Ureter, Urethra, Urinary Bladder — The Urogenital System

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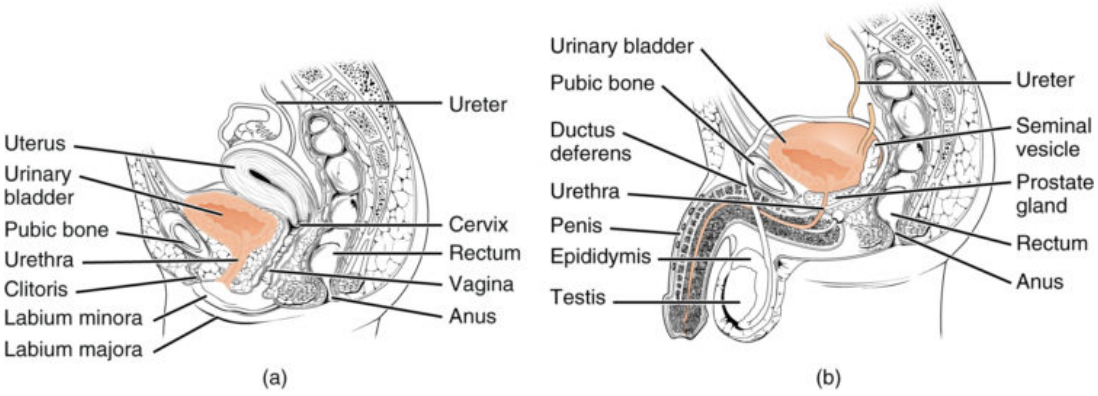
The term urogenital system compromises the genital and urinary organs. Besides having different tasks, they have a common embryological origin and are often discussed in relation to each other in a clinical perspective. The following article focuses on the diverting urinary organs, therefore the part from the ureters to the urinary bladder up to the urethra is regarded. The physiology also attracts attention concerning the micturition process apart from the anatomic aspect.



Ureter

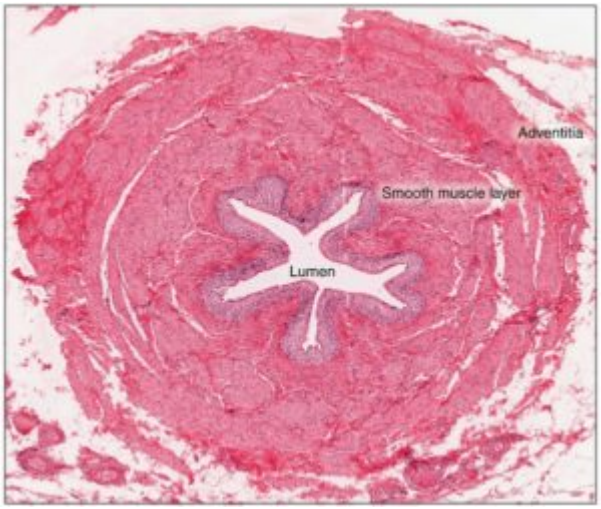


Image: Peristaltic contractions help to move urine through the lumen with contributions from fluid pressure and gravity. By Phil Schatz, Licence: CC BY 4.0

These are hollow organs that are organized in pairs and have an average length of 25–30 cm and connect the renal pelvis with the urinary bladder. The right ureter as compared to its partner is a bit shorter which correlates to the fact that the liver is located on the right side and is quite large.

Structure of the ureters

The ureters consist of 3 layers of tissue :

- An outer covering of fibrous tissue, continuous with the fibrous capsule of the kidney
- A middle muscular layer consisting of interlacing smooth muscle fibers that form a syncytium spiraling around the ureter, some in clockwise and some in anticlockwise directions and an additional outer longitudinal layer in the lower 3rd
- An inner layer, the mucosa, lined with transitional epithelium.

Course of the Ureters

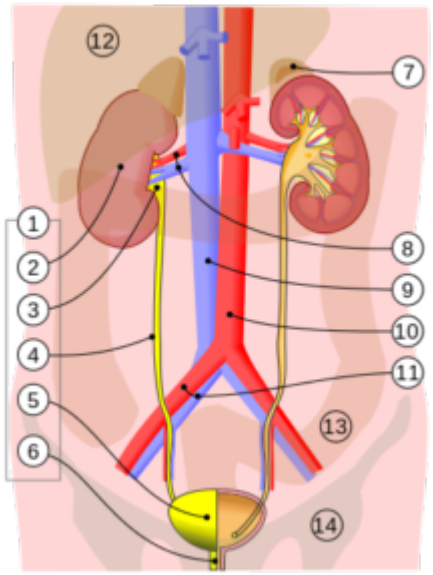


Image: Ureter (Schematic View): 1. Human urinary system: 2. Kidney, 3. Renal pelvis, 4. Ureter, 5. Urinary bladder, 6. Urethra (Left side with frontal section), 7. Adrenal gland. Vessels: 8. Renal artery and vein, 9. Inferior vena cava, 10. Abdominal aorta, 11. Common iliac artery and vein. With transparency: 12. Liver, 13. Large intestine, 14. Pelvis. By Jordi March i Nogué, License: CC BY-SA 3.0

Starting at the **renal pedicle**, the ureters run along the lateral edge of the *Musculus psoas major* in the retroperitoneal space from which point they **cross under** the *Arteria* and *Vena testicularis* or *ovarica* and finally **cross over** to the *Arteria* and *Vena iliaca communis*.

The ureters cross the small pelvis and cross under the Ductus deferens or the *Arteria uterine*. Finally, they flow from the back of the urinary bladder.

The diagonal entry is appropriately located as the ureters are, for example, they are pressed together by the surrounding muscles when lying down, so that urine cannot flow

back.

The ureters pass 3 physiological obstacles, the so-called ureter narrowings which dispose of inhibition for the transport, for example concerning the discharge of urinary calculi:

1. **Upper narrowing:** exit area from the renal pelvis
2. **Middle narrowing:** Crossing of the *Arteria iliaca externa* or *communis*
3. **Lower narrowing:** Passing through the urinary bladder wall

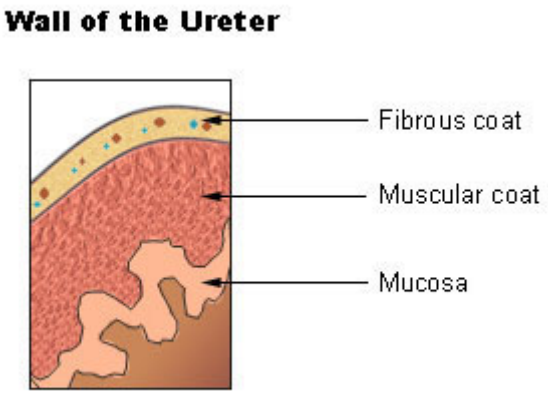
The ureter can anatomically be divided into 3 areas:

1. ***Pars abdominalis*** (kidney to *Linea terminalis*, back abdominal wall)
2. ***Pars pelvina*** (*Linea terminalis* to urinary bladder)
3. ***Pars intramurales*** (diagonally passes the bladder wall, important for the micturition process)

Note: The ureters are divided differently in a radiological context; the upper 3rd (renal pelvis to the upper end of the Os sacrum), the middle 3rd (upper to lower edge of the Os sacrum) and the distal 3rd (lower sacrum edge to the urinary bladder).

Histology/Microscopic anatomy of the ureter

Ureters consist of the following layers from the inside to the outside:



- Image: Wall of the ureter. By Arcadian, License: Public domain

Tunica mucosa: Urothelium of 4–5 cell layers which encloses a stellar lumen

- **Tela submucosa** or **Lamina propria:** loose connective tissue
- **Tunica muscularis:** spirally organized muscular tissues that are responsible for peristalsis. It is further divided into:
    - *Stratum longitudinale*
    - *Stratum circulare*
    - *Second Stratum longitudinale* (only in the pelvis area)
- **Tunica adventitia:** connective tissue layer in which blood and nerve vessels are located

Function of the ureter

On one hand, the ureters serve as a connection between the kidney and the urinary bladder.

On the other hand, their task is to transport urine. The by-products filtered by the kidney are lead in relation to water as urine or secondary urine to the ureters from the kidney in the ***Vesica urinaria*** (urinary bladder).

Image: Ultrasound demonstration of ureteral jet effect. By Nevit Dilmen, Licence: CC BY-SA 3.0

Peristaltic movements of the hollow organ are possible through the *Tunica muscularis*, so that urine can be transported in other body positions other than just when standing in the direction of the urinary bladder. The peristaltic wave takes place 1–4 times per minute. Through relaxation, urine is absorbed in the ureter and is transported caudally through the contraction of the walls.

Vascular supply of the ureter

Arterial:

The supply is assured by the small branches of the surrounding arteries or the *Rami ureterici* which arise from the arteries in the surroundings. The following arteries are involved:

- *Pars abdominalis*: *Arteria. renalis*, *A. testicularis* (in men), and *A. ovarica* (in women)
- *Pars pelvica*: *A. iliaca communis*, *A. iliaca externa* and *interna* with its visceral branches

Venous

The venous return passes the veins which run analogically along the arteries which also have the same name.

Nerval

The muscle contractions of the ureters are caused by pacemaker cells of the renal pelvis calico pelvic system so that the ureters contract from cranial to caudal and transport

urine in the direction of the urinary bladder.

The vegetative nerve system has the following influence:

The sympathetic innervation is assured by the *Ganglia aorticorenalia* and the *Plexus hypogastricus inferior.* These influence the regulation of vascular tone by inhibiting the ureter peristalsis.

The ureters are supplied parasympathetically through the *Nervi splanchnici pelvici* and partly through the *Nervus vagus*. These provide support and promote the ureter peristalsis.

Lymphatic

The lymphatic drainage of the left upper ureter takes place in the **paraortal lymph nodes** and that of the right upper ureter takes place in the **paracaval** as well as in the **interortocaval lymph nodes**. The lower part of the ureter drains its lymph-obliged load in the ***Nodi lympahtici iliacae and obturatoriae*** (pelvis lymph nodes).

Diseases and malformations of the ureter

Malformations

In the case of malformations of the ureter, the result is a disturbing urine transport or reflux. These can again cause several secondary diseases: hydroureter (extended ureters), recurring infections, inflammations of the kidney and its pelvis, formation of kidney and urinary calculi, and renal insufficiency.

In the case of constant reflux, it is possible that the inflammations of the renal pelvis and the urinary bladder are chronified. The manifested inflammations can again cause a **malakoplakia** (grey-whitish plaque at the ureter wall) or a ***Urerteritis cystica***.

The most common malformations are, amongst other things, ureteroceles, ureter orifice narrowings, and ureterectopies.

Ureteritis

Inflammation of a ureter is usually due to the upward spread of infection in cystitis.

Acute cystitis

This is an inflammation of the bladder and may be due to:

- Spread of microbes that are commensals of the bowel *(Escherichia coli* and *Streptococcus faecalis)* from the perineum, especially in women because of the short wide urethra, its proximity to the anus and the moist perineal conditions
- Mixed infection of coliform and other organisms which may follow the passage of a urinary catheter or other instruments
- Inflammation in the absence of microbes, e.g., following radiotherapy or passage of a catheter or other instrument.

The effects are inflammation, edema and small hemorrhages of the mucosa, which may be accompanied by hematuria. There is hypersensitivity of the sensory nerve endings in the bladder wall, which are stimulated before the bladder has filled leading to the frequency of micturition and dysuria (a burning sensation on micturition).

The urine may appear cloudy and have an unpleasant smell. Lower abdominal pain often

accompanies cystitis.

Predisposing factors: The most important predisposing factors are coliform microbes in the perineal region and stasis of urine in the bladder.

During sexual intercourse, there may be trauma to the urethra and transfer of microbes from the perineum, especially in the female.

Hormones associated with pregnancy cause relaxation of the perineal muscle and relaxation and kinking of the ureters. Towards the end of pregnancy, the pressure caused by the fetus may obstruct the outflow of urine.

In men, prostatitis provides a focus of local infection or an enlarged prostate gland may cause progressive urethral obstruction.

Chronic cystitis

This may follow repeated attacks of acute cystitis. It occurs most commonly in men over 60 years of age when compression of the urethra by an enlarged prostate gland prevents the bladder from emptying completely.

Ureter calculi, urinary calculi, and kidney calculi

The possibility of the formation of calculi increases with increasing age whereby men and women are affected equally.

The so-called calculi or these crystal accumulations can be caused by strongly concentrated urine accumulations, excessive meat consumption, inflammation as well as the congenital distraction of the deterioration of certain by-products, in which they do not dissolve in the urine and therefore accumulate as crystals.

In the prominent part of the calculi, about 70% consists of calcium oxalate and is produced by the lack of calculi dissolving substances or through an excess of calcium or oxalate. Ten to 15% of calculi are induced by seasoned purine bodies or excessive meat or alcohol consumption. Other calculi are caused by infection, cysteine, and xanthic stones which occur only rarely.

Uretercarcinoma

In the case of this malignant tumor, there are about 95% new malignant formations of the urothelium. The squamous epithelium is rarely affected. It occurs very rarely, and men at the age of 50–60 years are affected the most.

Symptoms mostly occur late. They appear in the form of microscopic hematuria or macroscopic hematuria. Additionally, a ureter blockage can cause 1-sided urinary retention through the tumor. In most cases, the pain only occurs when the metastasis takes place in the carcinoma. The 1st metastasis in most cases occurs in the liver, the lungs or the skeleton system.

Urinary Bladder

The *Vesica urinaria* is a muscular hollow organ that contains, depending on the size, 800–1500 mL urine fluid.

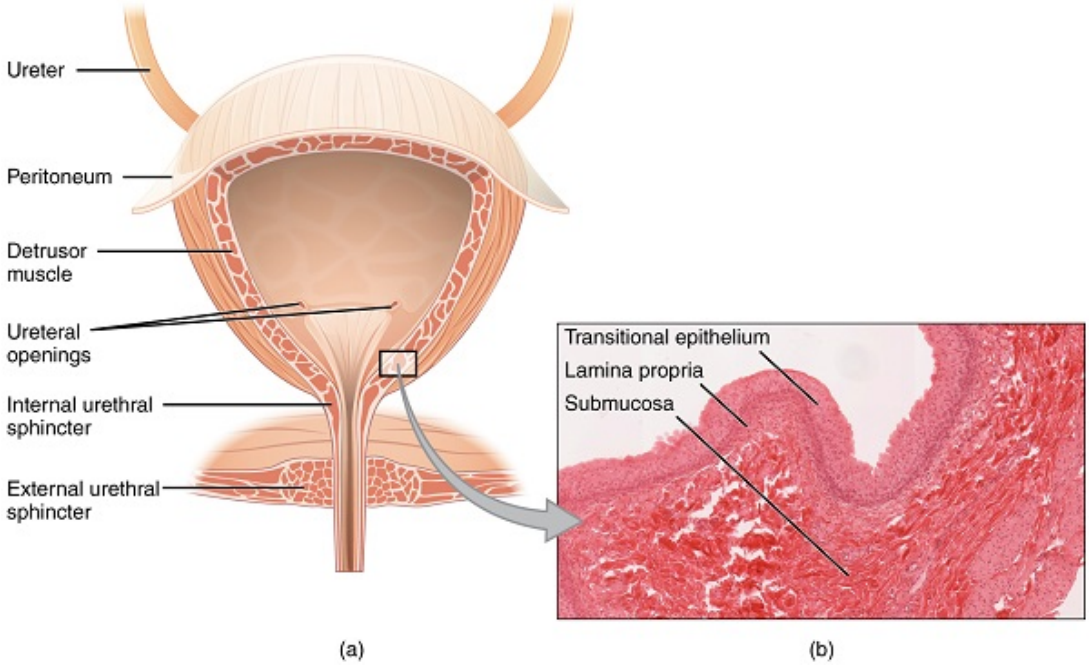


Image: (a) Anterior cross-section of the bladder. (b) The detrusor muscle of the bladder. By Phil Schatz, Licence: CC BY 4.0

Location of the urinary bladder

The urinary bladder is located retroperitoneally and is limited ventrally by the symphysis and the abdominal wall. In between lies the ***Spatium retropubicum*****,** which is filled with loose connective tissue and makes the cranial extension of the bladder, in case of the corresponding filling, possible.

The upper part of the urinary bladder is covered with peritoneum which runs from the ***Apex vesicae*** to the contact point of the ureters. The bladder is fixed from ventral cranial through the ***Ligamentum umbilicale medianum*** (*Apex vesicae* to navel). The peritoneal pouch is located on the backside of the bladder (man: *Excavatio rectovesicalis*, woman: *Excavatio vesicouterina*). At the caudal, the bladder is limited by the levator gap.

The prostate is located beneath the *Fundus vesicae*.

Anatomy of the urinary bladder

Anatomically, 4 areas exist:

- ***Apex vesicae*****:** the cranial area, covered by the peritoneum
- ***Corpus vesicae*****:** bladder body
- ***Fundus vesicae*****:** bladder base, on the inside the *Trigonum vesicae* is formed which is of ***Ostia ureterum*** (entries of the ureters) and the ***Ostium urethrae internum*** (exit of the urethra), cranial limitation through the *Plica interureterica* (fold of the mucous tissue between the ureters)
- ***Cervix vesicae*****:** bladder neck, funnel-shaped

Microscopic analysis:

The urinary bladder is composed of the following from the inside to the outside:

- ***Tunica mucosa*****:** urotehlion, in the *Trigonum vesicae* is the *Tunica mucosa* (*Lamina propria* is missing)

- ***Tela submucosa*:** *Lamina propria* (loose connective tissue), does not exist in the clinging *Trigonum vesicae*
- ***Tunica muscularis*:** smooth muscles which work as a functional entity in the form of the *M. detrusor vesicae*, but are differentiated again as follows:
    - *Stratum longitudinale internum*
    - *Stratum circulare*
    - *Stratum longitudinale externum*
- ***Tunica adventitia*:** loose connective tissue, called ***Tela subserosa*** in the peritoneal covered area
- ***Tunica serosa*:** partially existing peritoneal layer

Holding muscles of the urinary bladder

The bladder is only fixed on 2 points on the pelvic floor in order to cranially extend while filling up. These points are the *Fundus* and the *Cervix vesicae*.

But there are additional ligament mechanisms:

- ***Pubovesicale*** (Symphysis – *Fundus vesicae*)
- ***Puboprostatica*** (Symphysis – *Prostata*)
- ***Septa rectovesicalia*** (women: Os sacrum – rectum, men: Os sacrum – rectum – prostate)

Vascular supply of the urinary bladder

Arterial

- ***Vesicalis superior*:** supplies *Apex vesicae* and *Corpus vesicae*
- ***Vesicalis inferior*:** supplies *Fundus vesicae*
- ***Rectalis media*:** supplies the dorsal side of the bladder

Venous

The venous return is taken over by the ***Plexus venosus vesicalis***.

Nerval

The sympathetic innervation happens through the ***Plexus vesicalis*** (Th12–L1).

The urinal bladder is parasympathetically supplied by the ***Plexus hypogastricus inferior*** (S2–S4).

Musculus sphincter vesicae

The sphincter muscle of the urinary bladder serves as a closure mechanism and contains smooth as well as striated muscles. It has close contact to the muscles of the pelvic floor, but should strictly be distinguished from it.

The ‘smooth urinary bladder sphincter’, also called lissosphincter, circularly and longitudinally encloses the bladder neck from the *Trigonum vesicae*.

The striated part of the sphincter is hoof-shaped. There are again differences concerning its concrete place between the male and female wing: In women, the muscle fibers surround the proximal to the middle area of the urethra. In men, the striated part of the prostate runs through the whole extension of the membranous urethra.

Acquired and congenital disorders of the urinary bladder

The different diseases and restrictions are numerous, hence not everything can be mentioned and explained in this section. Only the most important disorders are named and briefly explained.

One of the most common diseases of the urinary bladder is the inflammation of the bladder, or cystitis, which is accompanied by pain in the lower abdomen and painful passing of urine. The infection often ascends from the urethra and as women have a shorter urethra, they suffer from it more often.

Physical influences (e.g., stress or fear) or physical impacts (e.g., in the case of paraplegia, detrusor-sphincter-dyssynergia) can cause a dysfunction in the closure mechanism and hence cause **urinary incontinence**. In particular, stress and burden incontinence is distinguished from urge incontinence. In this condition, there is involuntary passage of urine due to defective voluntary control of the external urethral sphincter.

Stress incontinence: This is leakage of urine when intra-abdominal pressure is raised, e.g., on coughing, laughing, sneezing, or lifting. It usually affects women when there is the weakness of the muscles of the pelvic floor or pelvic ligaments, e.g., after childbirth or as part of the aging process.

Urge incontinence: Leakage of urine follows a sudden and intense urge to void and may be due to a urinary tract infection, calculus, tumor or sudden stress.

Retention and overflow incontinence

This occurs when there is:

- Retention of urine due to obstruction of the urinary outflow, e.g., enlarged prostate or urethral stricture
- A neurological abnormality affecting the nerves involved in micturition, e.g., stroke, spinal cord injury or multiple sclerosis.

The bladder becomes distended and when the pressure inside overcomes the resistance of the urethral sphincter, urine dribbles from the urethra. The individual may be unable to initiate and/or maintain micturition.

A prostatic adenoma can cause a very uncomfortable urinary retention. This again can lead to an extension of the bladder up to a strain (***Vesica gigantea***).

An important issue in this section is, of course, **bladder carcinoma**. In most cases, it comes from the urothelium and usually causes symptoms only in the later stages. Symptoms include pain, micturition disturbances (‘stuttering urination’) or urine discolored by blood. Men are often more affected than women and smoking is considered to be the main risk factor.

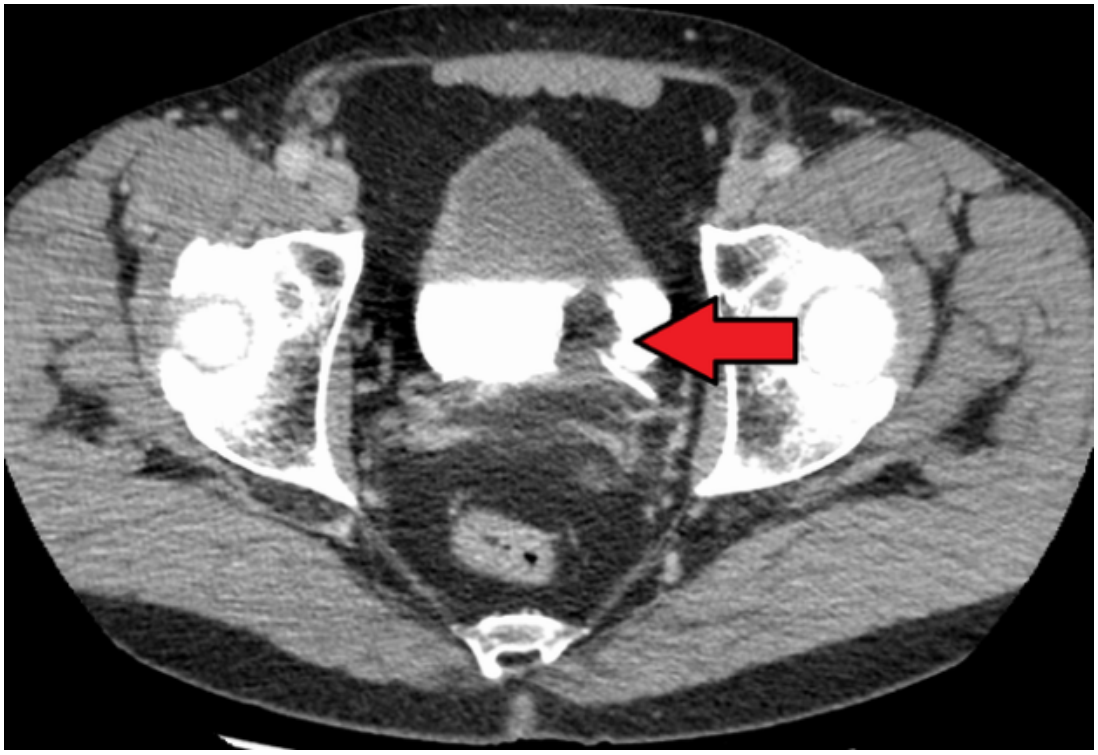


Image: Transitional cell carcinoma of the bladder. The white in the bladder is contrast. By James Heilman, MD.
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Urethra

As the anatomy of the urogenital wing in both men and women shows some significant differences, the structure of the urethras decisively mirrors them. Therefore, the urethras of both genders are examined separately.

Urethra feminina

The female urethra is clearly shorter than the male urethra with an average length of 3–5 cm. Because of the significantly shorter length, infections happen more frequently in women than in men, thus women are more prone to inflammation of the bladder.

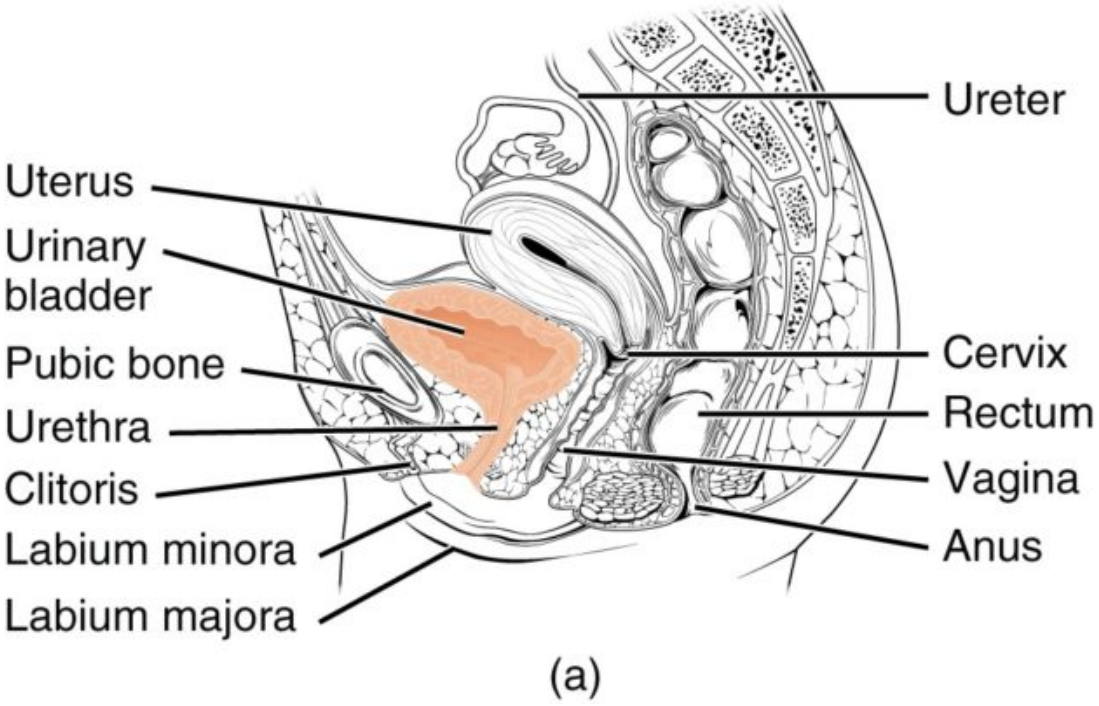

Image: The urethra transports urine from the bladder to the outside of the body. This image shows (a) a female urethra. By Phil Schatz, License: CC BY 4.0

Course of the female Urethra

Starting at the *Ostium urethrae internum*, the female urethra passes between the symphysis and the vagina into the *Vestibulum vaginae*. From this point, it extends to the back of the Glans clitoris in the *Ostium urethrae externum*.

Two parts of the female urethra are distinguished:

- *Pars intramuralis* (urinary bladder wall)
- *Pars cavernosa*

Microscopic anatomy of the female Urethra

The urethra consists of a histological perspective of the following layers, starting from the inside:

- ***Tunica mucosa*:** urothelium, merging into a multirow columnar epithelium and finally in a multi-layered non-cornified squamous epithelium. The lumen is formed as a slit.
- ***Tunica propria*:** with the vein net and the *Glandulae urethrales*
- ***Tunica muscularis*:** with the *Stratum longitudinale* and *circulare*

The supply of the urethra feminina takes place through the *Corpus spongiosum urethrae* which designate the plexus located there.

Urethra Masculina

The male urethra has an average length of 20–25 cm. It starts at the *Ostium urethrae internum* and ends at the end of the Glans penis, the *Ostium urethrae externum*. Its task

is, besides the passing of urine, the transport of seminal fluid.

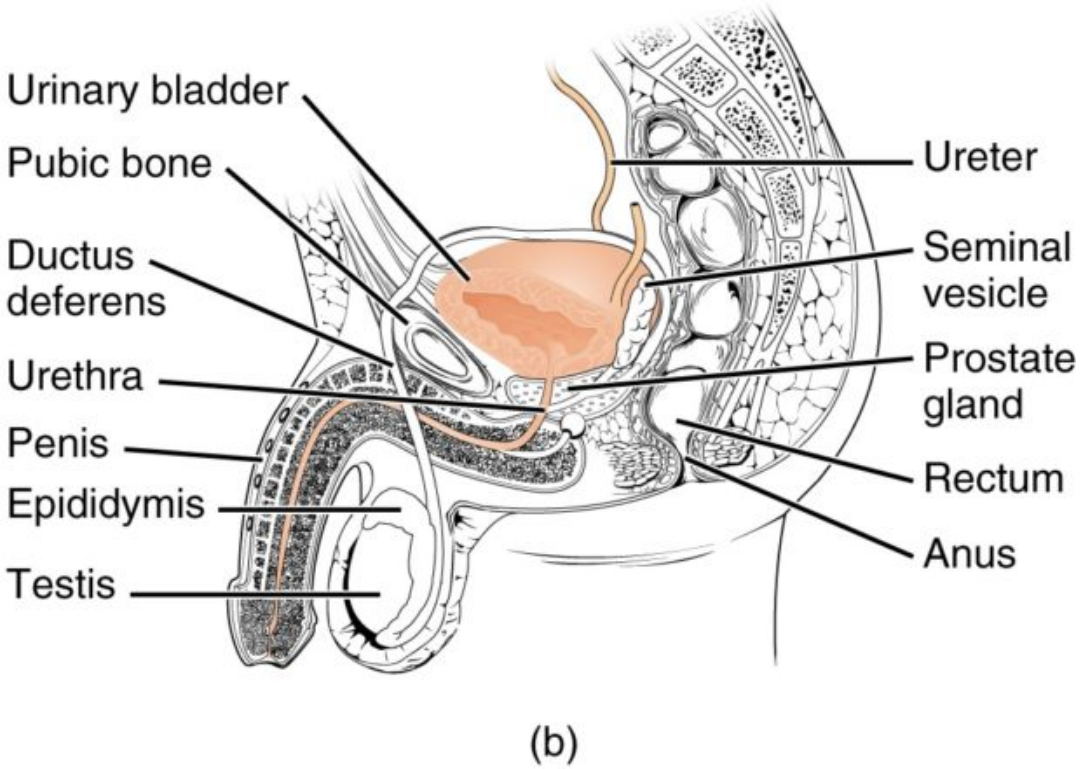

Image: The urethra transports urine from the bladder to the outside of the body. This image shows (b) a male urethra. By Phil Schatz, License: CC BY 4.0

Anatomy of the male Urethra

The *urethra masculina* is divided into 3 parts:

- ***Pars prostatica*:** inside the prostate, approx. 4 cm long
- ***Pars membranosa*:** runs about 2 cm through the *Diaphragma urogenitale* (above: *Musculus sphincter urethrae*, below *Ampulla urethrae*)
- ***Pars spongiosa*:** in the *Corpus spongiosum*, 10–20 cm long, extends to the *Fossa navicularis*

The urethra passes 2 curvatures on its course. On one hand, is the ***Curvatura infrapubica*** between the *Pars membrana* and the *Pars spongiosa* and on the other hand, is the ***Curvatura prepubica*** between the proximal and distal area of the *Pars spongiosa*.

Additionally, the urethra narrows and widens in 3 different places:

Narrowings

1. *Ostium urethrae internum*
2. Sphincter urethrae
3. *Ostium urethrae externum*

Dilations

1. *Pars prostatica*
2. Ampulla urethrae
3. *Fossa navicularis*

Microscopic

The urethra is composed of the following layers from the inside to the outside:

- ***Tunica mucosa*:** urothelium, from the *Pars prostatica* merging into a multi-layered and multi-row highly prismatic epithelium and from the *Fossa navicularis* into a multi-layered, non-cornified squamous epithelium
- ***Tunica propria*:** connective tissue with venous plexus
- ***Tunica muscularis*:** *Stratum longitudinale* and *circulare* consisting of *Stratum longitudinale* and *circulare*

Diseases of the urethra

Urethritis

This is an inflammation of the urethra. **Urethritis** is triggered by bacterial pathogens or by 'classic' sexually transmitted diseases. A common cause is *Neisseria gonorrhoeae* (gonococcus) spread by sexual intercourse directly to the urethra in the man and indirectly from the perineum in the woman. Many cases of urethritis have no known cause, i.e. *non-specific urethritis.* A stricture can occur as a complication.

Urethra stricture or urethra narrowing results from sexually transmitted diseases, infections, accidents, catheterism or congenital malformations as well. Urinary retention, painful micturition or incomplete urination (residual urine) can emerge.

Carcinoma of the urethra rarely occurs. Nevertheless, it originates in the bladder neck in 90% of all cases. Another form is, e.g., the *Condylomata acuminata* (acuminate wart) which occurs due to infections.

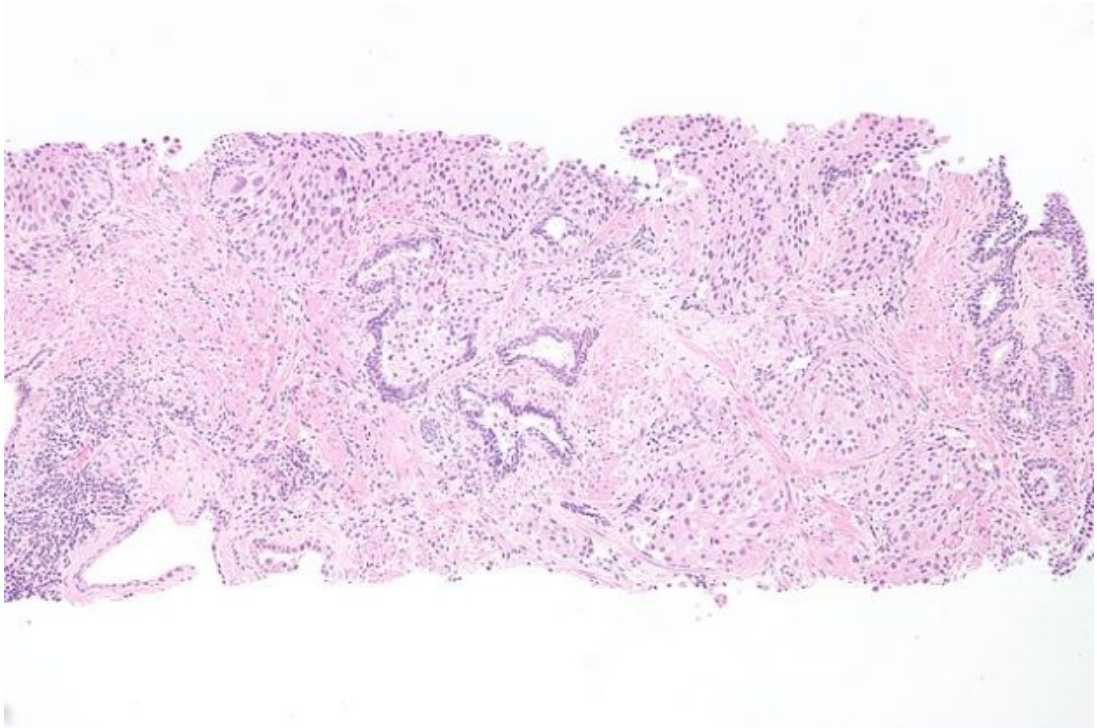

Image: More details Micrograph of urethral cancer (urothelial cell carcinoma), a rare problem of the urethra. By Nephron, License: CC BY-SA 3.0

Micturition

Micturition may also be called **urination** or **voiding**. In the case of a healthy adult, micturition usually is a random process. The random closure of the urethra happens through the *M. sphincter urethrae* which are innervated by the *Nervus pudendus*.

The urgency to pass urine in an adult occurs when the bladder is filled to about 300–500 mL. With an increased filling, the bladder wall is widened which then stretches the receptors of the wall; the stretching is sufficient to generate sensory impulses that travel to the sacral spinal cord, which eventually passes onto the parasympathetic centers of the spinal marrow by which the micturition reflex is finally triggered. This reflex is a spinal cord reflex over which voluntary control may be exerted. The stimulus for the reflex is the stretching of the detrusor muscle of the bladder. The bladder can hold as much as 800 mL of urine, or even more, but the reflex is activated long before the maximum is reached.

Motor impulses return along the parasympathetic nerves to the detrusor muscle. The *M. detrusor vesicae* are contracted in the willing micturition. Meanwhile, the ureter openings close, the blood of the uvula escapes and the *Ostium urethrae externum* is widened. The *M. sphincter urethrae* cause its contraction and through the work of the detrusor muscle and, if necessary, through the support of the Heimlich maneuver, the bladder can now be emptied.

This means, that the process of the passing of water is a combination of tension (detrusor and Heimlich maneuver) and relaxation (sphincter).

Urination can be prevented by voluntary contraction of the external urethral sphincter. However, if the bladder continues to fill and be stretched, voluntary control is eventually no longer possible.

Notes