Objectives:

by the end of this lecture you will be able to:

- Identify and describe the Functional Anatomy of Urinary Bladder.
- Describe the mechanism of filling and emptying of the urinary bladder.
- Cystometrogram.
- Appreciate neurogenic control of the mechanism of micturition reflex and its disorders.
Micturition (Urination):

Micturition is the process by which the bladder empties itself when it becomes full.

Functions of the lower urinary tract (LUT) (Bladder + urethra)

- Storage of urine (without leak)
- Emptying (voiding)

Abnormalities in bladder function may lead to

- Incontinence
- Obstruction

Urinary Bladder Anatomy:

It has 4 parts:

- Superior Surface
- Base
- Apex
- Inferolateral Surface

It also has a trigone and two sphincters
**Bladder wall layers:**

1. **Mucosa:**
   - The wall of UB is lined by a **transitional epithelium** that is continuous with that in the ureters.
   - When the bladder is empty, the mucosa has numerous folds called **rugae**.
   - As the bladder fills with urine these **rugae** **flatten out** and distend with little change in **intravesical pressure**.
   - This results in **high compliance** of the bladder, so the volume of the bladder can ↑ from 10 ml to 400 ml with a pressure change of only 10 cm H₂O.
   - The Rugae is like a balloon can accommodate a great increase in volume without significant increase in pressure due to ability to unfold

2. **Submucosa** → loose connective tissue.

3. **Smooth muscle layer** → Detrusor muscle → the main muscle of micturition.

4. **Serosa**

**ONLY in female slides**

- **Bladder has two parts:** Body & Neck.
- **What is Trigone?**
  - A smooth triangular region of the internal urinary bladder formed by the two ureteric orifices and the internal urethral orifice.
- **How many sphincters are there? And how are they different?**
  - Two sphincters.
    - Internal Urethral Sphincters:
      - On either sides of urethra, made of smooth muscles.
    - External Urethral Sphincter:
      - Made of skeletal muscles.
- Detrusor muscle is responsible for contraction and relaxation of bladder.
- Covers all of urinary bladder and is heavily innervated by para and sympathetic nerves.
- Nervous Control is mainly on smooth muscle of bladder. Stretch receptors detect tension.

Ureterovesical Junction:

- Detrusor muscle penetrates the wall at an angle to create a flap valve.
- Valve is open for easy urine influx when the bladder is empty.
- Nerve Control is mainly on smooth muscle of bladder. Stretch receptors detect tension.
Ureterovesical Junction Cont.

Urine Transport from Kidney to Bladder:
- Urine is transported through the ureters.
- Urine is propelled through the ureter and into the bladder by the help of peristalsis.
- Peristalsis is thought to be initiated by pacemaker cells in the renal pelvis.

What happens if the distance that the ureter courses through the bladder wall is short?
- Urine will pass backwards to the upper UT, therefore it may cause infection and edema, because of presence of bacteria.

<table>
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<tr>
<th>Sympathetic Stimulation</th>
<th>Parasympathetic Stimulation</th>
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<td>• ↓ Peristalsis</td>
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## Nerve Supply to the Bladder:

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<th>Nerve</th>
<th>Afferent supply</th>
<th>Efferent supply</th>
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| Hypogastric Nerve “Sympathetic” | Enter at T11-L2 (Sensory).  
- It transmit impulses from the pain receptors to the upper lumbar segment (via the lumbar dorsal n. roots) ->
resulting in:  
- The perception of pain sensation from the urethra & bladder e.g. severe bladder distention (degree of stretch) & in inflammation. | Leave at T11-L2 (Motor).  
- Inhibitory to the bladder wall (detrusor muscle) (relaxation).  
- Motor to the internal urethral sphincter (Contraction).  
- Motor to the seminal vesicle, ejaculatory duct. |
| Pelvic Nerve “Parasympathetic” | Enter at S2-S4 (Sensory).  
- It transmit impulses from the tension (stretch) & pain receptors present in the wall of U.B. to the sacral region of spinal cord (via the sacral dorsal n. roots) ->
resulting in:  
- both reflex micturition & sensation of bladder fullness (i.e. desire for micturition) [The tension receptors are stimulated when I.V.P. ↑]. | Leave at S2-S4 (Motor).  
- Motor to the bladder wall (Contraction) (detrusor muscle).  
- Inhibitory to the internal urethral sphincter. (relaxation)  
Effectst of sympathetic and parasympathetic are opposite on bladder and urethra. |
| Pudendal Nerve “Somatic Nerve” | Enter at S2–S4 Sensory info from external sphincter.  
- It transmit impulses for the sensation of:  
- Distention of the urethra.  
- Passage of urine through the urethra. | leave at S2–S4 (Motor).  
- Motor to the external urethral sphincter (contraction). |
Filling of the Bladder—Bladder Tone:

- **Bladder tone** = the relationship between bladder volume and pressure (intravesical pr.)
- The relationship between bladder volume and intravesical pressure can be studied using cystometry.
- The volume-pressure record is called a **cystometrogram**.

The Reservoir Function of U.B:

- Urine enters the urinary bladder without producing much increase in I.V.P. (Intra-Vesicular Pressure) till the bladder becomes well-filled.
Stages Of Cystometrogram:

1. **Stage Ia:** Represent initial slight rise in I.V.P. by about 10 cm (from zero) H₂O when the first increase in volume is produced by about 50 ml (from zero).

2. **Stage Ib:** It is a long (longest phase), nearly flat segment produced by further increase in filling up to nearly 150 (50–400) ml.
   
   It causes no significant increase in IVP because of the bladder’s ability to stretch.

3. **Stage II:** This segment is produced by further increment of volume (150 – 400 ml) & represent rise of pressure.
   
   Volumes > 400 ml trigger the micturition reflex.

Cystometrogram Procedure:

ONLY in males slides
Cystometrogram:

- In the urinary bladder → the tension on the wall increases as the volume increases & also the radius increases, so there is little change in pressure until the organ is filled & any increase in volume beyond this will not be accommodated & is reflected by rapid rise of pressure.
- Superimposed on this curve, periodic acute increase in pressure (IVP) which lasts very few seconds, & called "micturition waves" (voiding waves) & are caused by micturition reflex. They may last a few seconds to more than a minute.

Sensations from the U.B at Different Urine Volumes:

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<td>-&gt; the first urge to void urine</td>
<td>-&gt; sense of fullness of the bladder.</td>
<td>-&gt; sense of discomfort</td>
<td>-&gt; sense of pain.</td>
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- **Micturition reflexes** start to appear at the first stage.
- They are progressively intensified in the subsequent stages up to stage 4 (as the volume increases).
- Micturition reflexes can be voluntarily suppressed.
Micturition Reflexes:

A) Unconditioned (automatic) micturition:
- In infants → urination occurs through a series of spinal reflexes called “the micturition reflexes” which are automatic (not under voluntary control) because the nerve tracts are not yet myelinated in infants.
- The stimulus that initiates these reflexes is rise of the IVP (which stimulates stretch receptors in the bladder wall)
- It is an autonomic spinal reflex.
- Involuntary (not under higher CNS control)
- Between 2–3 years of age–they learn to control it and becomes voluntary.

B) Voluntary or conditioned micturition:
- In adults → the act of micturition occurs also through the micturition reflexes (autonomic spinal reflex), but however, it can be voluntarily controlled by certain higher (or supra–spinal) centers in the brain. The control is either facilitatory or inhibitory.
- Controlled by higher CNS centres:
  - Brain stem (Pons).
  - Cerebral cortex.
The cortical centers facilitate micturition by discharging signals that leads to:

1. Stimulation of sacral micturition center.
2. Inhibition of pudendal nerves \(\rightarrow\) relaxation of external urethral sphincter.
3. Contraction of anterior abdominal muscle & diaphragm to increase intra-abdominal pressure \(\rightarrow\) the intra-vesical pressure is increased. This intensifies the micturition reflex.

The higher centers will inhibit the micturition reflex by:

- Inhibition of sacral micturition center.
- Stimulation of pudendal nerves \(\rightarrow\) contraction of external urethral sphincter.
**Mechanism of voluntary control of micturition:**

1. Stretch receptors detect filling of bladder, transmit afferent signals to spinal cord.
2. Signals return to bladder from spinal cord segments S2 and S3 via parasympathetic fibers in pelvic nerve.
3. Efferent signals excite detrusor muscle.
4. Efferent signals relax internal urethral sphincter. Urine is involuntarily voided if not inhibited by brain.
5. For voluntary control, micturition center in pons receives signals from stretch receptors.
6. If it is timely to urinate, pons returns signals to spinal interneurons that excite detrusor and relax internal urethral sphincter. Urine is voided.
7. If it is untimely to urinate, signals from pons excite spinal interneurons that keep external urethral sphincter contracted. Urine is retained in bladder.
8. If it is timely to urinate, signals from pons cease and external urethral sphincter relaxes. Urine is voided.

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**The micturition reflexes can be summarized as follows:**

- Distention of the U.B. (as a result of I.V.P. & not by an increase in the bladder volume) produces reflex contraction of its wall & relaxation of the internal urethral sphincter & external urethral sphincter.
- The flow of urine in urethra will produce contraction of the U.B. wall & relaxation of both internal & external urethral sphincters.
Disturbances Of Micturition (mostly due to denervation):

1- Denervation of the Afferent Supply
E.g. in tabes dorsalis (syphilis) (tabetic bladder):
Characterized by:

- Loss of the U.B. sensations & reflex micturition.
- The bladder becomes distended (over stretched), thin walled & hypotonic (atonic/flaccid bladder) with ineffective contractions.
- Some intrinsic responses of the smooth muscle are retained.
- There is retention with overflow i.e. dribbling of urine when the bladder becomes over filled.

2- Denervation of Both Afferent & Efferent Supply:
E.g. in tumour, injury to cauda equina syndrome.
Characterized by:

- The bladder is hypertonic.
- Reflexes are abolished.
- Intrinsic responses of the smooth muscles are increased.

This is due to denervation hypersensitivity because:

- Degradation of acetylcholine by process of reuptake
- Cholinesterase in the tissue
- Number of cholinergic receptors.

Cauda equina syndrome (CES): is a condition due to damage to the bundle of nerves below the end of the spinal cord known as the cauda equina. Symptoms include low back pain, pain that radiates down the leg, numbness around the anus, and loss of bowel or bladder control.
3- **Spinal Cord Transection (Above the Sacral Region):**

The micturition reflex is intact, but there’s loss of higher center control. There are several phases:

1) **Stage of Spinal Shock**

   - The spinal centers become functionless for 2 – 6 weeks. So, the micturition reflex is abolished → “retention with overflow” i.e. the bladder distends until the I.V.P. exceeds the urethral sphincter resistance & so, urine starts to dribble.

2) **Stage of Recovery of the Spinal Centres:**

   - Automatic micturition: micturition reflex recovers but is not controlled by CNS. Occurs as soon as the I.V.P. rises to 15 – 20 cm water → reflex micturition occurs.

3) **Stage of failure recovery:**

   - Damage of the spinal centers by toxins of bacterial infections → abolishes the micturition reflex -> “Retention with overflow”.

4- **Uninhibited Neurogenic Bladder:**

   - Causes frequent relatively uncontrolled micturition.
   - Results from lesions to spinal cord or brainstem that mainly affects the inhibitory signals to spinal cord.

   - Frequent urination of small volume of urine.
   - This will cause a hyperactive detrusor muscle that will result in activation of micturition even at small urine volumes.
Summary:

Urinary bladder fills, stretching bladder wall

Afferent impulses from stretch receptors

Simple spinal reflex

Promotes micturition by acting on all three spinal efferents

Parasympathetic activity

Sympathetic activity

Somatic motor nerve activity

Detrusor contracts; internal urethral sphincter opens

External urethral sphincter opens

Micturition

Inhibits

Higher brain centers

Allow or inhibit micturition as appropriate

Pontine micturition center

Pontine storage center

Parasympathetic activity

Sympathetic activity

Somatic motor nerve activity

Brain

Spinal cord

Urinary bladder filling leads to mechanoreceptor activation in the spinal cord, which triggers the micturition reflex. If luminal pressure increases, the detrusor contracts, and the external sphincter relaxes. This sequence allows voiding to occur, with neural pathways involving parasympathetic and sympathetic nervous systems, as well as somatic motor neurons.
1- When you’re in formal situation and you can’t go to bathroom, but your bladder is full, what will happen?
A. Inhibit the Pelvic nerve.
B. Inhibit the pudendal nerve.
C. Inhibit the Hypogastric nerve.
D. Inhibit the Parasympathetic system.
E. Inhibit the sympathetic system.

2- Which of the following is the right concept of micturition reflexes?
A. Distention of the U.B. as a result of increase I.V.P. only produces reflex relaxation of its wall & contraction of the internal urethral sphincter & external urethral sphincter.
B. Distention of the U.B. as a result of increase I.V.P. only produces reflex contraction of its wall & the internal urethral sphincter & relaxation of external urethral sphincter.
C. Distention of the U.B. as a result of increase I.V.P. only produces reflex contraction of its wall & relaxation of the internal urethral sphincter & external urethral sphincter.
D. Distention of the U.B. as a result of decrease I.V.P. only produces reflex contraction of its wall & relaxation of the internal urethral sphincter & external urethral sphincter.

3- Diabetic patient comes to the clinic with loss of U.B sensations & reflex micturition, his bladder becomes distended, thin walled & hypotonic, with dribbling of urine if the bladder becomes over filled, what’s the most likely nerve could be injured? :
A. Denervation of both afferent and efferent nerve supply.
B. Denervation of the afferent supply only.
C. Denervation of the efferent supply only.
D. Damage of the spinal cord.

4- Patient survive from car accident after being in shock, his urination become controlled by scratching or tickling only, what’s the most likely nerve could be injured?:
A. Denervation of both afferent and efferent nerve supply.
B. Denervation of the afferent supply only.
C. Denervation of the efferent supply only.
D. Damage of the spinal cord.

5- Depending on the previous question, if the examination & investigation shows bacterial infection or/and toxins in his urine, he most likely to be in which stage of the following?
A. Stage of shock.
B. Stage of recovery.
C. Stage of failure of Recovery.
D. Stage in between A & B

1- B  2- C  3- B  4- D  5- C
Thank you for checking our work

Male Team:
- فهد القايز
- خالد المطلق
- نواف الهلال
- هشام الشاب
- خالد العقيلي
- عبدالله الزياد
- حسين علامي
- سلطان الفهد
- خالد المطيري
- فهد النهاي
- عمر الياس

Female Team:
- أس السويدة
- أس السيف
- خالد شويل
- ريان الموسي
- سعد الهداب
- سلطان الناصر
- سعود العطوي
- سيف المشاري
- عبد الجبار إسماعيلي
- عبد الرحمن آل دخيم
- هشام الموسي
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