Micturition

Objectives:

1. Review the anatomical organization of the urinary system from a physiological point of view.
2. Describe the micturition reflex.
3. Predict the lines of treatment of renal failure.
4. State the basic physical and physiological idea of renal dialysis.

Micturition is the process by which the urinary bladder empties when it becomes filled. This involves two main steps: First, the bladder fills progressively until the tension in its walls
rises above a threshold level; this elicits the second step, which is a nervous reflex called the micturition reflex that empties the bladder or, if this fails, at least causes a conscious desire to urinate. Although the micturition reflex is an autonomic spinal cord reflex, it can also be inhibited or facilitated by centers in the cerebral cortex or brain stem.

**Physiologic Anatomy and Nervous Connections of the Bladder**
The urinary bladder is a smooth muscle chamber composed of two main parts: (1) the body, which is the major part of the bladder in which urine collects, and (2) the neck, which is a funnel-shaped extension of the body connecting with the urethra. The smooth muscle of the bladder is called the detrusor muscle. Its muscle fibers extend in all directions and, when contracted, can increase the pressure in the bladder to 40 to 60 mm Hg. Thus, contraction of the detrusor muscle is a major step in emptying the bladder. Smooth muscle cells of the detrusor muscle fuse with one another so that low-resistance electrical pathways exist from one muscle cell to the other. Therefore, an action potential can spread throughout the detrusor muscle, from one muscle cell to the next, to cause contraction of the entire bladder at once.

On the posterior wall of the bladder, lying immediately above the bladder neck is a small triangular area called the trigone. At the lowermost apex of the trigone, the bladder neck opens into the urethra, and the two ureters enter the bladder at the uppermost angles of the trigone. Each ureter, as it enters the bladder, courses obliquely through the detrusor muscle and then passes another 1 to 2 centimeters beneath the bladder mucosa before emptying into the bladder. The bladder neck (posterior urethra) is 2 to 3 centimeters long, and its wall is composed of detrusor muscle interlaced with a large amount of elastic tissue. The muscle in this area is called the internal sphincter. Its natural tone normally keeps the bladder neck and posterior urethra empty of urine and, therefore, prevents emptying of the bladder until the pressure in the main part of the bladder rises above a critical threshold.

Beyond the posterior urethra, the urethra passes through the urogenital diaphragm, which contains a layer of muscle called the external sphincter of the bladder. This muscle is a voluntary skeletal muscle, in contrast to the muscle of the bladder body and bladder neck, which is entirely smooth muscle. The external sphincter muscle is under voluntary control of the nervous system and can be used to consciously prevent urination even when involuntary controls are attempting to empty the bladder.
Innervation of the Bladder

The principal nerve supply of the bladder is by way of the pelvic nerves, which connect with the spinal cord through the sacral plexus, mainly connecting with cord segments S-2 and S-3. Coursing through the pelvic nerves are both sensory nerve fibers and motor nerve fibers. The sensory fibers detect the degree of stretch in the bladder wall. Stretch signals from the posterior urethra are especially strong and are mainly responsible for initiating the reflexes that cause bladder emptying.

The motor nerves transmitted in the pelvic nerves are parasympathetic fibers. These terminate on ganglion cells located in the wall of the bladder. Short postganglionic nerves then innervate the detrusor muscle.

In addition to the pelvic nerves, two other types of innervation are important in bladder function. Most important are the skeletal motor fibers transmitted through the pudendal nerve to the external bladder sphincter. These are somatic nerve fibers that innervate and control the voluntary skeletal muscle of the sphincter. Also, the bladder receives sympathetic innervation from the sympathetic chain through the hypogastric nerves, connecting mainly with the L-2 segment of the spinal cord. These sympathetic fibers stimulate mainly the blood vessels and have little to do with bladder contraction.
Some sensory nerve fibers also pass by way of the sympathetic nerves and may be important in the sensation of fullness.

**Transport of Urine from the Kidney through the Ureters and into the Bladder**

Urine that is expelled from the bladder has essentially the same composition as fluid flowing out of the collecting ducts; there are no significant changes in the composition of urine as it flows through the renal calyces and ureters to the bladder. Urine flowing from the collecting ducts into the renal calyces stretches the calyces and increases their inherent pacemaker activity, which in turn initiates peristaltic contractions that spread to the renal pelvis and then downward along the length of the ureters thereby forcing urine from the renal pelvis toward the bladder. The walls of the ureters contain smooth muscle and are innervated by both sympathetic and parasympathetic nerves as well as by an intramural plexus of neurons and nerve fibers that extends along the entire length of the ureters. As with other visceral smooth muscle, peristaltic contractions in the ureter are enhanced by parasympathetic stimulation and inhibited by sympathetic stimulation.

The ureters enter the bladder through the detrusor muscle in the trigone region of the bladder. Normally, the ureters course obliquely for several centimeters through the bladder wall. The normal tone of the detrusor muscle in the bladder wall tends to compress the ureter, thereby preventing backflow of urine from the bladder when pressure builds up in the bladder during micturition or bladder compression. Each peristaltic wave along the
ureter increases the pressure within the ureter so that the region passing through the bladder wall opens and allows urine to flow into the bladder.

**Pain Sensation in the Ureters,**
The ureters are well supplied with pain nerve fibers. When a ureter becomes blocked (e.g., by a ureteral stone), intense reflex constriction occurs, associated with severe pain. Also, the pain impulses cause a sympathetic reflex back to the kidney to constrict the renal arterioles, thereby decreasing urine output from the kidney. This effect is called the **ureterorenal reflex** and is important for preventing excessive flow of fluid into the pelvis of a kidney with a blocked ureter.

**Micturition Reflex**
Two muscular sphincters surround the urethra. The upper sphincter, composed of smooth muscle, is called the internal urethral sphincter; the lower sphincter, composed of voluntary skeletal muscle, is called the external urethral sphincter. The actions of these sphincters are regulated in the process of urination, which is also known as **micturition.**

Micturition is controlled by a reflex center located in the second, third, and fourth sacral levels of the spinal cord. Filling of the urinary bladder activates stretch receptors that send impulses to this micturition center. As a result, parasympathetic neurons are activated, causing rhythmic contractions of the detrusor muscle of the urinary bladder and relaxation of the internal urethral sphincter.

At this point, a sense of urgency is perceived by the brain, but there is still voluntary control over the external urethral sphincter.

When urination is consciously allowed to occur, descending motor tracts to the micturition center inhibit somatic motor fibers to the external urethral sphincter. This muscle then relaxes, and urine is expelled. The ability to voluntarily inhibit micturition generally develops between the ages of 2 and 3.

**Facilitation or Inhibition of Micturition by the Brain**
The micturition reflex is a completely autonomic spinal cord reflex, but it can be inhibited or facilitated by centers in the brain that normally exert final control of micturition as follows:

1. The higher centers keep the micturition reflex partially inhibited, except when micturition is desired.
2. The higher centers can prevent micturition, even if the micturition reflex occurs, by continual tonic contraction of the external bladder sphincter until a convenient time presents itself.
3. When it is time to urinate, the cortical centers can facilitate the sacral micturition centers to help initiate a micturition reflex and at the same time inhibit the external urinary sphincter so that urination can occur.

**Voluntary urination** is usually initiated in the following way: First, a person voluntarily contracts his or her abdominal muscles, which increases the pressure in the bladder and allows extra urine to enter the bladder neck and posterior urethra under pressure, thus stretching their walls. This stimulates the stretch receptors, which excites the micturition reflex and simultaneously inhibits the external urethral sphincter. Ordinarily, all the urine will be emptied, with rarely more than 5 to 10 milliliters left in the bladder.

**Artificial Kidney**

Severe loss of kidney function either acutely or chronically is a threat to life or requires removal of toxic waste products and restoration of body fluid volume and composition toward normal. This can be accomplished by dialysis with an artificial kidney. In certain types of acute renal failure, an artificial kidney may be used to tide the patient over until the kidneys resume their function. If the loss of kidney function is irreversible, it is necessary to perform dialysis chronically to maintain life. In the United States alone, nearly 300,000 people with irreversible renal failure or even total kidney removal are being maintained by dialysis with artificial kidneys. Because dialysis cannot maintain completely normal body fluid composition and cannot replace all the multiple functions performed by the kidneys, the health of patients maintained on artificial kidneys usually remains significantly impaired. A better treatment for permanent loss of kidney function is to restore functional kidney tissue by means of a kidney transplant.

**Basic Principles of Dialysis**
The basic principle of the artificial kidney is to pass blood through minute blood channels bounded by a thin membrane. On the other side of the membrane is a dialyzing fluid into which unwanted substances in the blood pass by diffusion. Blood flows continually between two thin membranes of cellophane; outside the membrane is a dialyzing fluid. The cellophane is porous enough to allow the constituents of the plasma, except the plasma proteins, to diffuse in both directions from plasma into the dialyzing fluid or from the dialyzing fluid back into the plasma. If the concentration of a substance is greater in the plasma than in the dialyzing fluid, there will be a net transfer of the substance from the plasma into the dialyzing fluid.

The rate of movement of solute across the dialyzing membrane depends on (1) the concentration gradient of the solute between the two solutions, (2) the permeability of the membrane to the solute, (3) the surface area of the membrane, and (4) the length of time that the blood and fluid remain in contact with the membrane.

Another way of dialysis is to use the peritoneal cavity as an area for exchange of the waste products of the body by filling it with dialyzing fluid for about half an hour and replace it with new one and this process might take 1 to 3 days of continuous filling and emptying till the electrolytes level became accepted.