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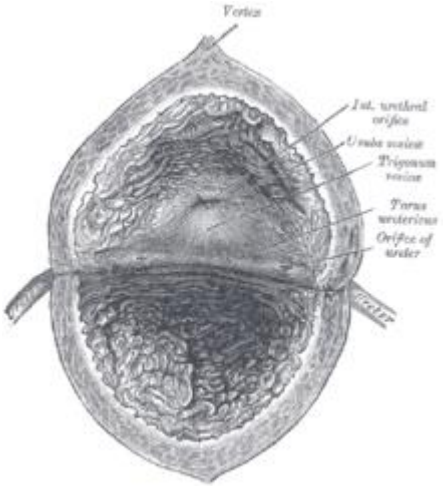
Micturition

Micturition or Urination is the release of urine from the urinary bladder through the urethra to the outside of the body. It is the urinary system's form of excretion. It is also known medically as micturition, voiding, uresis, or, rarely, emiction, and known colloquially by various names including peeing, weeing, and pissing.

In healthy humans (and many other animals) the process of urination is under voluntary control. In infants, some elderly individuals, and those with neurological injury, urination may occur as a reflex. It is normal for adult humans to urinate up to seven times during the day.

In some animals, in addition to expelling waste material, urination can mark territory or express submissiveness. Physiologically, urination involves coordination between the central, autonomic, and somatic nervous systems. Brain centres that regulate urination include the pontine micturition center, periaqueductal gray, and the cerebral cortex. In placental mammals, urine is drained through the urinary meatus, a urethral opening in the male penis or female vulval vestibule.

Anatomy of the bladder and outlet



The interior of the bladder

The main organs involved in urination are the urinary bladder and the urethra. The smooth muscle of the bladder, known as the detrusor, is innervated by sympathetic nervous system fibers from the lumbar spinal cord and parasympathetic fibers from the sacral spinal cord.[4] Fibers in the pelvic nerves constitute the main afferent limb of the voiding reflex; the parasympathetic fibers to the bladder that constitute the excitatory efferent limb also travel in these nerves. Part of the urethra is surrounded by the male or female external urethral sphincter, which is innervated by the somatic pudendal nerve originating in the cord, in an area termed Onuf's nucleus.

Smooth muscle bundles pass on either side of the urethra, and these fibers are sometimes called the internal urethral sphincter, although they do not encircle the urethra. Further along the urethra is a sphincter of skeletal muscle, the sphincter of the membranous urethra (external urethral sphincter). The bladder's epithelium is termed transitional epithelium which contains a superficial layer of dome-like cells and multiple layers of stratified cuboidal cells underneath when evacuated. When the bladder is fully distended the superficial cells become squamous (flat) and the stratification of the cuboidal cells is reduced in order to provide lateral stretching.

Physiology of Micturition

The physiology of micturition and the physiologic basis of its disorders are subjects about which there is much confusion, especially at the supraspinal level. Micturition is fundamentally a spinobulbo spinal reflex facilitated and inhibited by higher brain centers such as the pontine micturition center and, like defecation, subject to voluntary facilitation and inhibition.

In healthy individuals, the lower urinary tract has two discrete phases of activity: the storage (or guarding) phase, when urine is stored in the bladder; and the voiding phase, when urine is released through the urethra. The state of the reflex system is dependent on both a conscious signal from the brain and the firing rate of sensory fibers from the bladder and urethra. At low bladder volumes, afferent firing is low, resulting in excitation of the outlet (the sphincter and urethra), and relaxation of the bladder. At high bladder volumes, afferent firing increases, causing a conscious sensation of urinary urge. When the individual is ready to urinate, he or she consciously initiates voiding, causing the bladder to contract and the outlet to relax. Voiding continues until the bladder empties completely, at which point the bladder relaxes and the outlet contracts to re-initiate storage. The muscles controlling

micturition are controlled by the autonomic and somatic nervous systems. During the storage phase the internal urethral sphincter remains tense and the detrusor muscle relaxed by sympathetic stimulation. During micturition, parasympathetic stimulation causes the detrusor muscle to contract and the internal urethral sphincter to relax. The external urethral sphincter (sphincter urethrae) is under somatic control and is consciously relaxed during micturition.

In infants, voiding occurs involuntarily (as a reflex). The ability to voluntarily inhibit micturition develops by the age of 2–3 years, as control at higher levels of the central nervous system develops. In the adult, the volume of urine in the bladder that normally initiates a reflex contraction is about 300–400 millilitres (11–14 imp fl oz; 10–14 US fl oz).

Storage phase

During storage, bladder pressure stays low, because of the bladder's highly compliant nature. A plot of bladder (intravesical) pressure against the depressant of fluid in the bladder (called a cystometrogram), will show a very slight rise as the bladder is filled. This phenomenon is a manifestation of the law of Laplace, which states that the pressure in a spherical viscus is equal to twice the wall tension divided by the radius. In the case of the bladder, the tension increases as the organ fills, but so does the radius. Therefore, the pressure increase is slight until the organ is relatively full. The bladder's smooth muscle has some inherent contractile activity; however, when its nerve supply is intact, stretch receptors in the bladder wall initiate a reflex contraction that has a lower threshold than the inherent contractile response of the muscle.

Action potentials carried by sensory neurons from stretch receptors in the urinary bladder wall travel to the sacral segments of the spinal cord through the pelvic nerves. Since bladder wall stretch is low during the storage phase, these afferent neurons fire at low frequencies. Low-frequency afferent signals cause relaxation of the bladder by inhibiting sacral parasympathetic preganglionic neurons and exciting lumbar sympathetic preganglionic neurons. Conversely, afferent input causes contraction of the sphincter through excitation of Onuf's nucleus, and contraction of the bladder neck and urethra through excitation of the sympathetic preganglionic neurons.

Diuresis (production of urine by the kidney) occurs constantly, and as the bladder becomes full, afferent firing increases, yet the micturition reflex can be voluntarily inhibited until it is appropriate to begin voiding.

Voiding phase

Voiding begins when a voluntary signal is sent from the brain to begin urination, and continues until the bladder is empty.

Bladder afferent signals ascend the spinal cord to the periaqueductal gray, where they project both to the pontine micturition center and to the cerebrum. At a certain level of afferent activity, the conscious urge to void becomes difficult to ignore. Once the voluntary signal to begin voiding has been issued, neurons in pontine micturition center fire maximally, causing excitation of sacral preganglionic neurons. The firing of these neurons causes the wall of the bladder to contract; as a result, a sudden, sharp rise in intravesical pressure occurs. The pontine micturition center also causes inhibition of Onuf's nucleus, resulting in relaxation of the external urinary sphincter. When the external urinary sphincter is relaxed urine is released from the urinary bladder when the pressure there is great enough to force urine to flow out of the urethra. The micturition reflex normally produces a series of contractions of the urinary bladder.

The flow of urine through the urethra has an overall excitatory role in micturition, which helps sustain voiding until the bladder is empty.

After urination, the female urethra empties partially by gravity, with assistance from muscles. Urine remaining in the male urethra is expelled by several contractions of the bulbospongiosus muscle, and, by some men, manual squeezing along the length of the penis to expel the rest of the urine.

For land mammals over 1 kilogram, the duration of urination does not vary with body mass, being dispersed around an average of 21 seconds (standard deviation 13 seconds), despite a 4 order of magnitude (1000×) difference in bladder volume. This is due to increased urethra length of large animals, which amplifies gravitational force (hence flow rate), and increased urethra width, which increases flow rate. For smaller mammals a different phenomenon occurs, where urine is discharged as droplets, and urination in smaller mammals, such as mice and rats, can occur in less than a second. The posited benefits of faster voiding are decreased risk of predation (while voiding) and decreased risk of urinary tract infection.

Voluntary control

The mechanism by which voluntary urination is initiated remains unsettled. One possibility is that the voluntary relaxation of the muscles of the pelvic floor causes a sufficient downward tug on the detrusor muscle to initiate its contraction. Another possibility is the excitation or disinhibition of neurons in the pontine micturition

center, which causes concurrent contraction of the bladder and relaxation of the sphincter.

There is an inhibitory area for micturition in the midbrain. After transection of the brain stem just above the pons, the threshold is lowered and less bladder filling is required to trigger it, whereas after transection at the top of the midbrain, the threshold for the reflex is essentially normal. There is another facilitatory area in the posterior hypothalamus. In humans with lesions in the superior frontal gyrus, the desire to urinate is reduced and there is also difficulty in stopping micturition once it has commenced. However, stimulation experiments in animals indicate that other cortical areas also affect the process.

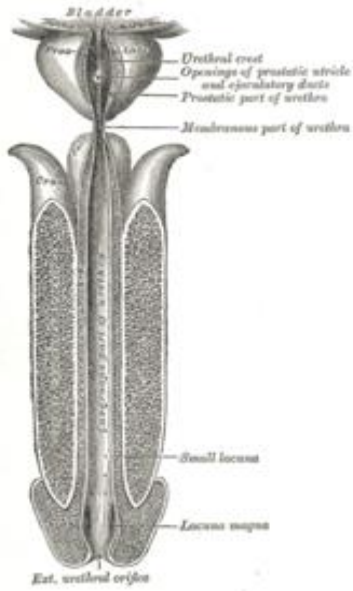
The bladder can be made to contract by voluntary facilitation of the spinal voiding reflex when it contains only a few milliliters of urine. Voluntary contraction of the abdominal muscles aids the expulsion of urine by increasing the pressure applied to the urinary bladder wall, but voiding can be initiated without straining even when the bladder is nearly empty.

Voiding can also be consciously interrupted once it has begun, through a contraction of the perineal muscles. The external sphincter can be contracted voluntarily, which will prevent urine from passing down the urethra.

Experience of urination

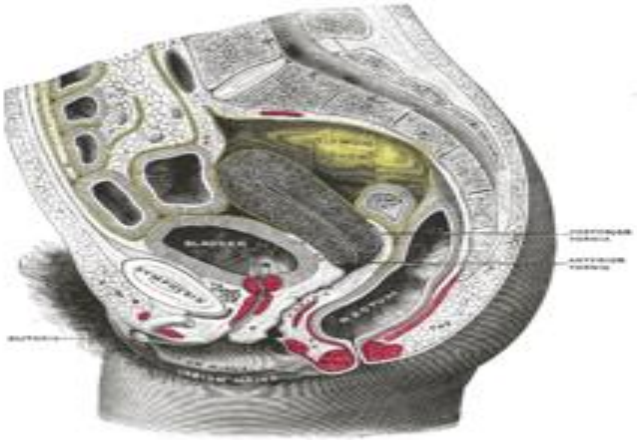
The need to urinate is experienced as an uncomfortable, full feeling. It is highly correlated with the fullness of the bladder.[15]In many males the feeling of the need to urinate can be sensed at the base of the penis as well as the bladder, even though the neural activity associated with a full bladder comes from the bladder itself, and can be felt there as well. In females the need to urinate is felt in the lower abdomen region when the bladder is full. When the bladder becomes too full, the sphincter muscles will involuntarily relax, allowing urine to pass from the bladder. Release of urine is experienced as a lessening of the discomfort.

Male urination



Most males prefer to urinate standing while others prefer to urinate sitting or squatting. Elderly males with prostate gland enlargement may benefit from sitting down while in healthy males, no difference is found in the ability to urinate. For practicing Muslim men, the genital modesty of squatting is also associated with proper cleanliness requirements or awrah.

Female urination



Location of the bladder and urethra in adult human female (sagittal section)

In human females, the urethra opens straight into the vulva. Hence, urination can take place while sitting or squatting for defecation. It is also possible for females to urinate while standing, and while clothed. It is common for women in various regions of Africa to use this method when they urinate, need quotation to verify as do

women in Laos. failed verification]Herodotus described a similar custom in ancient Egypt. An alternative method for women to urinate standing is to use a tool known as a female urination device to assist.

Young children

A common technique used in many undeveloped nations involves holding the child by the backs of the thighs, above the ground, facing outward, in order to urinate.

Fetal urination

The fetus urinates hourly and produces most of the amniotic fluid in the second and third trimester of pregnancy. The amniotic fluid is then recycled by fetal swallowing.

Control of micturition

Children and adults have considerable control over when and where they pass urine. They can also increase or decrease the rate of flow and even stop and start again, so micturition is clearly more than just a simple reflex. This control is learnt in infancy and involves other sensory fibres in the bladder wall. These fibres convey information on the degree of bladder fullness via the spine to the higher centres of the brain, the thalamus and cerebral cortex. This causes us to become aware that we need to pass urine and of the urgency of the situation.

These links between the spine and cerebral cortex are not established until about two years of age and it is suggested that toilet-training is therefore not physiologically possible until that time.

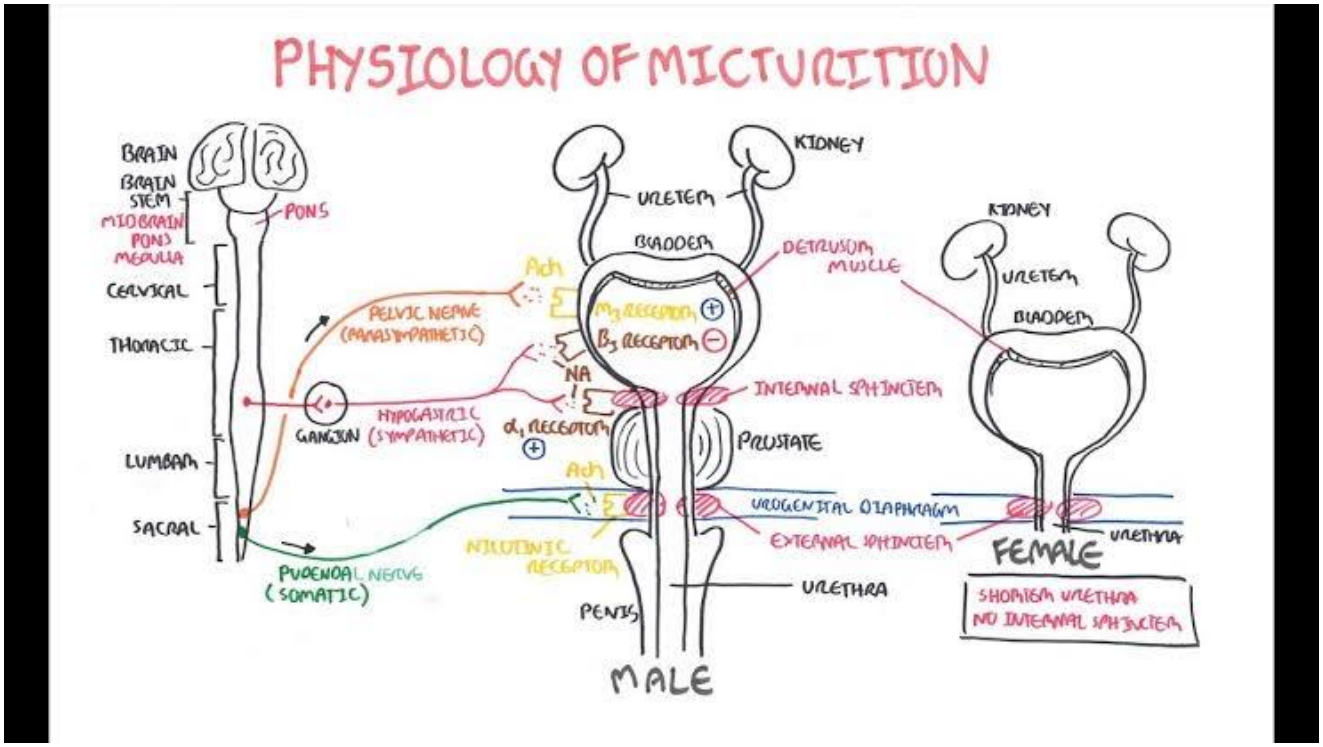
The brain is able to override the micturition reflex by inhibiting the parasympathetic motor nerve fibres to the bladder and reinforcing contraction of the external sphincter. The internal sphincter will not open until the external sphincter does.

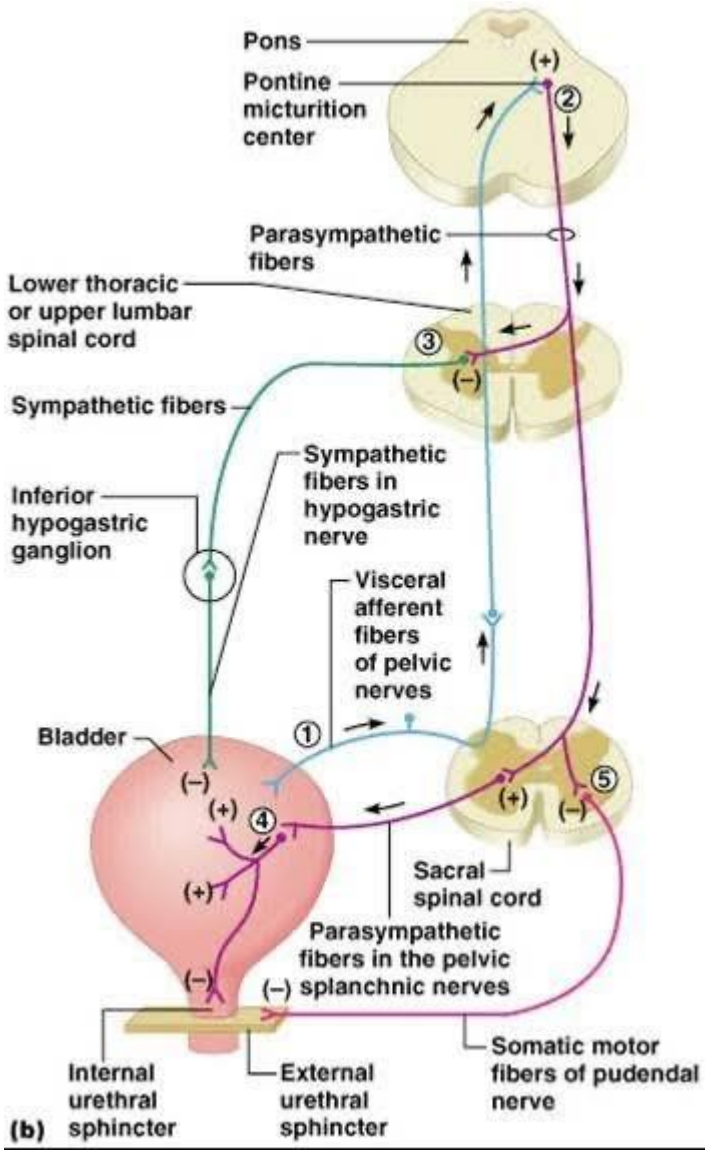
The increase in bladder volume increases stretch receptor and nerve activity, making the sensation of pressure more acute. When it is convenient, the brain centres remove the inhibition and permit micturition under our conscious control. When the bladder contains about 500ml, pressure may force open the internal sphincter; this in turn forces open the external sphincter and urination occurs whether it is convenient or not.

We can increase the rate of urine flow by contraction of the abdominal muscles and by the performance of Valsalva's manoeuvre (forced expiration against a closed glottis). Contraction of the strong pelvic floor muscles can stop urine in mid-flow. The

sound of running water also encourages micturition but some people cannot urinate in the presence of others, no matter how great their need.

After micturition, less than 10ml of urine remains in the bladder and the cycle begins again.




Pons
Pontine micturition center
(+)
②
Parasympathetic fibers
Lower thoracic or upper lumbar spinal cord
③
(–)
Sympathetic fibers
Sympathetic fibers in hypogastric nerve
Inferior hypogastric ganglion
Visceral afferent fibers of pelvic nerves
①
Bladder
(–)
(+)
④
(+)
(–)
(+)
⑤
(–)
Sacral spinal cord
Parasympathetic fibers in the pelvic splanchnic nerves
(–)
Somatic motor fibers of pudendal nerve
Internal urethral sphincter
External urethral sphincter
(b)