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.

Human Urogenital System

The urogenital system, as the name suggests, comprises 2 main components: the urinary tract related to urine production, the kidney and the urinary organs (ureter, bladder, and urethra) and the genitals.

Although urinary and genital systems exhibit different functions, they are topographically and functionally linked based on developmental origin. The male and female genital organs are additionally divided into internal and external genitals.

Classification of Male Genital Organs

Similar to female genitals, male genitals can be divided into internal and external genital organs based on embryonic organ development, for e.g., the testicle is considered an internal genital organ, even though it leaves the abdominal cavity during the course of
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: **vesicula seminalis** (the seminal vesicle), paired; **bulbourethral glands** (Cowper’s gland), paired; and **the prostate** (the prostate gland)

Functions of 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.

**Location of the testis**

The plum-shaped, firm, resilient testis is about 4–5 centimeters long. It is located outside the abdominal cavity in the scrotum, a 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 dorsomedially located mediastinum testis.

**Tunica vaginalis**

The testis is ensheathed by several layers derived from muscles and fascia of the abdominal wall as well as the peritoneum. The sequence of the tunica vaginalis from the outer to the inner regions is:

- external spermatic fascia (fascia spermatica externa)
- cremasteric fascia (fascia cremasterica)
- cremaster muscle (m. cremaster)
- internal spermatic fascia (fascia spermatica interna)
- 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, i.e., the periorchium. Both laminae encase the scrotal cavity.

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

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

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

Vessels and nerves of the testis

Arterial supply to the testis is via the arteria 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 vena cava, via the vena testicularis. The blood is then shunted to the left, into the vena renalis sinistra. Vegetative innervation occurs via the plexus coeliacus, whose fibers lead to the testis via the arteria testicularis.

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 contains the efferent ducts that are connected to the rete testis. The corpus and the cauda lie dorsal to the testis.

The efferent ducts 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 arteria testicularis and through a branch of the arteria deferentialis (arteria ductus deferentis).

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

The vas deferens is about 40–50 cm (15.7–19.6 in) long and serves to transport sperm from the epididymis to the male urethral-spermatic duct. It continues from the ductus epididymis along the lower epididymis, and within the spermatic cord (funiculus spermaticus), and reaches the abdominal cavity via the inguinal canal, where it leads subperitoneally along the wall of the pelvis minor, and lies 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 spermatic cord

Similar to the ductus deferens, the spermatic cord (funiculus spermaticus) carries the blood vessels into 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 ramus genitalis nervi genitofemoralis. These structures, together with their coverings (which correspond to the layers of the testis), pass via the inguinal canal to the spermatic cord.

These coverings correspond to the layers of the abdominal wall, which migrated together
with the testis through the inguinal canal into the scrotum (descensus testis), during the 7th month of gestation.

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

- fascia spermatica externa (fascia abdominis superficialis)
- fascia cremasterica
- musculus cremaster (musculus obliquus internus abdominis, which is fascia)
- fascia spermatica interna (fascia transversalis)

**Location and function of seminal vesicle**

The seminal vesicle is a sac about 10–15 cm (3.9–5.9 in) long and is attached to the posterior wall of the bladder, in pairs. Seminal vesicles are located dorsal to the posterior wall of the bladder—lateral to the ampullae ductus deferentis, but medial to the ureters. The seminal vesicles are extraperitoneal, with their fundus in contact with the peritoneum of the excavatio rectovesicalis.

The excretory duct of the seminal vesicle, the ductus excretorius, leads into the ductus deferentis, within the prostate.

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

**Structure of the prostate**

The prostate is firm and resilient and comparable to chestnut in size. It is located between the base of the bladder and the urogenital diaphragm. It encases the prostatic portion of the urethra. It is surrounded by a capsule of rough connective tissue.

The prostate consists of 5 lobes: an anterior lobe, a posterior lobe, 2 lateral lobes, and a median lobe. The anterior lobe, or isthmus, lies anterior to the urethra while the posterior lobe is posterior to the urethra and inferior to the ejaculatory ducts. The lateral lobes lie on either side of the urethra and constitute 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 is also divided into 3 zones: the periurethral zone around the urethra, the inner zone, and the outer zone. Benign prostatic hyperplasia involves an enlargement of the periurethral zone, especially in the case of elderly patients. Prostate carcinoma, however, usually starts from the outer zone of the prostate.

**Prostate function**

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 with their viscous secretions provide lubrication of the urethra for the ejaculate. These round, pea-sized glands are located at the posterior end of the bulbus
The final common pathway in the ejaculatory duct

The ejaculatory duct is the terminal portion shared by the ductus deferens and the ductus excretorius belonging to the seminal vesicle. The ejaculatory duct traverses the prostate inside the gland on the seminal hillock (colliculus seminalis). This opening is located on both sites of the prostatic utricle, a blind sack representing a rudiment of the Mullerian duct, which is approx. 1 cm (0.4 in) long.

The prostate is supplied via the inferior vesical artery and drained via the prostatic venous plexus into the iliac vein. The neural supply to the prostate occurs via the prostatic plexus facilitated by the sympathetic fibers of the lumbar splanchnic nerves and by the parasympathetic fibers emerging from the pelvic splanchnic nerves.

The Formation of Male Germ Cells
(Spermatogenesis)

Spermatogenesis or the formation of male gametes starts before birth and from puberty onwards occurs in the testis. Compared with women, germ cells are produced continuously in men.

Mitosis of spermatogonia, the original germ cells of the testis, generates a stem cell reserve to produce sperm constantly. In the case of women, however, the maximum number of oocytes is reached in the 7th 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 lead to efferent ducts of the epididymis. They are connected to the ductus deferens (sperm duct) via the ductus epididymis.

Sertoli cells are located in the tubuli seminiferi and act as supporting cells. Healthy Sertoli cells facilitate 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 approx. 70 days, the cells migrate from the basal membrane to the lumen of seminiferous tubules.

Maturation of the spermatogonia

The spermatogonia, designed for reproduction, develop into 1st-order spermatocytes. Following the 1st meiotic division (meiosis) they become 2nd-order spermatocytes, which in turn undergo a 2nd meiotic division to form spermatids.

Genetic recombination occurs during meiosis. The spermatids carry a haploid set of chromosomes (23X or 23Y), which further mature in the testis and eventually reach the final stage of spermatozoa (sperm). The process is called spermiogenesis (spermatids → spermatozoa). After additional maturation in the epididymis, the sperm finally obtain their full mobility.
Breakdown of spermatogenesis

Spermatogenesis requires a temperature of 32°C (89.6°F), which is provided by storage within the scrotum. However, if the testis is kept too warm, for instance, by wearing tight clothing or taking frequent hot baths, it can result in decreased sperm production and sub-fertility.

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 approx. 3-5% of newborns and should be remedied hormonally or surgically by the end of the 1st year of life in order to prevent testicular damage.

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)

Structure of the penis

The penis (member) contains the urethra (urethral-spermatic duct) and consists of several cavernous bodies, which are responsible for the erection. The paired roots of the penis (radix penis) are 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, which along with the **frenulum of the penis** (or simply frenulum), is attached at the bottom of the glans.

### 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** (the erectile tissue).

The 2 cavernous bodies of the penis are connected by the deep penis fascia and form the penis shaft. Each of the corpora cavernosa continues 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 2 corpora cavernosa that are separated by the septum in the middle.

The urethral-spermatic duct is located in the corpus spongiosum, on the bottom of the corpora cavernosa. The erectile tissue of the penis starts with the bulbus penis at the diaphragm urogenital, which is surrounded by the **bulbospongiosus muscle** and 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 arteria 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, which enlarges and stiffens the penis (erection). The **dorsal artery of the penis** supplies the glans penis.

### Innervation of the penis

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

The male urethra (urethra masculina) is considered part of 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 (renal pelvis, ureter, bladder, and 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 (7.8 in) long and is subdivided into 4 sections. It contains 3 corresponding constrictions and expansions.

Sections of the male urethra

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

- **Pars prostatica urethrae** (prostatic urethra), which runs through the prostate. The openings of the 2 ejaculatory ducts are on the **colliculus seminalis** (seminal hillock) leading into the urethra.
Pars membranacea urethrae masculinae (membranous urethra) in the area of the diaphragm urogenitale is a short section between the prostate and the cavernous body, surrounded by the musculus 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 bulbourethral glands.

Pars spongiosa (spongy urethra) in the spongy body of the penis is the longest section (approx. 15 cm (5.9 in)). The pars spongiosa drains into the ostium urethrae externum at the glans penis, following the extension, fossa navicularis urethrae.

Constrictions and Expansions of the male urethra

The male urethra carries 2 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 (curvatura prepubica) is located at the transition to the moving part of the penis.

The 3 constrictions are located:

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

The 3 subdivisions of urethra include:

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

Transurethral catheterization for men

Knowledge about the constrictions, expansions, 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; however, it is also difficult to catheterize the male urethra. The penis is lifted and overstretched when attempting to compensate for curvature prepubica.

References


Wilson, J. (1821). Lectures on the structure and physiology of the male urinary and genital