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.

Ureters

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

The ureters are hollow tubes, organized in pairs, that connect the renal pelvis with the
urinary bladder. The ureters have an average length of 25–30 cm; however, the right ureter is usually slightly shorter than the left to accommodate space for the liver.

**Structure of the ureters**

The ureters consist of three 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 are responsible for peristalsis
- An inner layer, the mucosa, lined with transitional epithelium, that protects the ureter tissue from urine.

**Courses of the Ureters**

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 located appropriately since the ureters are, for example, pressed together by the surrounding muscles when lying down, so that urine cannot flow back.

The ureters pass three physiological obstacles, the so-called ureter narrowing, which facilitates transport. For example, concerning urinary calculi discharge:
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 three areas:

1. **Abdominal** (kidney to the back of the abdominal wall)
2. **Pelvic** (from the pelvic brim to the bladder)
3. **Intravesical or intramural** (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 (the upper to the 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:

![Wall of the Ureter](Image: Ureter wall. 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:
  - Longitudinal fibers
  - Circular fibers
  - Oblique fibers
- **Tunica adventitia**: connective tissue layer containing blood and nerve vessels

**Ureter Function**

The ureters connect the kidney and the urinary bladder. Their task is to transport urine. The by-products filtered by the kidney are led, with water as urine or secondary urine, to the ureters from the kidney in the *Vesica urinaria* (urinary bladder).
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, which arise from the surrounding arteries. The following arteries are involved:

- Abdominal – renal artery, testicular/ovarian artery, and ureteral branches directly from the abdominal aorta
- Pelvic – superior and inferior vesical arteries.

**Venous**

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

**Nervous**

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:**

Nervous supply to the ureters is delivered via the renal, testicular/ovarian, and hypogastric plexuses. Sensory fibers from the ureters enter the spinal cord at T11-L2.

**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 *pelvic lymph nodes*.

**Diseases and malformations of the ureter**

**Malformations**

Ureter malformations disturb urine transport or reflux, which can cause several secondary diseases: hydroureter (extended ureters), recurring infections, inflammations of the kidney and its pelvis, the formation of kidney and urinary calculi, and renal insufficiency.

Constant reflux may cause inflammations of the renal pelvis and the urinary bladder. The manifested inflammation can again cause a *malakoplakia* (grey-whitish plaque at the ureter wall) or a *Ureteritis cystica*.

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

**Ureteritis**

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

**Acute cystitis**

This is bladder inflammation; possible causes include:

- 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 that 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, possibly 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 frequent 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 urine outflow.

In men, prostatitis focuses on 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, when an enlarged prostate gland compresses the bladder and prevents it from emptying completely.

**Ureter calculi, urinary calculi, and kidney calculi**

The probability of calculi formation increases with advancing age, affecting men and women equally. Calculi are crystal accumulations and can be caused by inadequate fluid intake, excessive meat consumption, or inflammation. A higher solute concentration means certain by-products do not dissolve in urine and, therefore, accumulate as crystals.

About 70% of calculi consist of calcium oxalate, which is produced by the lack of calculi-dissolving substances or an excess of calcium or oxalate. Seasoned purine bodies or excessive meat or alcohol consumption induce 10-15% of calculi. Other calculi are caused by infection, cysteine, and, in rare instances, xanthic stones.

**Ureter carcinoma**

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

Symptoms mostly occur late. They appear in the form of microscopic or macroscopic hematuria. Additionally, a ureter blockage can cause one-sided urinary retention through the tumor. In most cases, the patient only experiences pain when metastasis occurs. The first metastasis, in most cases, occurs in the liver, the lungs, or the skeletal system.

**Urinary Bladder**

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

The urinary bladder is located retroperitoneally and is limited ventrally by the symphysis and the abdominal wall. In between lies the retropubic space, 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 urinary bladder apex the contact point of the ureters. The bladder is fixed from the ventral cranial through the medium umbilical ligament. The peritoneal pouch is located on the back of the bladder. At the caudal, the bladder is limited by the levator gap.

The prostate is located beneath the bladder base.

Anatomy of the urinary bladder

Anatomically, four areas exist:

- **Urinary bladder apex** covered by the peritoneum
- **Bladder body**
- **Bladder base**, consisting of ureter entries, the exit to the urethra, and the cranial limitation through the fold of the mucous tissue between the ureters
- **Bladder neck**, which is funnel-shaped

Microscopic analysis:

The urinary bladder, from the inside to the outside, consists of:

- The urothelium, also called the transitional epithelium, is the layer of cells that lines the inside of the kidneys, ureters, bladder, and urethra
- Lamina propria consisting of connective tissue
- Muscularis propria, the outer layer of muscle tissue
Fatty connective tissue covering the outside of the bladder and separating it from other organs

**Holding muscles of the urinary bladder**

The bladder is only fixed on two points on the pelvic floor for cranial extension while filling up. The ligaments consist of three strands of pelvic fascia in the female that correspond to the puboprostatic ligament in the male and that support the bladder passing from its neck to the pubic symphysis or to the pubis on one side.

**Vascular supply of the urinary bladder**

**Arterial**

The arterial supply is via the superior vesical branch of the internal iliac artery. In males, this is supplemented by the inferior vesical artery, and in females by the vaginal arteries. In both sexes, the obturator and inferior gluteal arteries may also contribute small branches.

**Venous**

Venous drainage is achieved by the vesical venous plexus, which empties into the internal iliac veins. The vesical plexus in males is in continuity at the retropubic space with the prostate venous plexus (plexus of Santorini), which also receives blood from the dorsal vein of the penis.

**Nerval**

The bladder receives input from both the autonomic (sympathetic and parasympathetic) and somatic arms of the nervous system.

- **Sympathetic** - the hypogastric nerve (T12 – L2) relaxes the detrusor muscle, promoting urine retention.
- **Parasympathetic** - the pelvic nerve (S2-S4) signals detrusor contraction, stimulating micturition.
- **Somatic** - the pudendal nerve (S2-4) stimulates the external urethral sphincter, providing voluntary control over micturition.

In addition to the efferent nerves supplying the bladder, there are sensory (afferent) nerves in the bladder wall that signal the need to urinate when the bladder becomes full.

**Musculus sphincter vesicae**

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

The ‘smooth urinary bladder sphincter’, also called the 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 urinary bladder diseases is cystitis, which is inflammation accompanied by pain in the lower abdomen and painful passing of urine. The infection often ascends from the urethra and, since women have a shorter urethra, they are at higher risk.

Physical influences (e.g., stress or fear) or physical impacts (e.g., paraplegia, detrusor-sphincter-dyssynergia) can cause a dysfunction in the closure mechanism, leading to **urinary incontinence**. In particular, stress and burden incontinence is distinguished from urge incontinence. In this condition, there is an 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., coughing, laughing, sneezing, or lifting. It usually affects women with weak pelvic floor muscles or ligaments, e.g., after childbirth or as part of the aging process.

**Urge incontinence:** Urine leakage 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 essential issue in this section is **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 hematuria. Men are often more affected than women, and smoking is considered to be the main risk factor.
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.

Feminine urethra

The female urethra is clearly shorter than the male urethra, with an average length of 3–5 cm. Because of the significantly shorter length, women have a higher risk of infection than men and are more prone to bladder inflammation.
Female urethra course

The female urethra consists of the bladder neck, the striated urethral sphincter, the urogenital diaphragm, and bulbocavernous muscle.

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 female urethra takes place through the Corpus spongiosum urethrae, which designate the plexus.

Urethra Masculina

The male urethra has an average length of 20–25 cm. It starts at the Ostium urethrae internum and ends at the Glans penis, the Ostium urethrae externum. Its task is, besides the passing of urine, the transport of seminal fluid.
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 two curvatures on its course: The **Curvatura infrapubica** is between the Pars membrana and the Pars spongiosa. The **Curvatura prepubica** is between the proximal and distal area of the Pars spongiosa.

Additionally, the urethra narrows and widens in three 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, 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.

**Urethral stricture** or urethra narrowing results from sexually transmitted diseases, infections, accidents, catheterism, or congenital malformations. 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 the *Condylomata acuminata* (acuminate wart), which is caused by 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 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 is 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 the increased filling, the bladder wall widens, stretching 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, triggering the micturition reflex. This 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 through the work of the detrusor muscle and, if necessary, through the support of the Heimlich maneuver, the bladder can now be emptied. In other words, the process of urination 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.

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