جامعة الملك سعود
King Saud University

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Physiology of Micturition

Lecture 4

RENAL BLOCK

PHYSIOLOGY TEAM 437

تمت المراجعة
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Editing file

A recommended overview of the lecture (16 min)

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.

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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:

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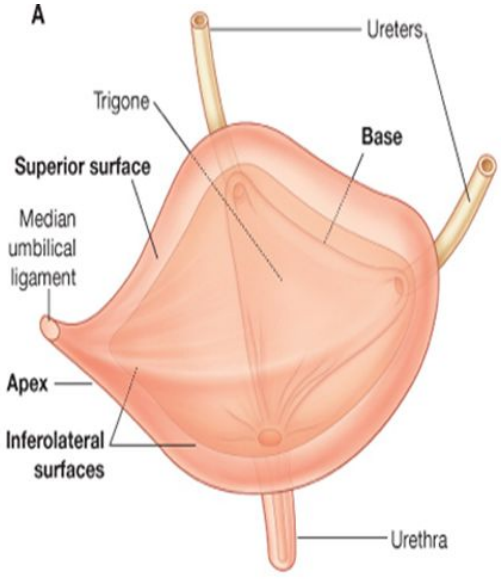
It has 4 parts:

- Superior Surface
- Base
- Apex
- Inferolateral Surface

It also has a **trigone** and **two sphincters**



- 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.

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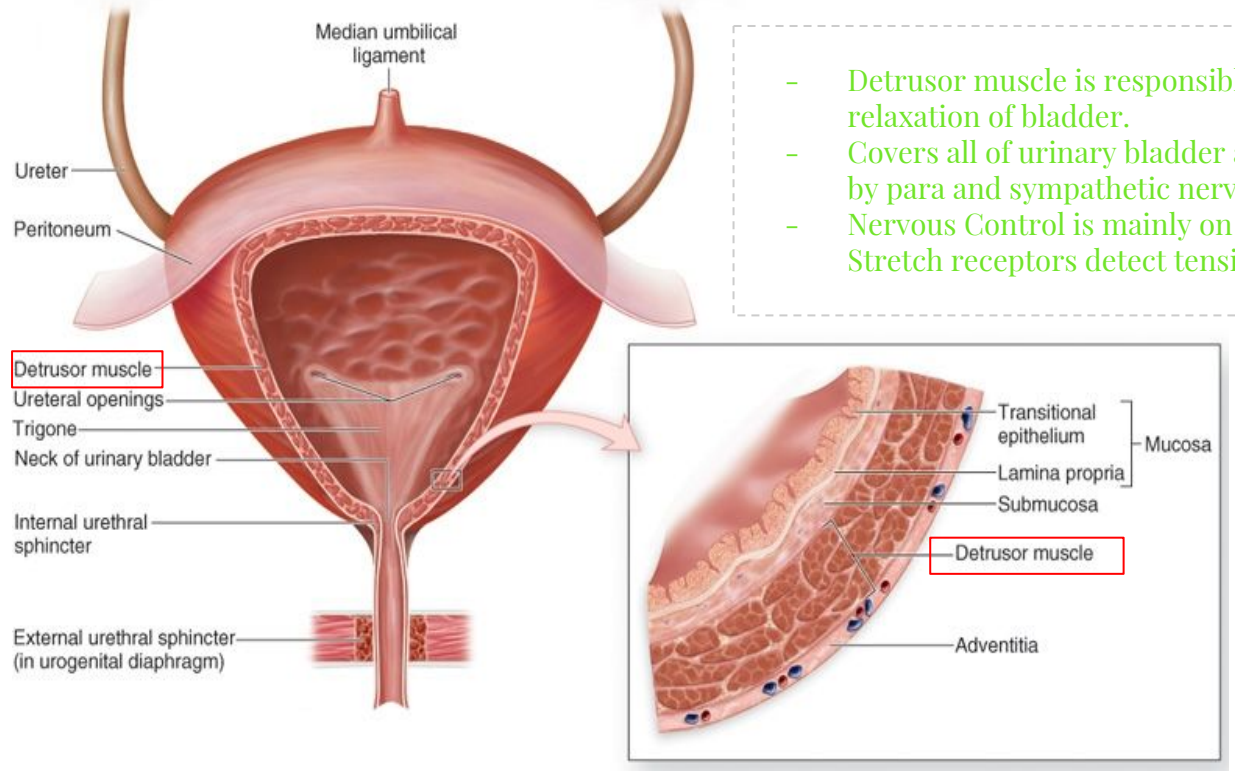
Bladder wall layers:

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 H_2O.**
   - 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



- 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:

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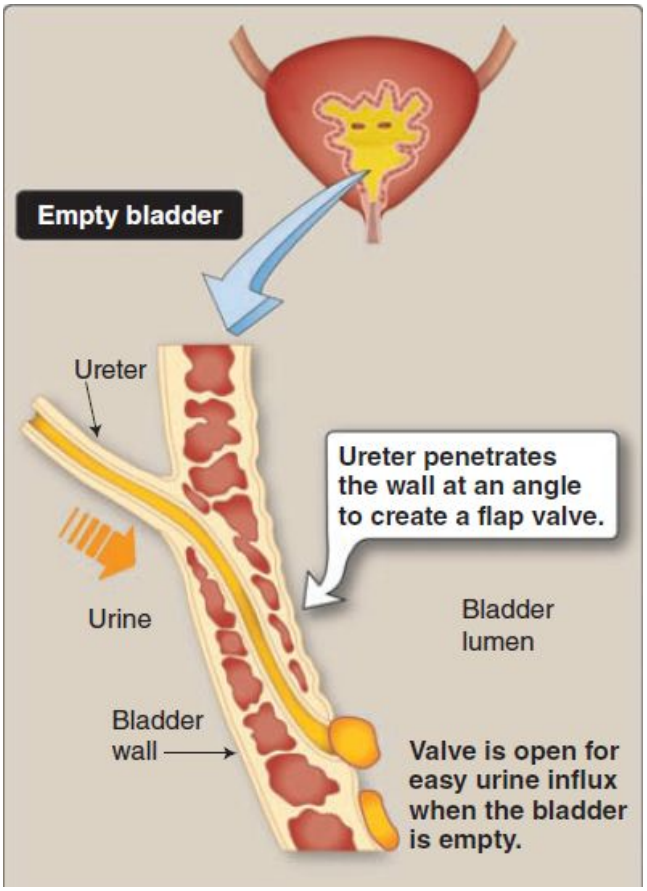

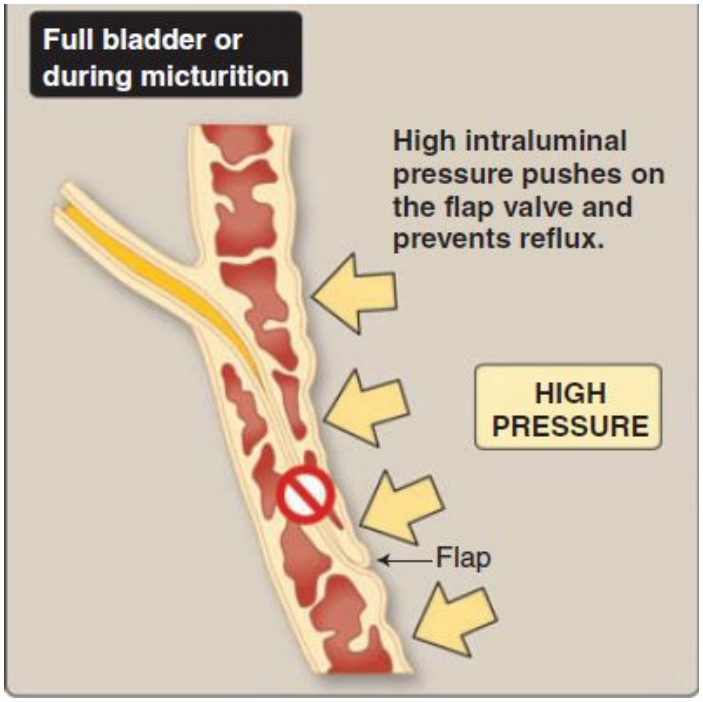

Ureterovesical Junction Cont.

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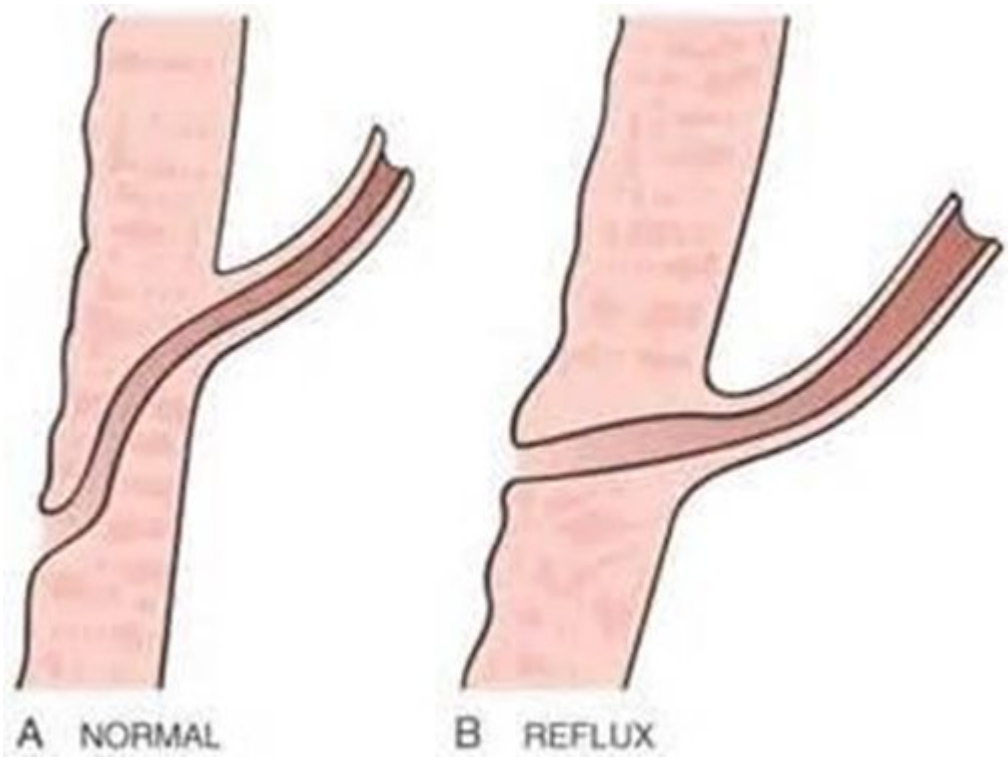


- What happens if the distance that the ureter courses through the bladder wall is short?
- Urine will pass backwards to the upper UT, therefore it may cause infection and edema, because of presence of bacteria.

Urine Transport from Kidney to Bladder:

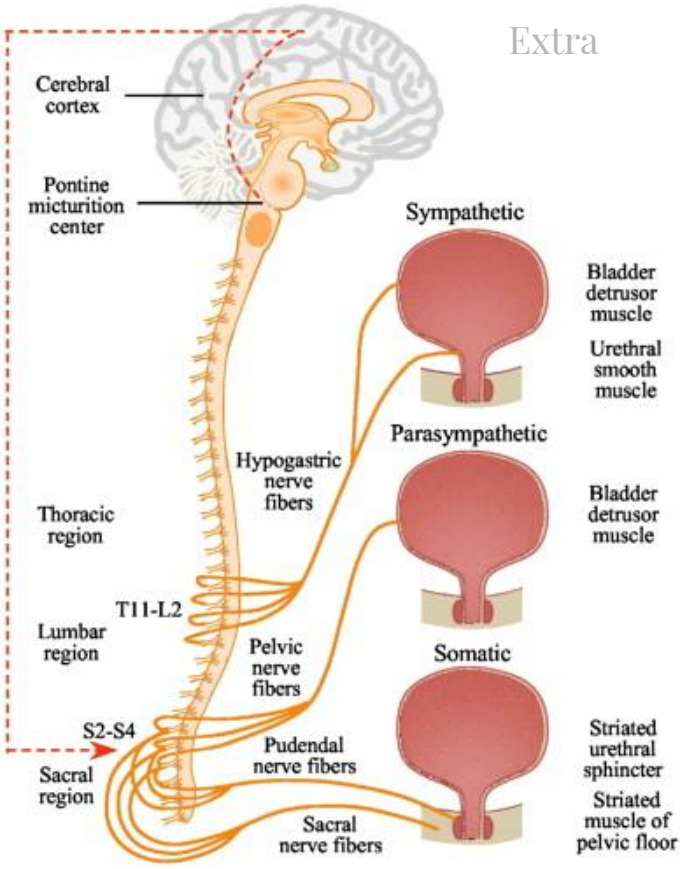
- Urine is transported through the ureters.
- Urine is propelled through the ureter and into the bladder by the help of peristalsis.
- Peristalsis is thought to be initiated by pacemaker cells in the renal pelvis.

Sympathetic Stimulation	*Parasympathetic Stimulation*
• ↓ Peristalsis	• ↑ Peristalsis

Nerve Supply to the Bladder:

Nerve	Afferent supply	Efferent supply
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) Effects 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).

Extra



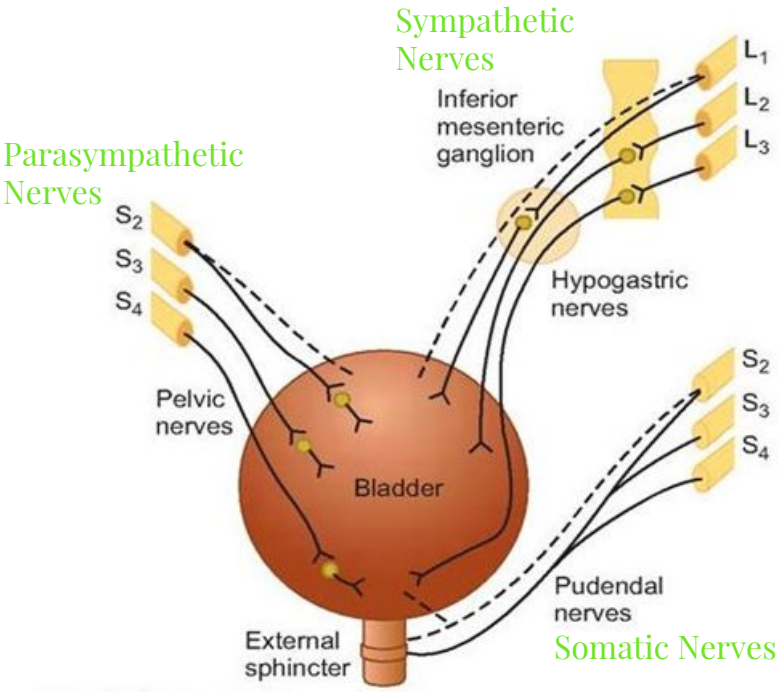


FIGURE 38–20 **Innervation of the bladder.** Dashed lines indicate sensory nerves. Parasympathetic innervation is shown at the left, sympathetic at the upper right, and somatic at the lower right.

Filling of the Bladder–Bladder Tone:

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- ***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:

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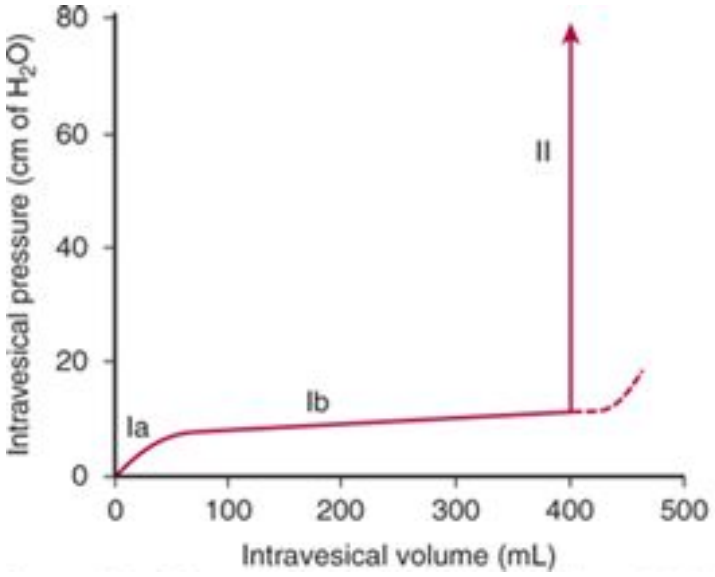
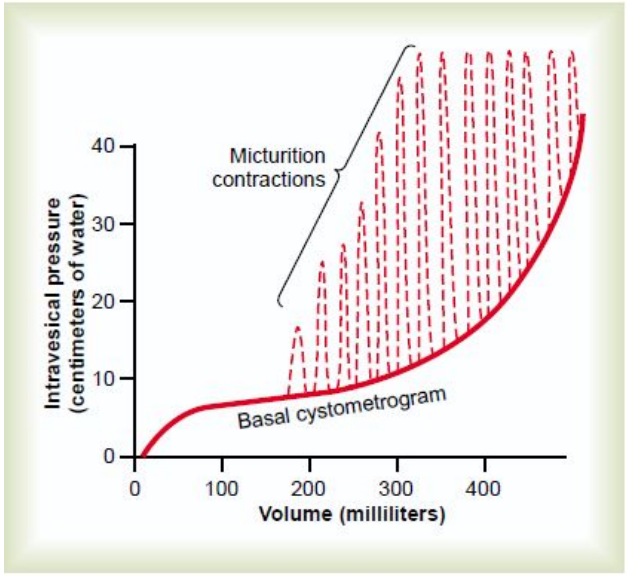
- Urine enters the urinary bladder without producing much increase in I.V.P. (Intra-Vesicular Pressure) till the bladder becomes well-filled.

Stages Of Cystometrogram:





1. **Stage Ia:** Represent initial slight rise in I.V.P. by about 10 cm (from zero) H_2O 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.

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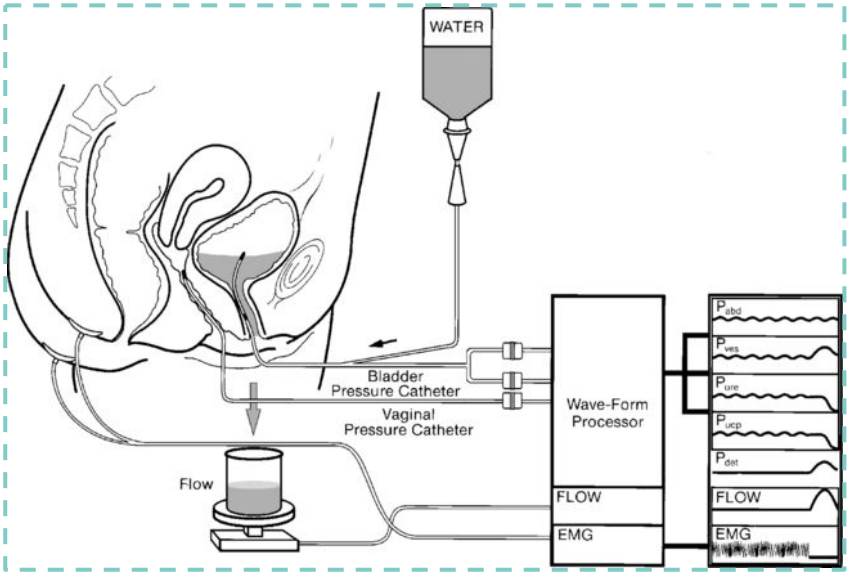
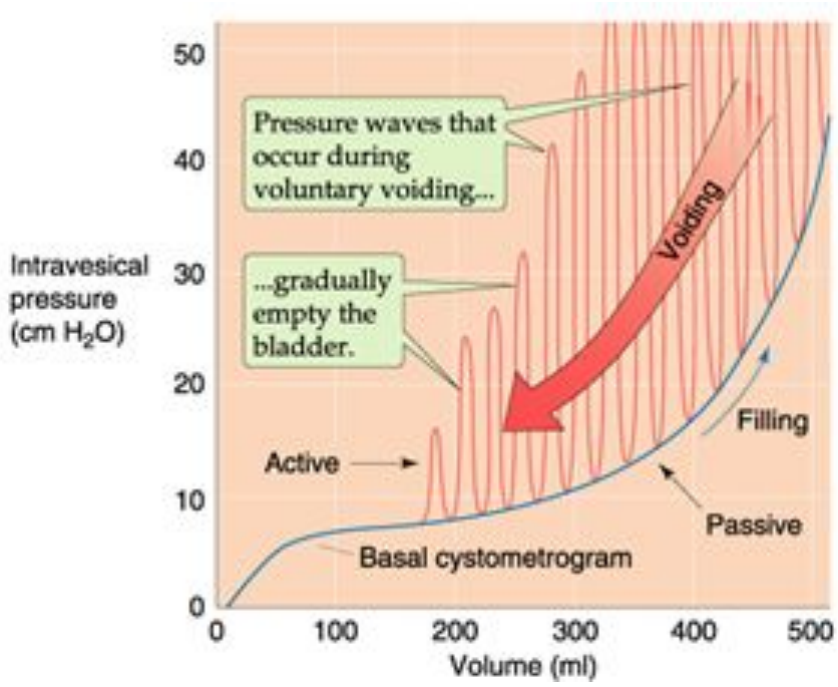
Cystometrogram Procedure:



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:

Stage 1: U.V **150 –300 ml** -> the first urge to void urine

Stage 2: U.V **300 - 400 ml** -> sense of fullness of the bladder.

Stage 3: U.V **400 - 600 ml** -> sense of discomfort

Stage 4: U.V **600 - 700 ml** -> sense of pain.

Break point: U.V **700 ml** micturition **can't** be suppressed.

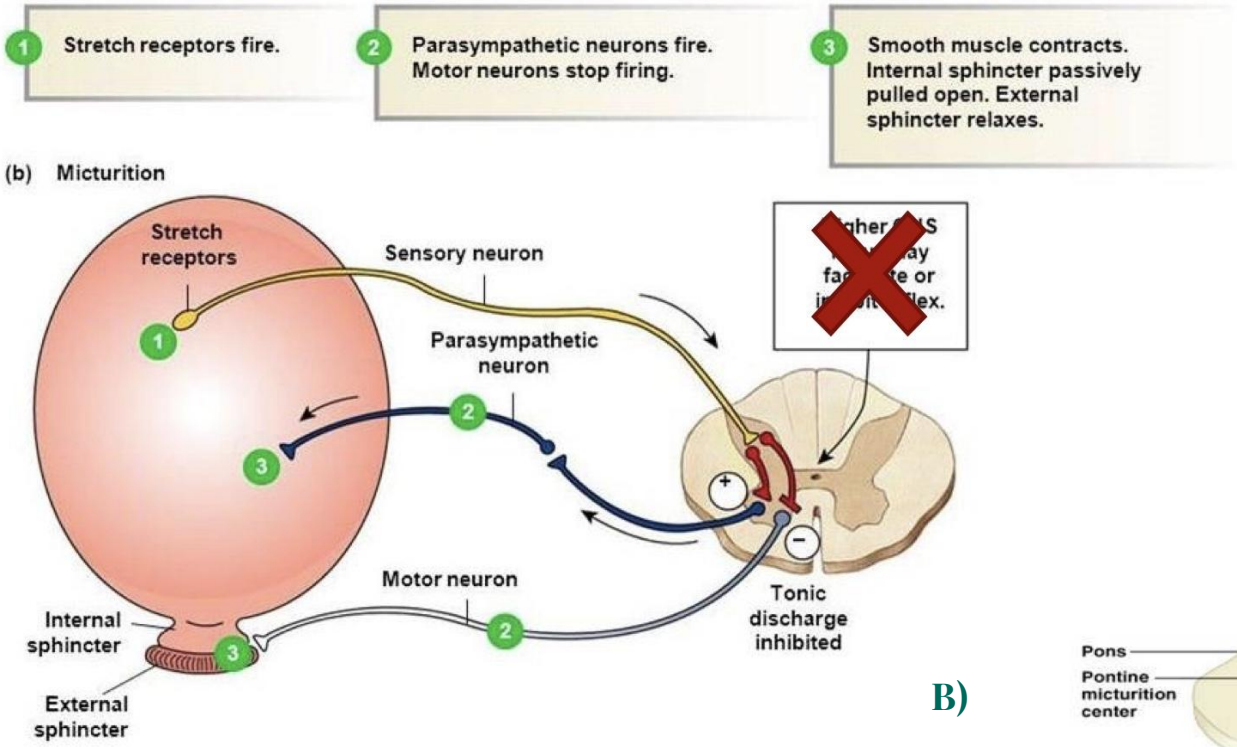
- **Micturition reflexes** start to appear at the first stage.
- They are progressively intensified in the subsequent stages up to stage 4 (as the volume increases).
- Micturition reflexes can be voluntarily suppressed.

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.

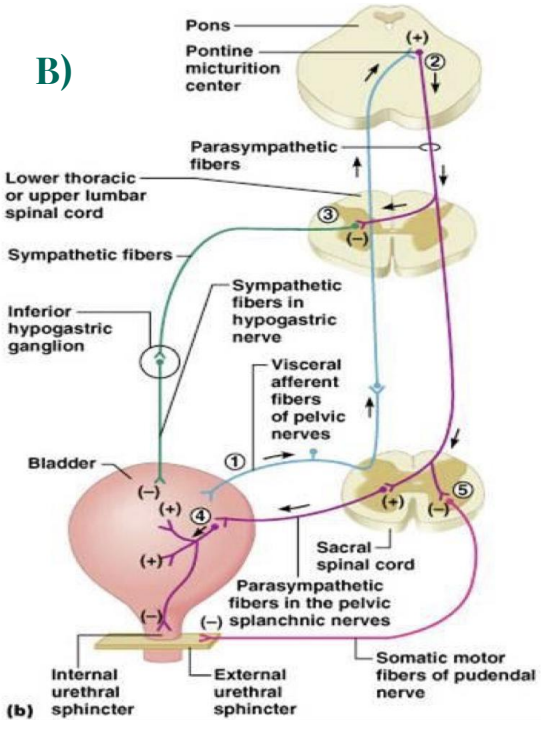
A)



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.

B)



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Facilitatory	*Inhibitory* *(Increase tone of external sphincter)*
• In pontie area. • Posterior Hypothalamus. • Other cortical centers.	• In the midbrain.

Mechanism of voluntary control of micturition:

Filling of the bladder beyond **300 –400 ml**

causes stretching of sensory stretch receptors.

These sensory signals stimulate sacral segment, which is consciously appreciated by higher centers

If the conditions are favorable

The cortical centers facilitate micturition by discharging signals that leads to:

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

If the conditions are unfavorable

The higher centers will inhibit the micturition reflex by:

- Inhibition of sacral micturition center.
- Stimulation of pudendal nerves → contraction of external urethral sphincter.

Micturition Reflexes (Normally Involuntary):

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.

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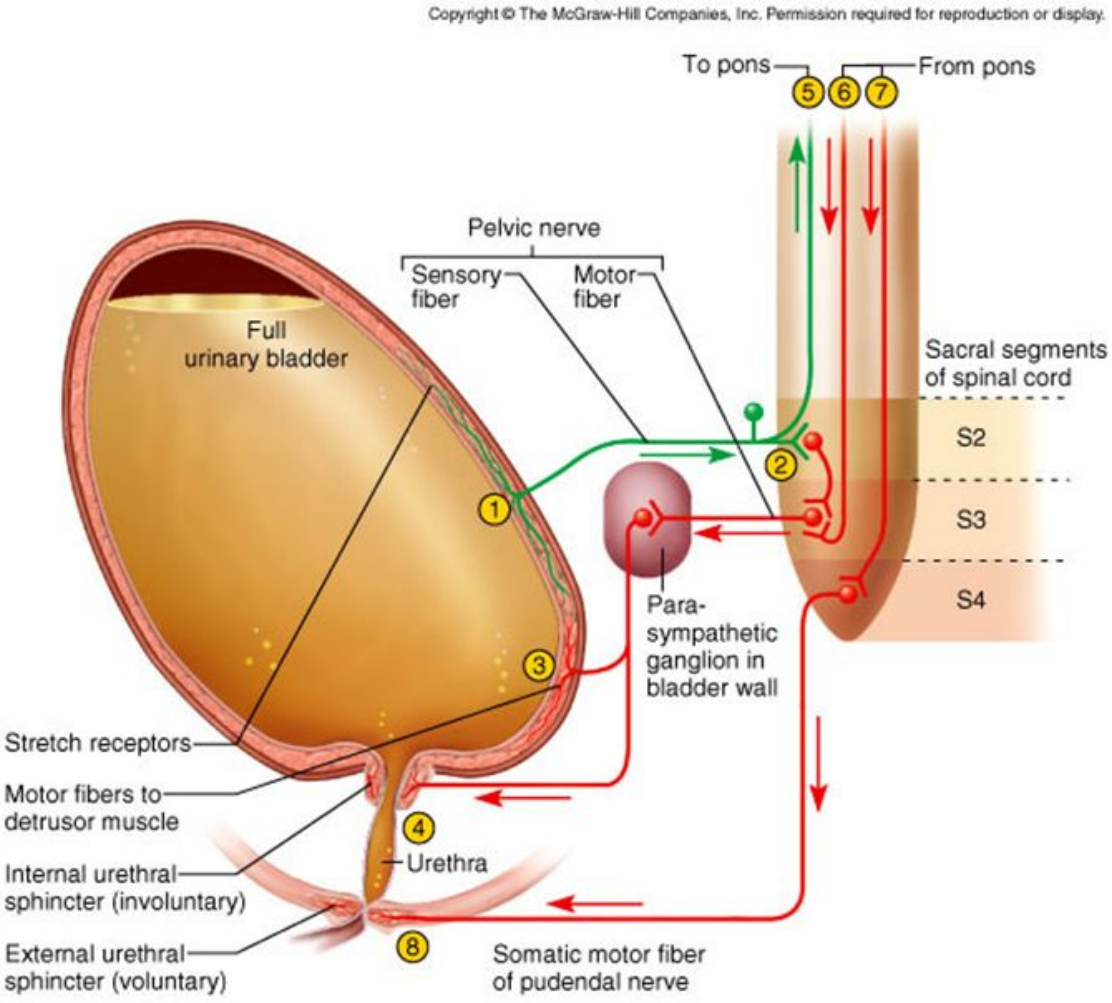
Mechanism of voluntary control of micturition:



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.

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

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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

- This occurs due to the sudden separation of the spinal centers from the higher centers that control them.
- 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:

- Same as stage 1
- Damage of the spinal centers by toxins of bacterial infections → abolishes the micturition reflex -> **"Retention with overflow".**

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4- Uninhibited Neurogenic Bladder:

- Causes frequent relatively uncontrolled micturition.
- Frequent urination of small volume of urine.
- Results from lesions to spinal cord or brainstem that mainly affects the inhibitory signals to spinal cord.
- This will cause a hyperactive detrusor muscle that will result in activation of micturition even at small urine volumes.

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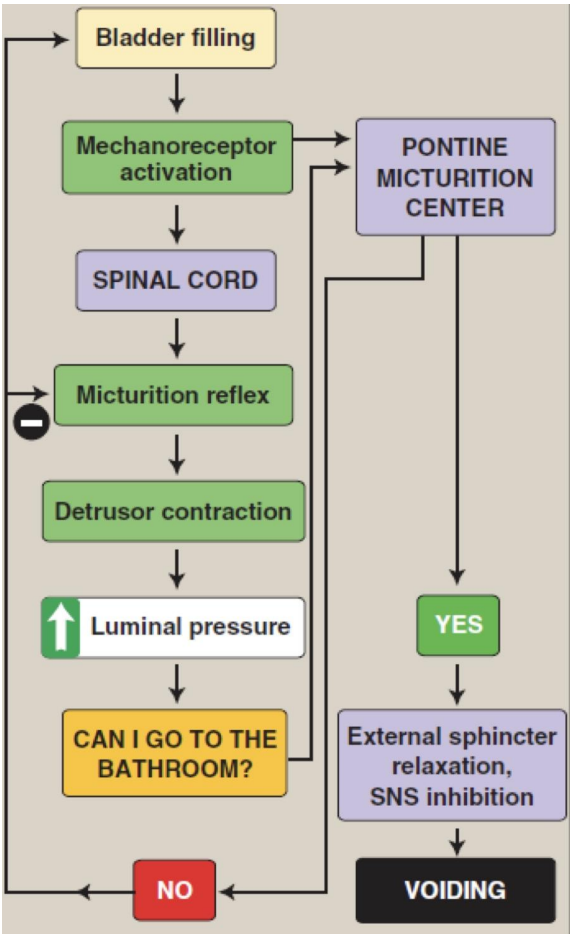
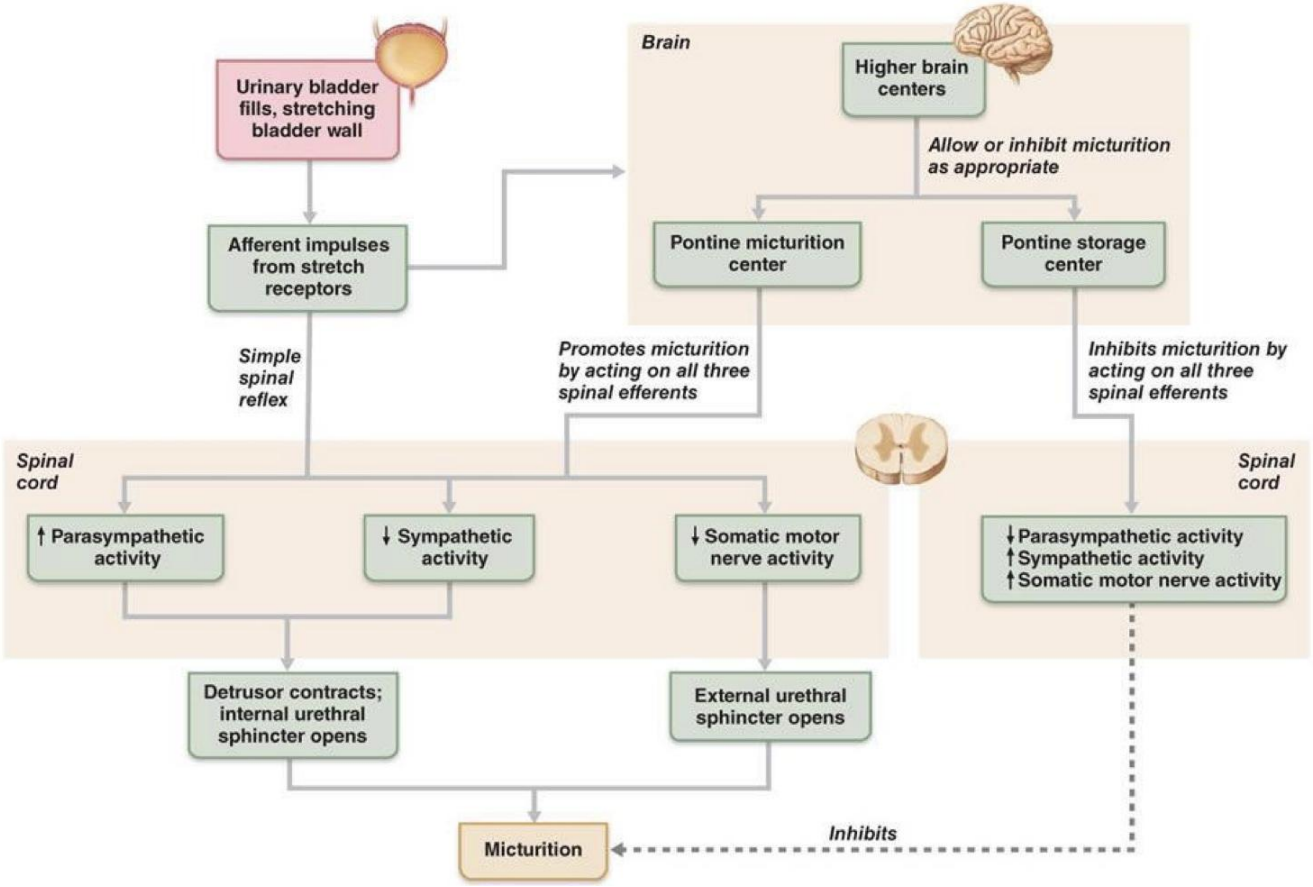
Summary:





Quiz

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:

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هشام الموسى

فهد الفايز
خالد المطلق
نواف الهلال
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