Ureter, Urethra, Urinary Bladder — The Urogenital System

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. LM × 128. (Micrograph provided by the Regents of the University of Michigan Medical School © 2012).” by Phil Schatz. Licence: CC BY
These are hollow organs, that are organised 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 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 form a syncytium spiraling round the ureter, some in clockwise and some in anticlockwise directions and an additional outer longitudinal layer in the lower third
- An inner layer, the mucosa, lined with transitional epithelium.

Course of the ureters

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

The ureters cross the small pelvis and cross under the Ductus deferens or the A. 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
The ureters pass 3 physiological obstacles, the so-called ureter narrowings which dispose an 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 A. iliaca externa or Communis
3. **Lower narrowing**: Passing through of 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 third (renal pelvis to the upper end of the Os sacrum), the middle third (upper to lower edge of the Os sacrum) and the distal third (lower sacrum edge to urinary bladder).

**Histology/Microscopic anatomy of the ureter**

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

- **Tunica mucosa**: Urothelion of 4-5 cell layers which encloses a stellar lumen
- **Tela submucosa** or **Lamina propria**: loose connective tissue
- **Tunica muscularis**: spirally organised muscular tissues which 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).

![Ultrasound demonstration of ureteral jet effect](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:** A. renalis, A. testicularis (in men) bzw. A. ovarica (in women)
- **Pars pelvica:** A. iliaca communis, A. iliaca externa et 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 calicopelvic 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 the 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 lymphatici iliacae et obturatoriae (pelvis lymph nodes).

Diseases and malformations of the ureter

Malformations

In case of malformations of the ureter, the result is a disturbed urine transport or a 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 case of a 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 Ureteritis 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 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
- A mixed infection of coliform and other organisms which may follow the passage of a urinary catheter or other instrument
- Inflammation in the absence of microbes, e.g. following radiotherapy or passage of a catheter or other instrument.

The effects are inflammation, with edema and small haemorrhages of the mucosa, which may be accompanied by haematuria. There is hypersensitivity of the sensory nerve endings in the bladder wall, which are stimulated before the bladder has filled leading to 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 perineal muscle and relaxation and kinking of the ureters. Towards the end of pregnancy pressure caused by the fetus may obstruct the outflow of urine.

In the male, 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 males 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, 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, inflammations as well as congenital distraction of the deterioration of certain by-products, in which they do not dissolve in urine and therefore accumulate as crystals.

In the prominent part of the calculi, about 70% consists of calcium oxalate and is produced by lack of calculi formation inhibiting substances or through an excess of calcium or oxalate. 10-15% 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 tumour, there are about 95% new malignant formations of the urothelion. The squamous epithelium is rarely affected. It occurs very rarely, and men at the age of 50 to 60 are affected the most.

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

**Urinary Bladder**

The Vesica urinaria is a muscular hollow organ which contains, depending on the size, 800-1500ml urine fluid.
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 Lig. 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
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 form of the M. detrusor vesicae, but is differentiated again as follows:
- Stratum longitudinale internum
- Stratum circulare
- Stratum longitudinale externum

Tunica adventitia: loose connective tissue, Tela subserosa called in the peritoneal covered area

Tunica serosa: partially existing peritoneal layer

Holding muscles of the urinary bladder
The bladder is only fixed on two 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 (female: Os sacrum – rectum, male: 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).

M. 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 the female body, the muscle fibres surround the proximal to middle area of the urethra. In the male body, the striated part of the prostate runs through the whole extension of the membranous urethra.
Received and congenital disorders of the urinary bladder

Because of the mass of different diseases and restrictions, not everything can be mentioned and explained in this section. Therefore, 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 (for example stress or fear) or physical impacts (for example in the case of paraplegia, detrusor-sphincter-dysnergy) 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 weakness of the muscles of the pelvic floor or pelvic ligaments, e.g. after childbirth or as part of the ageing 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 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 (*Vesicagigantea*).

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 discoloured by blood. Men are often more affected than women and smoking is considered to be the main risk factor.
Urethra

As the anatomy of the male and female urogenital wing shows some significant differences, the structure of the urethras decisively mirrors them. Therefore, the male and female urethras are examined separately.

Urethra feminina

The female urethra is clearly shorter than the male variant 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 inflammations of the bladder.
The urethra transports urine from the bladder to the outside of the body. This image shows (a) a female urethra *by Phil Schatz. Licence:* [CC BY 4.0](https://creativecommons.org/licenses/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 vagina. 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:** Urothelion, merging into a multirow columnar epithelium and finally in a multi-layered uncornified 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 designates 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.

Anatomy of the male Urethra

Macroscopic

The Urethra masculina is divided into 3 parts:

- **Pars prostatica**: inside the prostate, about 4 cm long
- **Pars membranosa**: runs about 2 cm through the Diaphragma urogenitale (above: M. 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 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**: at first urothelion, from the Pars prostatica merging into a multi-layered and multi-row highly prismatic epithelium and from the Fossa navicularis into a multi-layered, uncornified squamos epithelium
- **Tunica propria**: connective tissue with venous plexus
- **Tunica muscularis**: Stratum longitudinale und circulare consisting of Stratum longitudinale and circulare

Diseases of the urethra

Urethritis

This is 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 male and indirectly from the perineum in the female. 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 originate in the bladder neck in 90% of all cases. Another form is for example the Condylomata acuminata (acuminate wart) which occurs due to infections.
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 is innervated by the N. pudendus.

The urgency to pass urine in an adult occurs when the bladder is filled to about 300-500 ml. With 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 pass onto the parasympathetic centres 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 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 parasympathetic nerves to the detrusor muscle. The M. detrusor vesicae is 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 causes its contraction and through the work of the detrusor muscle and, if necessary, through 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, 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.

Review Questions

The solutions can be found below the references.

1. Which of the following statements concerning the anatomy of the Vesica urinaria do you not agree with?

A. The urinary bladder is located in the retroperitoneal abdominal area and is limited in the ventral area by the symphysis and the abdominal wall.

B. The Apex vesicae which is covered by the peritoneum is located in the caudal area of the bladder.

C. The Vesica urinaria is additionally to the connecting points on the pelvic floor fixed by 3 retaining straps in order to allow for an extension to caudal.

D. Lissosphincter is a synonym for the smooth urinary bladder sphincter.

E. The venous return follows the Plexus venosus vesicae.

2. Micturition is a physiological process by which a healthy, adult person willingly empties the urinary bladder. Which of the following possible answers correctly describes the process or parts of the micturition?

A. The stretch receptors are stimulated at a filling of the bladder of about 300-500 ml through the widening of the bladder wall, so that these electric impulses are transmitted to the sympathetic centres of the brain.

B. While the M. detrusor vesicae contracts, the openings of the ureters close, the
Ostitium urethrae externum is widened and the blood escapes from the uvula.
C. The M. sphincter urethrae contracts while the detrusor muscle relaxes simultaneously.
D. The Heimlich maneuver supports the retention of urine in case of a full bladder.
E. The N. pudendus innervates the M. sphincter urethrae which closes the ureters.

3. Which of the following statements on the topic of urological diseases was put in the wrong context?

A. Cystitis can be caused by excessive meat and alcohol consumption.
B. Physical factors such as fear or stress can lead to urinary incontinence.
C. The stricture of the urethra can be triggered by, amongst others things, sexually transmitted diseases and can be noted because of symptoms such as painful and incomplete micturition.
D. Men are more often likely affected by a carcinoma of the urinary bladder than women.
E. A reflux induced by a ureterocele can amongst others things be cause a hydrourerter or relapsing infections

References

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Correct answers: 1B, 2B, 3A

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