a stiffening of the penis (erection). The dorsal artery of the penis supplies the glans penis.

Innervation of the penis

The penis is somatosensorily supplied by the n. dorsalis penis, a branch of the n. pudendis. Fibers of the nervi splanchnici pelvici (parasympathetic, S2-S4) and the nervi splanchnici sacrales (sympathetic) control the erection (parasympathetic) and the ejaculation (sympathetic).
The structure and function of the male urethra

The male urethra (urethra masculina) is assigned to the external male genitals by many authors, together with the member (penis) and the scrotum (scrotum sac). The urethra forms the last part of the urinary system (the renal pelvis, the ureter, the bladder, and the urethra).

It leads from the bladder to the external opening of the urinary tract. Unlike the female urethra, it serves to transport not only urine but also ejaculate. Therefore, it is also referred to as the urethral-spermatic duct.

The male urethra is about 20 cm long and it is subdivided into four sections. It possesses three corresponding constrictions and expanses, which is always a popular exam topic.

The sections of the male urethra

- **the pars intramuralis urethrae musculinae** (intemural part of the male urethra), located in the wall of the urinary bladder, surrounded by the musculus sphincter urethrae internus.

- **the pars prostatica urethrae** (prostatic urethra), which runs through the prostate - here, the opening of the two ductus ejaculatorii is, in each case, on the colliculus seminalis (seminal hillock), going into the urethra.
- the pars membranacea urethrae masculinae (membranous urethra) in the area of the diaphragm urogenitale: this is a short section between the prostate and the cavernous body, surrounded by the m. sphincter urethrae externus (split-offs from the musculus transversus perinei profundus). The ampulla urethrae are located in the distal section with the outlets of the gll. bulbourethrales.

- the pars spongiosa (spongy urethra) in the spongy body of the penis: longest section (approximately 15 cm). The Pars spongiosa disembogues with the ostium urethrae externum at the glans penis, following the extension, fossa navicularis urethrae.

The constrictions and expenses of the male urethra

The male urethra has two curvatures which together form an S-shape. The so-called fixed curvature (curvatura infrapubica) is located at the entrance of the corpus cavernosum. The movable urethra bend (curvature prepubica) is located at the transition to the moving part of the penis.

The three constrictions are located:

1. in the pars intramuralis (m. sphincter urethrae internus),
2. in the pars membranacea urethrae (m. sphincter urethrae externus, the narrowest part of the urethra)
3. at the ostium urethrae externum

These are the three expenses:

1. the pars prostatica
2. the ampulla urethrae
3. the fossa navicularis urethrae

Transurethral catheterization for men

Knowledge about the constrictions, expenses, and curvatures of the male urethra are not just a recurring exam topic in attestations and exams, they are also important when it comes to urological surgery or catheterization.

Being longer than the female urethra, the male urethra enjoys better protection against infections - yet this also makes it more difficult to catheterize the male urethra. The penis is lifted and overstretched when attempting to compensate for curvature prepubica.

Review Questions

The answers are found below the references.

1. How long does sperm maturation take (based on the division of the spermatogonia)?
   
   A. 3 – 4 weeks
   B. 5 days
   C. 24 hours
   D. 70 – 80 days
   E. 6 months
2. Fructose in semen provides nutrition for spermatozoa. Which anatomical structure is responsible for the production of the fructose-containing secretion?

A. The prostate  
B. Glandula bulbourethral  
C. Eq. vesiculosa  
D. Epididymis  
E. Corpus spongiosum penis

3. What are the means by which the male erection is controlled?

A. Nn. splanchnici sacrales  
B. Nn. splanchnici pelvici  
C. N. dorsalis penis  
D. D.R. genitalis n. genitofemoralis  
E. Vegetative fibers from the ggl. coeliacum

References


Wilson, J. (1821). Lectures on the structure and physiology of the male urinary and genital organs of the human body and on the nature and treatment of their diseases: Delivered before the Royal College of Surgeons in 1821. London: Burgess and Hill.

Correct answers: 1D, 2C, 3B

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