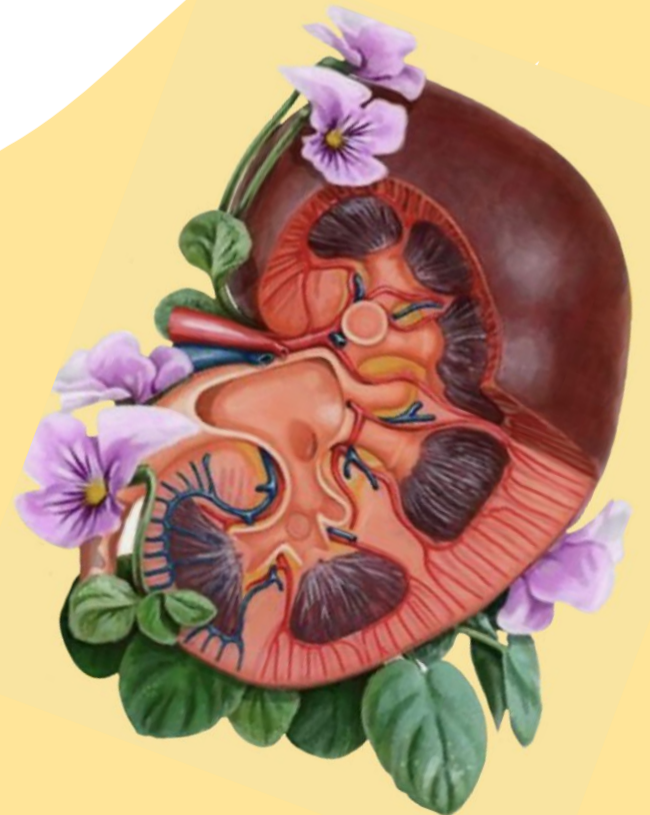




PHYSIOLOGY OF MICTURITION



Black: in male AND female slides
Red : important
Pink: in female slides only
Blue: in male slides only
Green: Dr' notes
Gray: extra information

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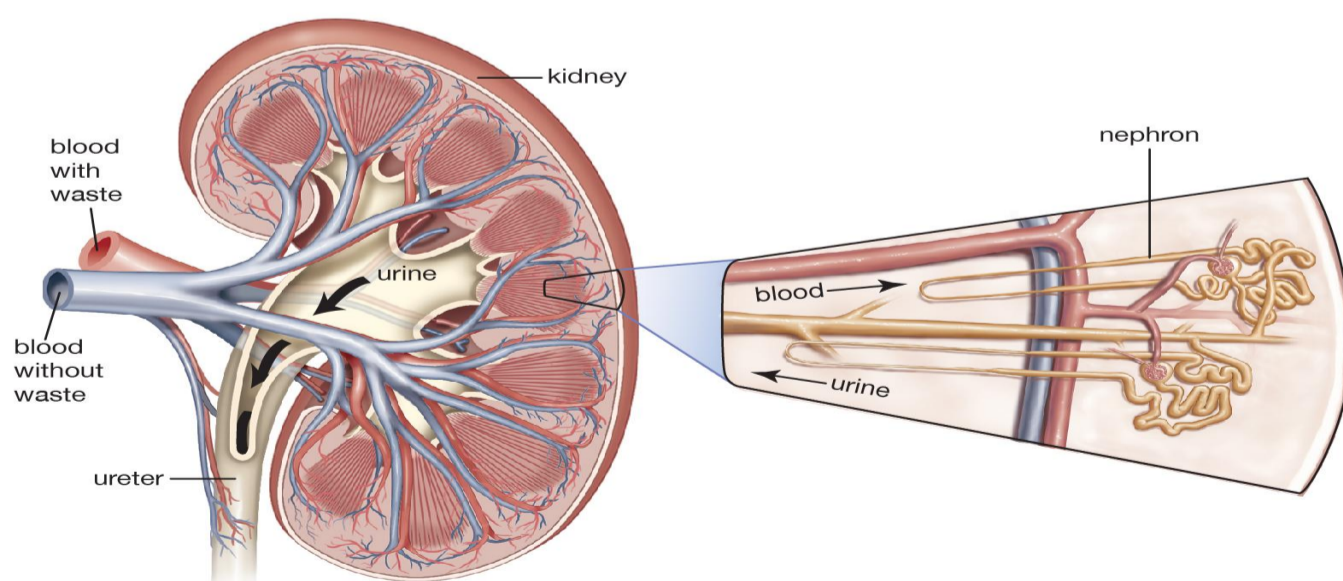
Objectives:

At the end of this session, students should be able to:

- Define micturition.
- Identify and describe the functional anatomy of the urinary bladder.
- Describe the neural control of the urinary bladder and sphincters.
- Describe the mechanism of filling and emptying of the urinary bladder.
- Cystometrogram.
- Explain the neurogenic control of the micturition reflex and its disorders.

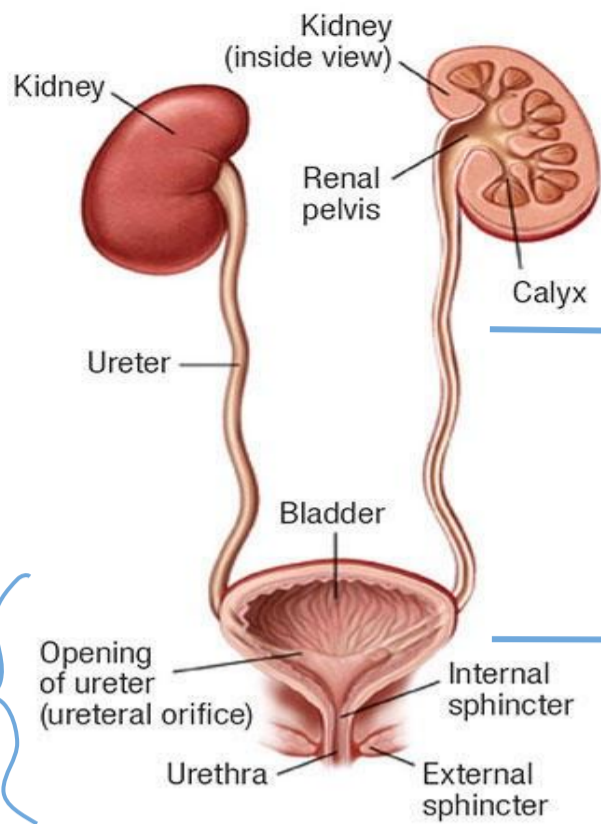
Introduction

- Micturition (urination): is the process by which we empty our bladder of urine
- GFR = **125 ml/min** *الوحدات مهمة*
- Tubular reabsorption = **124 ml/min**
- Rate of urine formation = **1 ml/min**
- Ureters conduct urine to bladder.
- Urine is stored in the bladder until voiding.



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Recap: blood that contains waste enter the kidney through the artery, then passes through all vessels and it branches until it reaches afferent arterioles —> then to glomerular where the plasma gets filtered and carrying chemical waste products, then the important component gets reabsorbed, and the waste product excreted from collecting duct into renal pelvic, **Once urine reaches the pelvic it cannot get modified (all the modification happens in the tubules), then urine transport from the pelvis to the border through ureters.**



Ureters conduct urine to bladder

How?

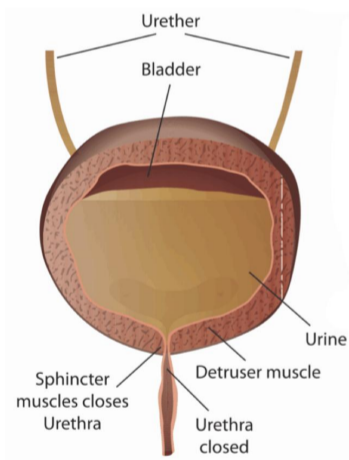
By contraction and relaxation of the ureter, this movement called a ureteral peristalsis

Urine is stored in the bladder until voiding

الى متى؟ لما يصير عندي كمية كافية من
Urine
Then it will excreted

Functions of the Lower UT (bladder and urethra)

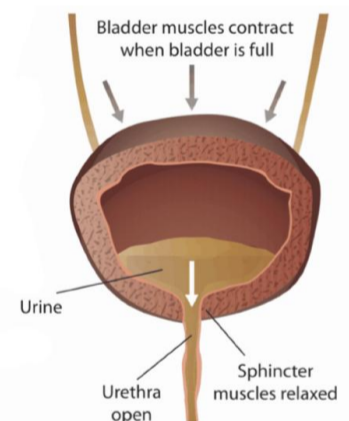
urine storage



- Bladder wall relaxed to accommodate this amount on urine.
- outlet or sphincter is closed (contracted).
- Store without leakage**

voiding (micturition)

Expel the urine out when it's more than enough.



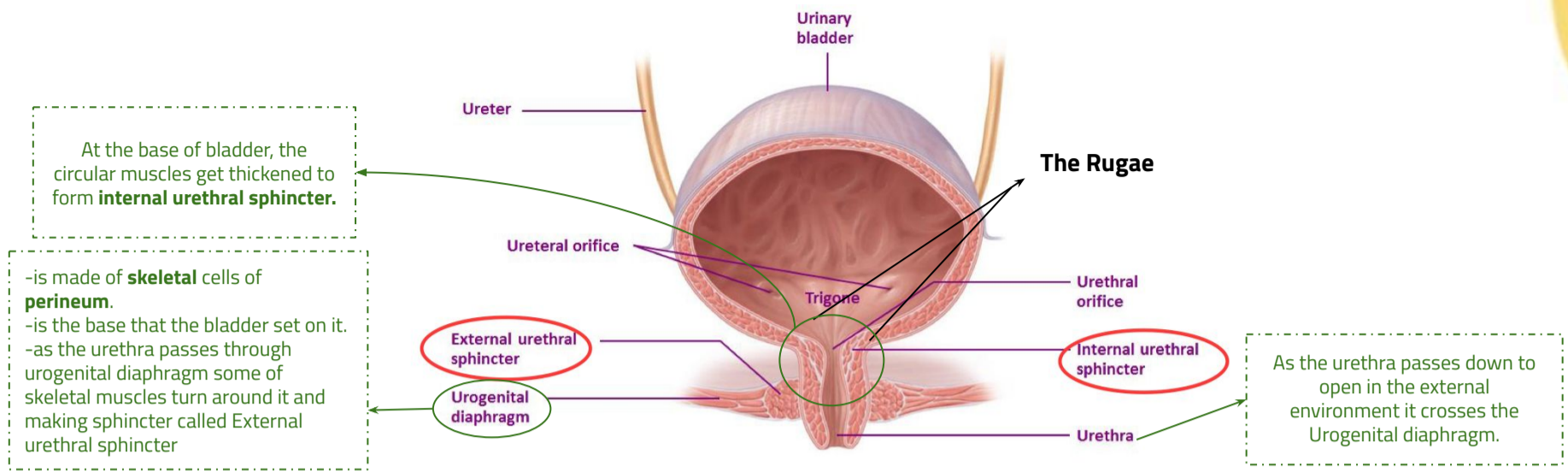
- Bladder wall contracted and the outlet or sphincter is open (Relaxed).
- Empty when appropriate** because if the bladder starts to empty but not in the appropriate time this is not good.

- To understand how the lower urinary tract performs this function, one must understand:

1- Functional anatomy of the bladder

2- Neural control of the bladder. Because micturition is controlled by neural mechanism (by nerves).

1-Functional Anatomy of The Bladder



Urinary Bladder:

- Muscle chamber composed of two main parts: **body** and **neck**.
- When the bladder relaxed we see ridges in the wall called **Rugae** is like a balloon can accommodate a great increase in volume without significant increase in pressure due to ability to unfold.

What is the trigone ?

A **smooth** triangular area in the internal urinary bladder bounded by **2 ureteric orifice** and **internal urethral orifice**. Its mucous membrane is elastic (not folded).

How many sphincters are there and how are they different?

Two sphincters:

- Internal sphincter** is made up of **smooth muscle** (involuntary by autonomic nerves).
- External sphincter** is made up of **skeletal muscle** (voluntary by somatic nerves).

bladder wall has 4 layers :

mucosa —> transitional epithelium —> has folds "rugae", that will flatten out as the bladder fill in with little, the benefit of these folds is to allow stretching of the wall when it gets filled of urine.

- change in intravesical pressure.
- this result in high compliance of the bladder.

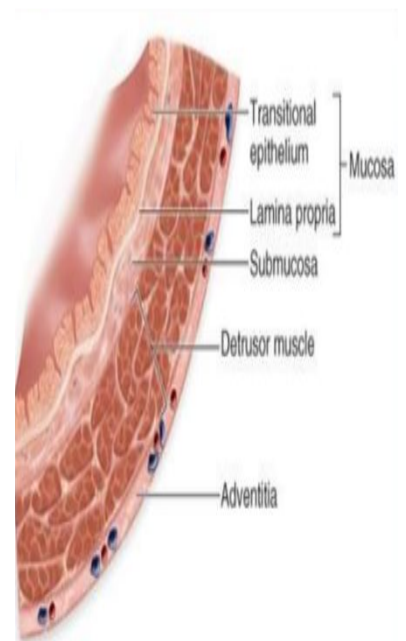
submucosa: loose connective tissue.

Smooth muscle layer —> Detrusor muscle: the main muscle of micturition. 3 layers, but it overlaps not distinct layers + fibers ماشية بجميع الاتجاهات: longitudinal + circular + oblique fibers

WHY? To push the urine effectively, Because there are pockets in the bladder.

- 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

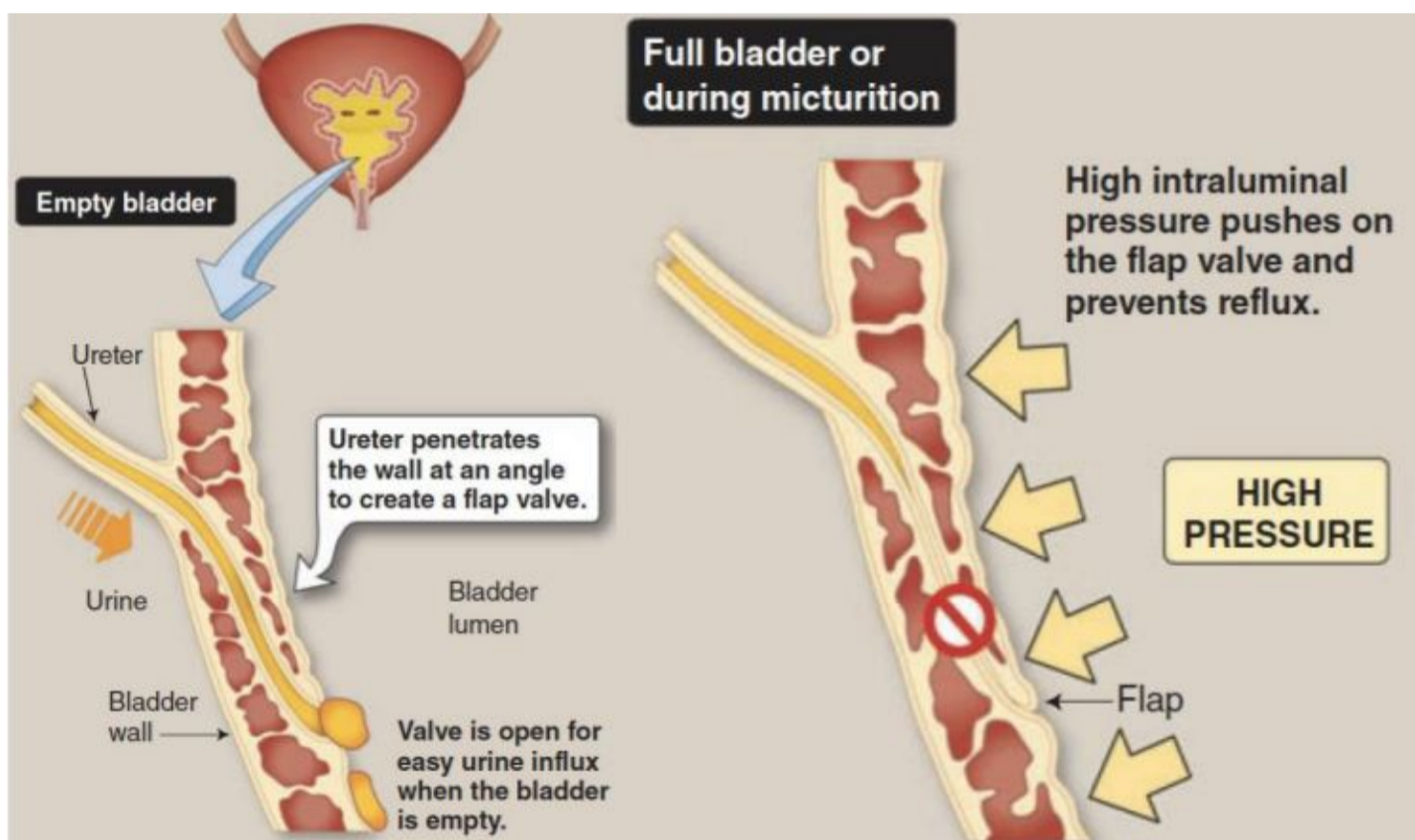
Serosa



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 → inhibits peristalsis.
- ❖ Parasympathetic stimulation → enhance peristalsis.

Ureterovesical Junction



- ❖ The ureter penetrates the bladder through the ureteric orifice.
- ❖ When the bladder gets full, the opened junction will close due to the increase in the intravesical pressure (pressure inside the bladder) to prevent the urine from entering it.

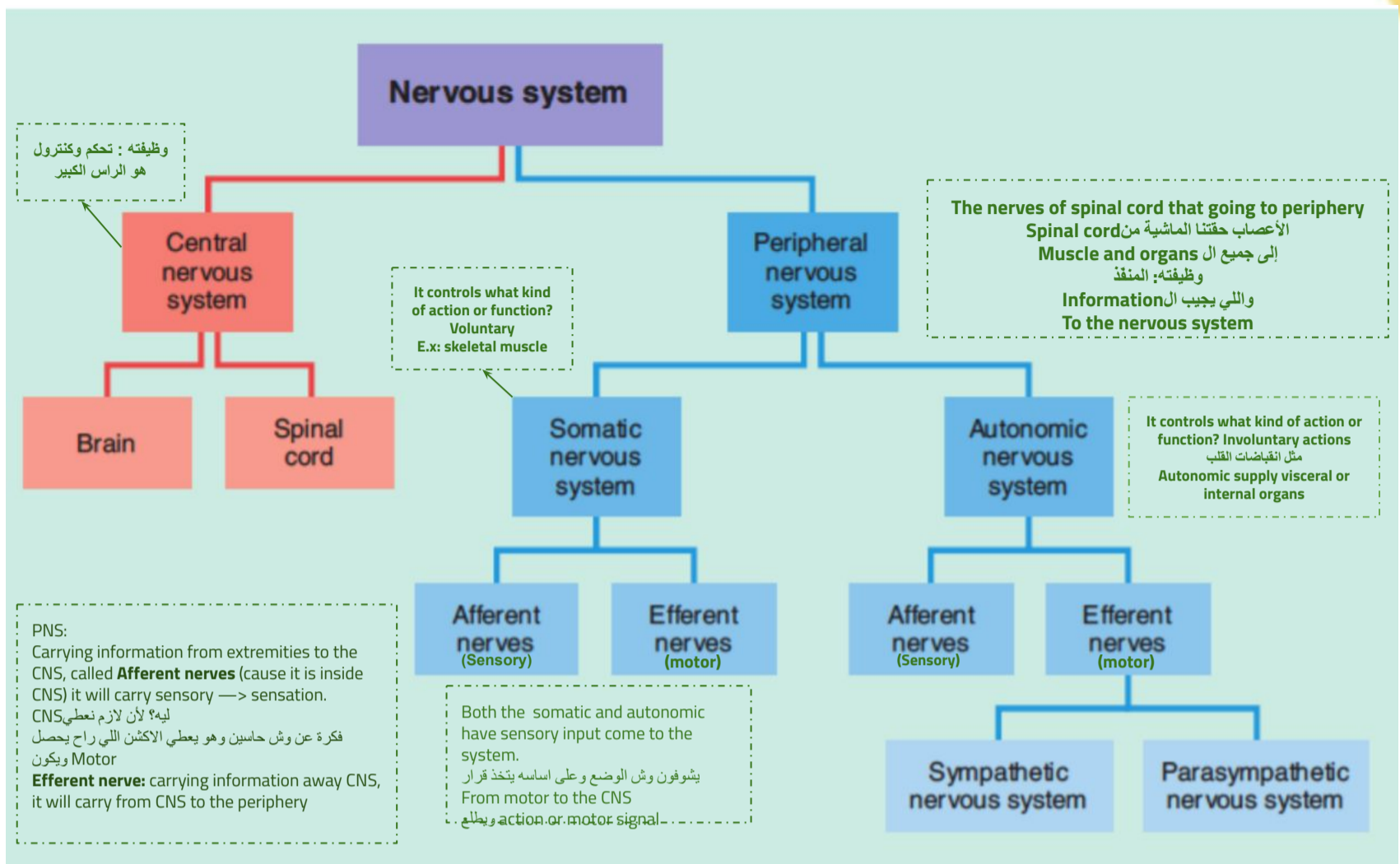
The ureter passes **obliquely** through the wall of the urinary bladder. what is the benefit of this? To make an anatomical as well as a physiological valve (sphincter like). what is the benefit of the valve?

If the course of the ureter was straight → the bladder when it gets filled with urine → this urine will go back to the ureter and this is a very bad thing because it will go back also to the kidney → kidney will get larger because of accumulation of urine on it (Hydronephrosis) also the person will get infections → damage of the kidney → Renal failure.

So to protect the ureter from backflux or Reflux of urine → the course of ureter becomes oblique through the muscle wall so when bladder gets filled → the pressure of urine will push the wall then it gets blocked → so there is NO reflux.

There is a congenital anomalies in children → The ureterovesical junction instead of coursing obliquely it becomes straight course. so when the child comes to you with Recurrent upper urinary tract infection (e.g: pyelonephritis) so i have to question if there is a congenital anomalies causing reflux of urine which cause infections and hydronephrosis.

A General Look at the Nervous System



2-Neural Innervation of the LUT (Bladder and Urethra)

Nerve supply of the Lower urinary tract

Somatic (S2-S4)

The action is voluntary —> so it will innervate skeletal muscles (Remember which muscle in LUT has skeletal muscle?) **External urethral sphincter.** it will innervate it via Pudendal Nerves
Function:
 -Contraction of External Sphincter.

Autonomic

Sympathetic (T11 or T10-L2):

It's autonomic so it's involuntary —> It will innervate smooth muscles (the body of the bladder) + **internal urethral sphincter** via Hypogastric nerves. Remember that it always come from the thoracolumbar region.
 -it's opposite to Parasympathetic , It FAVORS STORAGE
Function:
 -Relaxes bladder
 -Contracts internal sphincter

Parasympathetic (S2-S4):

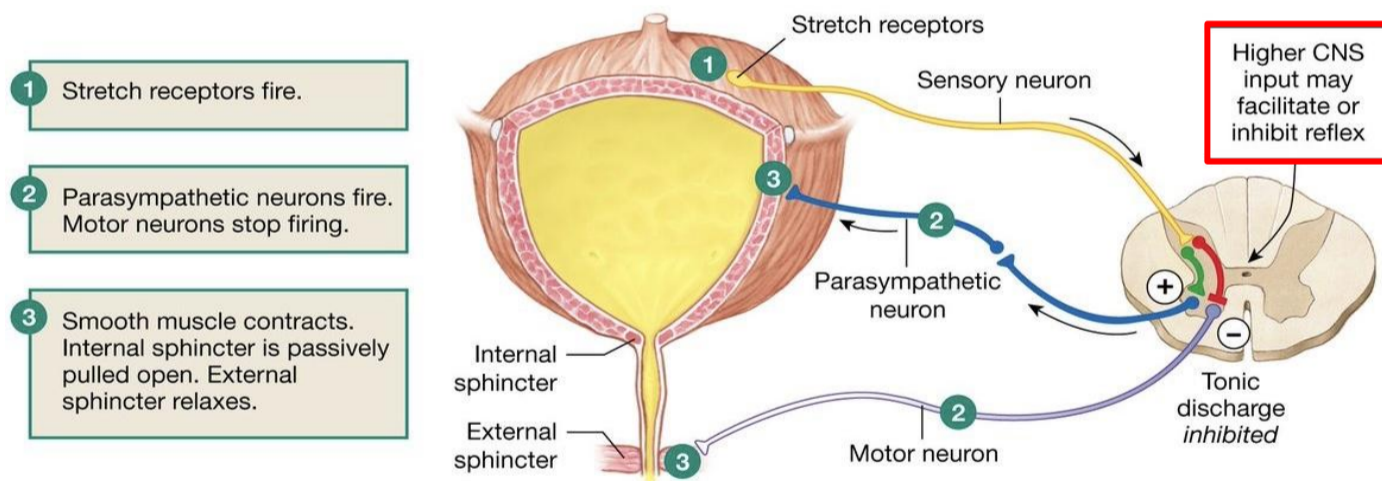
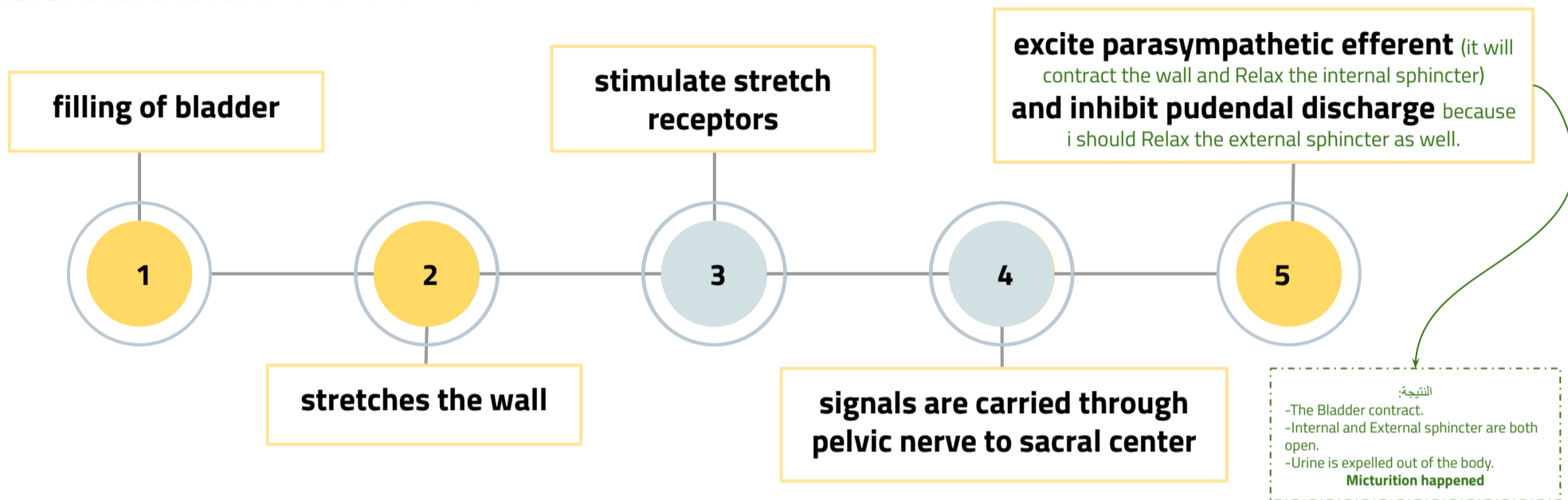
It's autonomic so it's involuntary —> It will innervate smooth muscles of the bladder (the body of the bladder) + **internal urethral sphincter** via Pelvic nerves.
Function:
 -contracts the wall of the bladder
 -Relaxes internal sphincter

The micturition reflex

(Normally Involuntary but it's a reflex undergo voluntary control from higher center)

- ❖ Micturition : the process by which the urinary bladder empties when it becomes full.
- ❖ Micturition is a **visceral** function → under control of autonomic nervous system
- ❖ **How is Micturition different from other visceral functions?**

The special thing about Micturition is although it's mediated by autonomic nervous system (which make it involuntary) → it controlled by higher brain center CNS (voluntary control) so that's why we can control ourselves. unlike other visceral organ e.g:intestinal movement → I can not control my stomach when it digests food or not this is not under my control.



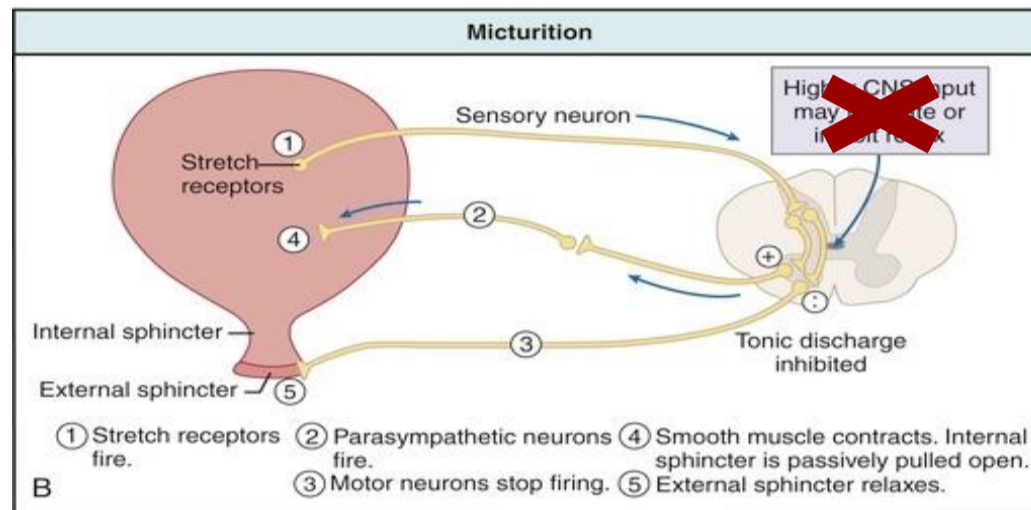
- ❖ **The micturition reflex** is an autonomic reflex that can be facilitated or inhibited by higher centers



- ❖ If the conditions for emptying are favourable, emptying will occur
- ❖ If the conditions for emptying are unfavourable, reflex is inhibited, however, there is the conscious desire to urinate.

The micturition reflex - **INFANTS**

1. An autonomic spinal reflex The stimulus that initiates these reflexes is rise of the IVP (which stimulates stretch receptors in the bladder wall)
2. **Involuntary**, not yet under higher CNS control because the nerve tracts aren't yet myelinated in infants
3. Between 2-3 years age they learn to control it and becomes voluntary

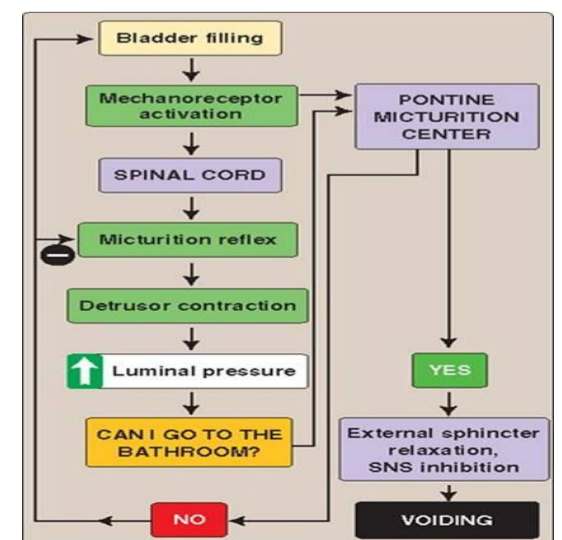


The micturition reflex - **ADULTS**

- ❖ An autonomic spinal reflex.
- ❖ **Voluntary** controlled by higher (supraspinal) CNS centers: **brain stem (pons) & cerebral cortex**
- ❖ Control is either inhibitory (in the midbrain) which (Increase tone of external sphincter) or facilitatory (in pontine area, posterior hypothalamus and other cortical centers).

It can be summarized as follows

- 1- Distention of the U.B. (as a result of I.V.P. & not by an in the bladder volume) produce : reflex contraction of its wall & relaxation of the internal urethral sphincter & external urethral sphincter.
- 2- The flow of urine in urethra will produce contraction of the U.B. wall & relaxation of both internal & external urethral sphincters.



Mechanism of voluntary control of micturition

1

Filling of the bladder beyond 300-400 causes stretching of sensory stretch receptors.

2

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

If the condition is favourable

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 unfavourable

The higher centers will inhibit the micturition reflex by:

1

Inhibition of sacral micturition center.

2

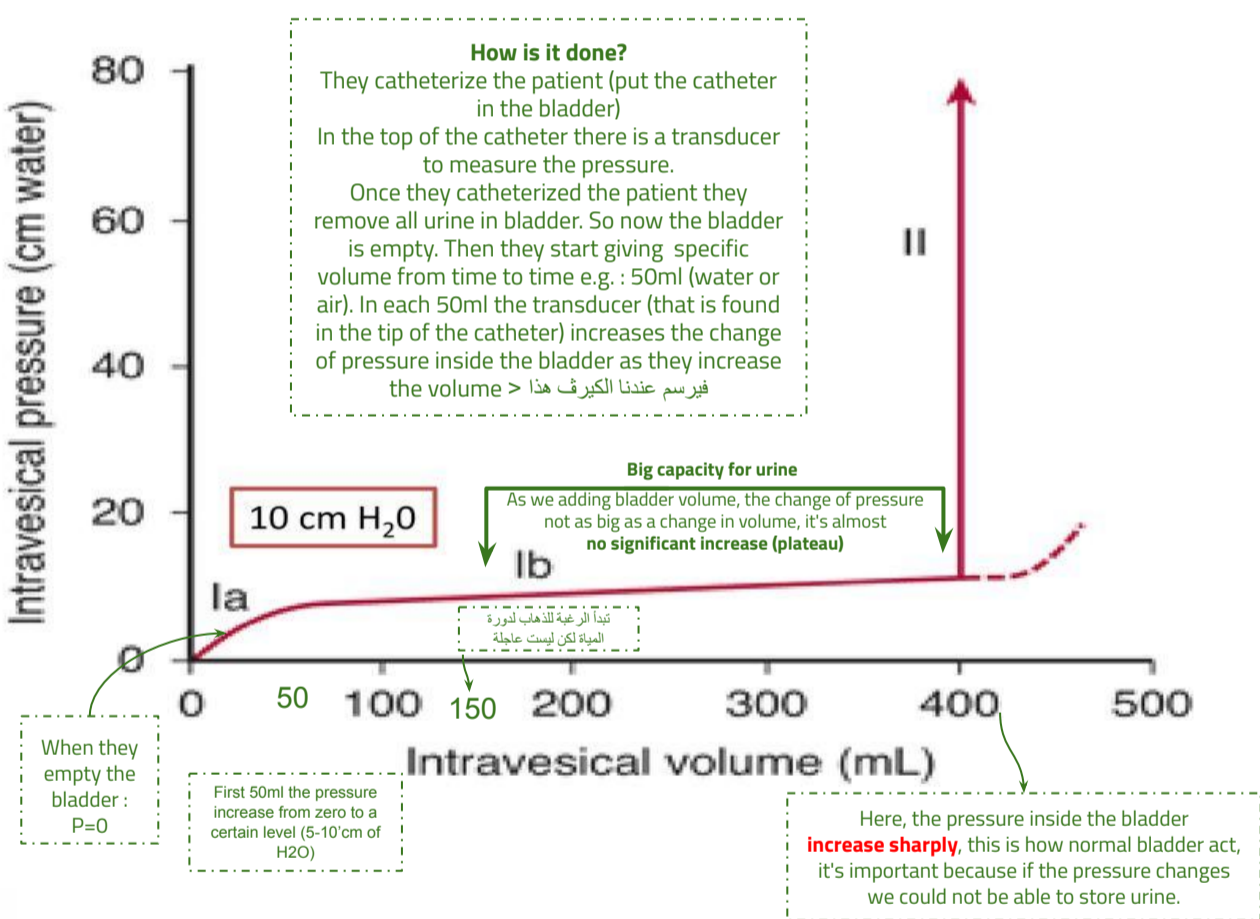
Stimulation of pudendal nerves contraction of external urethral sphincter.

The Cystometrogram

● Filling of bladder-bladder tone

- ❖ **Bladder tone (bladder function)** = the relationship between bladder volume and pressure (intravesical pressure vesical means bladder). الضغط من داخل Bladder بفعل Filling = Reflet bladder tone
- ❖ The relationship between bladder volume and intravesical pressure can be studied using **cystometry**.
- ❖ The volume-pressure record is called a **cystometrogram**.
- ❖ They use it specially when they want to know what's the problem of bladder function to assess it. And this is still done clinically.

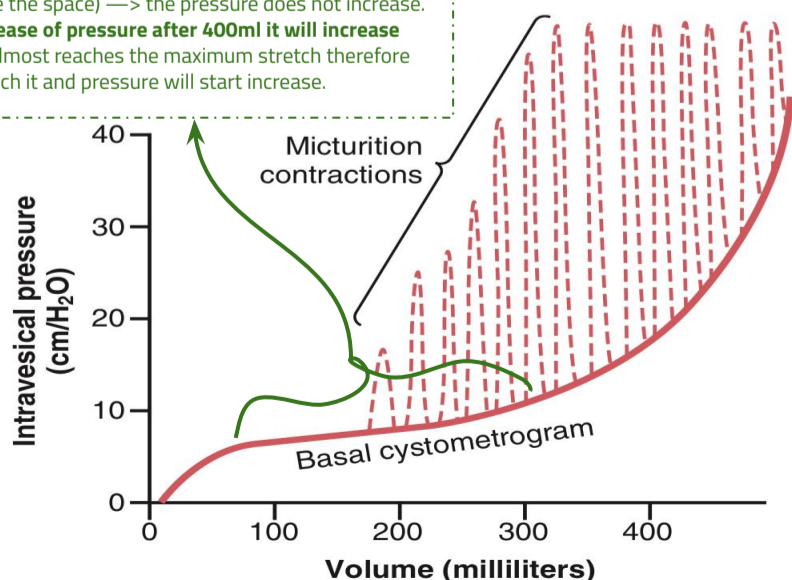
● Cystometrogram



We can describe this diagram by **three phases** as following:

- ❖ **Ia phase**: an increase in IVP from zero to ten cm H₂O approximately, at an initial increase in volume from zero to 50 ml.
- ❖ **Ib phase**: filling of bladder from 50 to 400 ml urine causes no significant increase in IVP, Why? Because of high compliance.
- ❖ **II phase**: volumes greater than 400 ml will cause a steep increase in IVP triggering the micturition reflex.

Why this plateau? because as I increase the volume → the bladder stretches and expands (increase volume + increase the space) → the pressure does not increase. Once it reaches 400ml → any increase of pressure after 400ml it will increase sharply why? because the bladder almost reaches the maximum stretch therefore any increase of volume will not stretch it and pressure will start increase.



- ❖ Superimposed on the basal cystometrogram are periodic sharp increases in IVP that may last a few seconds to more than a minute.
- ❖ These peaks are called "Micturition waves" (voiding waves), and they are **caused by Micturition reflex**

Figure 26-8. A normal cystometrogram, showing also acute pressure waves (dashed spikes) caused by micturition reflexes.

Bladder sensations at different urine volumes

Urine volume of **150 - 300 ml** → first urge (a strong desire) to void.

From **300 - 400 ml** → sense of bladder fullness.

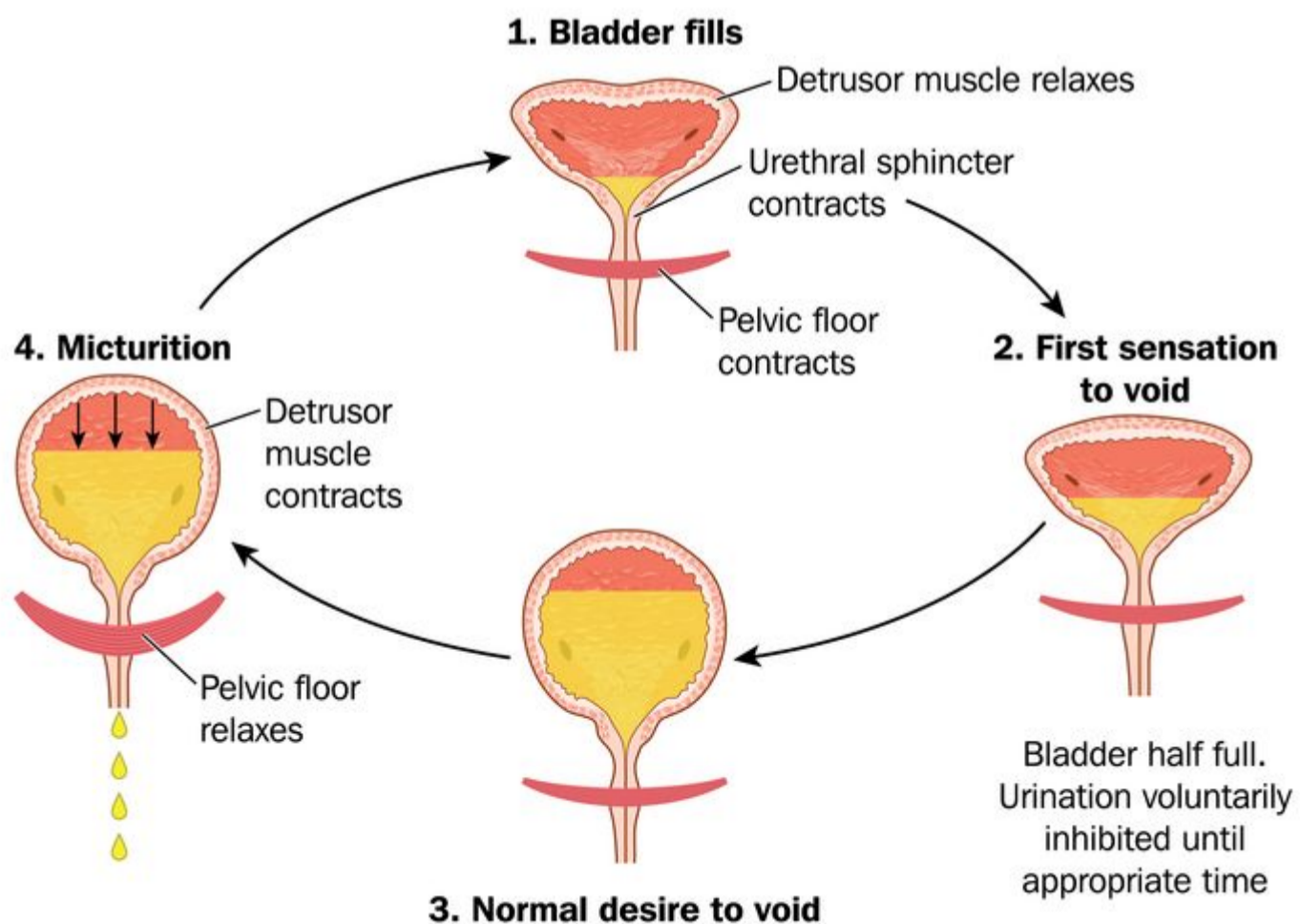
From **400 - 600 ml** → sense of discomfort.

From **600 - 700 ml** → sense of pain.

At **700 ml** → breakpoint and it's so painful →
Micturition can not be suppressed.

Micturition reflexes start to appear at the first stage and progressively increase in intensity as the volume increases. Micturition reflexes can be voluntarily suppressed.

The picture below describes the circulation of urination process from empty bladder to the micturition reflex.



Abnormalities In Micturition

As a general role of injury in Nervous system:

1-Upper motor neuron lesions: any injuries that affect the **CNS** whether in spinal cord or Brain —> The end result is **Spastic (tense) or overactivation of the organ** that get its innervation from CNS (**e.g: Bladder**) —> **it will become overactive** (why overactive happen? because most of the reflexes in spinal cord are undergo Facilitatory more than Inhibitory, most of signals come from brain are facilitatory more than inhibitory **more details in next slide in the 3rd lesion.**)

2- Lower motor neuron lesions (damage in PNS): any injuries or in damage that affect the peripheral nerves that come from spinal cord whether sensory, motor or whatever —> The end result is **flaccid of the organ** that get its innervation from PNS (e.g: Bladder) —> it will become flaccid and its tone decrease **more details in 1st lesion.**

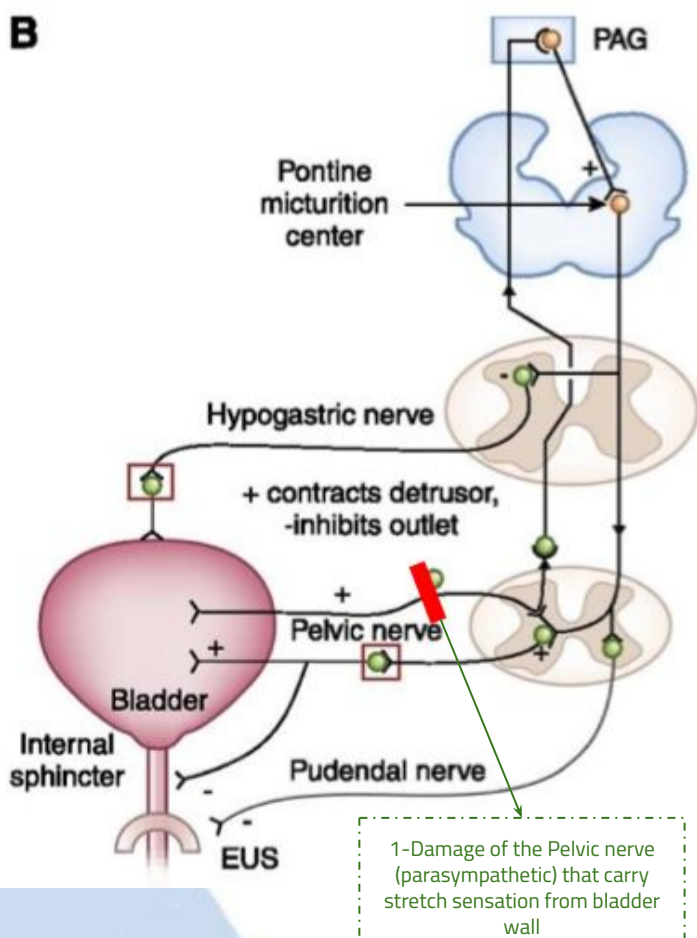
1-Lesions affecting the afferent sensory nerves

Causes

- Tabes dorsalis (Syphilis, **Tabetic bladder**)
- Diabetes

Characteristics

- Results in an atonic (flaccid) bladder.
- Injury of the Afferent nerves —> loss of perception of bladder fullness + micturition reflex can not be initiated —> bladder overstretching —> thinning of the wall and ineffective contractions.
- Retention of urine with overflow.



Lesion in the afferent sensory fibers that carry **stretch sensation** from bladder wall.

Feeling of bladder fullness is **lost**
Cannot initiate the **reflex**

The bladder **cannot empty** urine but urine **continues to collect**

Urine will collect until **pressure** in bladder becomes **high** causing **dribbling of urine**

Overflow incontinence

Because the bladder has been filled to the maximum until the pressure inside it becomes higher than pressure of the closing outlet —> فيبدأ يقطر بول بشكل لا إرادي

Abnormalities In Micturition

Only in Male's slides

2-Denervation of the afferent & efferent supply

Causes

- Tumor
- Injury to Cauda equine syndrome

Characteristics

- Reflexes are abolished.
- Intrinsic responses of the smooth muscles are increased.
- The bladder is hypertonic due to denervation hypersensitivity because:
 - **Decrease** Degradation of Acetylcholine by process of Reuptake.
 - **Decrease** Cholinesterase in the tissue. (enzyme that degrades Ach)
 - **Increase** Number of Cholinergic receptors.
- Uncontrolled periodic micturition about 25 – 100 ml at a time

3-Damage to spinal cord above the sacral region

Characteristics

- The **micturition reflex is intact**, but **lost higher center** control.
- Divided into 3 phases:

ملخص الموضوع:

As we said in the previous slide most of signals that come from brain are **facilitatory more than inhibitory** so if the spinal cord gets damage in any area and for any reason —> there will be loss of facilitatory impulses (there is nothing tell this Reflex to take place) —> **at the beginning** the reflex gets shocked (ما في احد يقوله يصير) (او ما يصير) —> **after a while** the reflex it will gain a momentum (بيبدأ يشتغل هو مع نفسه ولكن حيصير اوتوماتيك) —> the reflex becomes **automatic** and a **big active** because the inhibitory impulses are lost.

1- Acute phase - spinal shock (2-6 wks)

Occurs due to the **separation** of the spinal centers from the brain

Loss of facilitatory impulses from CNS

Micturition reflex is **inhibited**

Bladder fills but **cannot void**

(Retention with overflow incontinence)

Bladder needs to be emptied periodically by catheterization

↳ To protect the bladder from the accumulation of urine.

2- Recovery from spinal shock (involuntary reflex micturition)

Micturition reflex **recovers**

Not controlled by CNS

Bladder fills and **voids** automatically
(Automatic bladder)

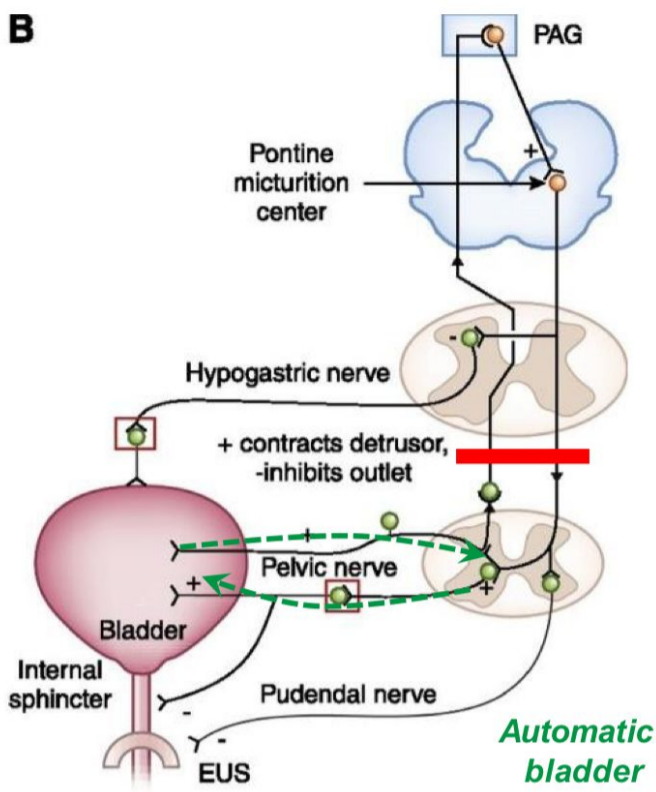
-their bladder becomes like infant bladder act automatically—> when it fills it will empty (ليست خاضعة لكنترول)

3-Failure phase: Retention with overflow

Only in Male's slides

In case of **bacterial damage** by toxins to spinal cord

continuation of 3rd lesion..



Lesion in the spinal cord **above** the sacral center.

Loss of facilitatory impulses from higher centers.

Micturition reflex is **inhibited**.

Urine will collect until **pressure** in bladder becomes **high** causing dribbling of urine.

Overflow incontinence

Micturition reflex regains function but not under CNS control.

Spinal shock phase

Recovery

4- Uninhibited neurogenic bladder

Causes

Lesions to spinal cord or brain stem that affects inhibitory signals to spinal cord.

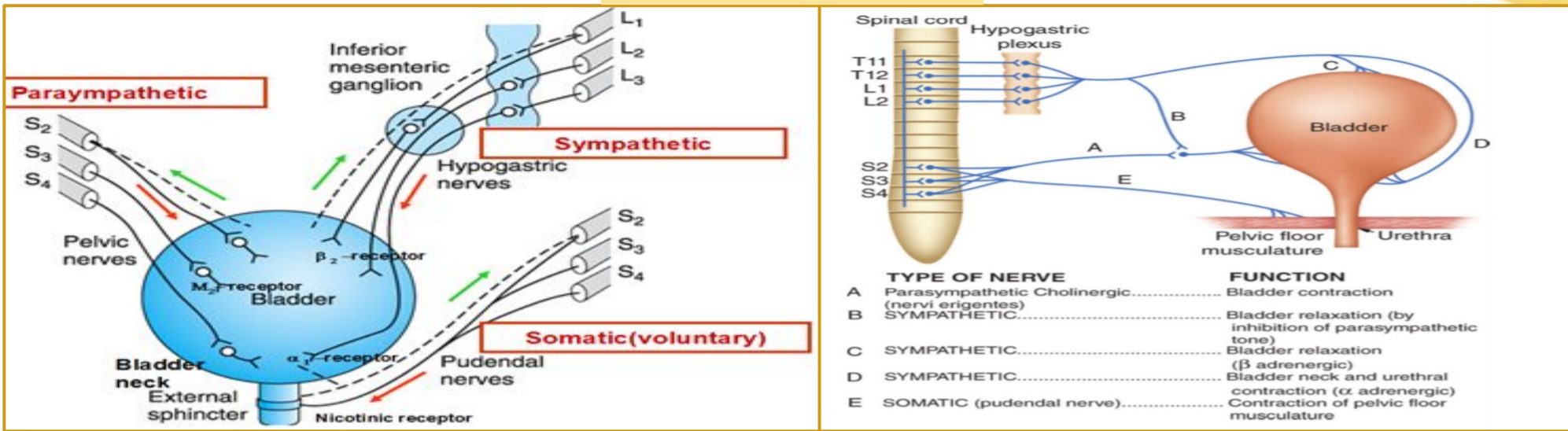
Characteristics

It will cause:

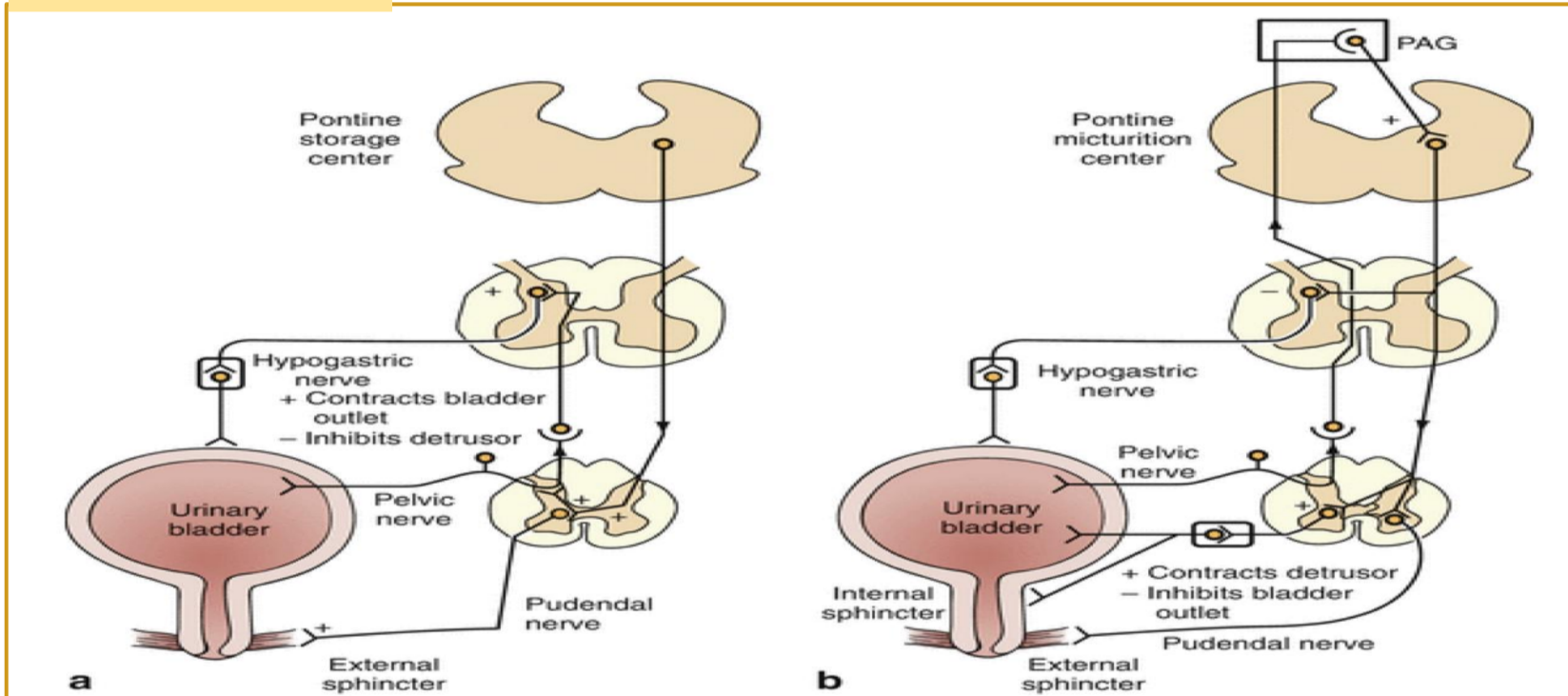
- Frequent relatively uncontrolled micturition (Frequent urination of small volume of urine).
- Hyperactive detrusor muscle that will result in activation of micturition even at small urine volumes.

Pictures of the lecture

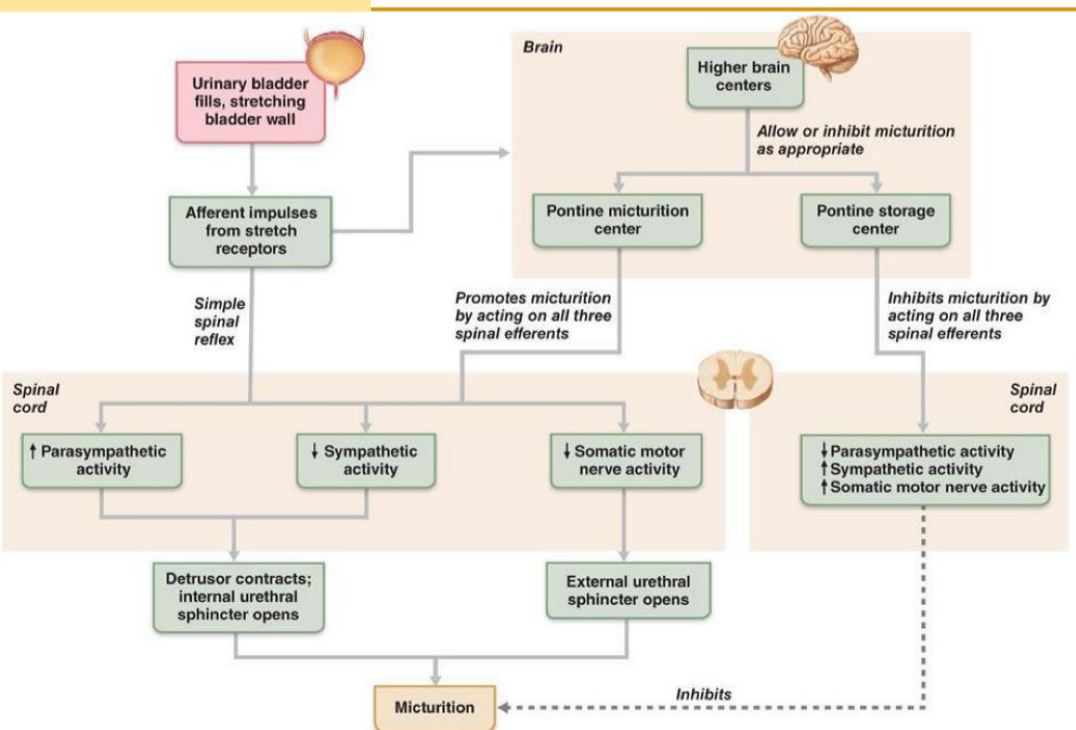
Neural innervation of bladder



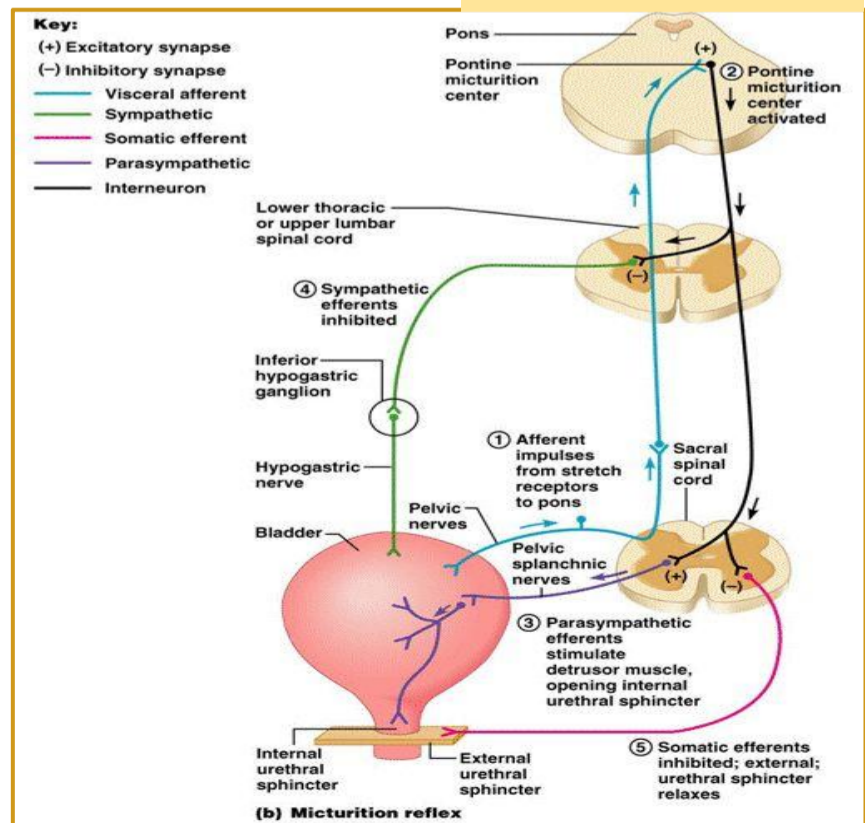
Summary of the lecture



Summary of the lecture



Micturition Reflex in Adult



Summary

❖ Define Micturition?

the process by which the urinary bladder empties when it becomes full.

❖ Describe the mechanism of filling and emptying of the urinary bladder?

Bladder filled > stretch of sensory stretch receptors > stimulation of sacral segments appreciated by higher centers > inhibition of pudendal nerves > relaxation of external urethral sphincter and the contraction of anterior abdominal muscle & the diaphragm to increase the intra abdominal pressure > the intra-vesical pressure is increased and this intensifies the micturition reflex.

❖ Identify and describe the functional anatomy of the urinary bladder ?

bladder has a body and a neck, with two sphincters, internal and external.

internal sphincter is made up of smooth muscle.

external sphincter is made up of skeletal muscle.

The bladder is made up of 4 layers:

1. Mucosa: transitional epithelium, has folds "rugae" that will flatten out as the bladder fills in.
2. Submucosa: loose connective tissue.
3. Smooth muscle layer : Detrusor muscle, main muscle of micturition.
4. Serosa.

❖ Describe the neural control of the urinary bladder and sphincters?

1. Autonomic nerves:
 - a. Sympathetic (hypogastric nerve)(L1-L3)
 - i. Afferent: sensation of pain from the urethra and bladder.
 - ii. Efferent: inhibitory to the detrusor muscle, motor to the internal urethral sphincter ,seminal vesicle and ejaculatory duct.
 - b. Parasympathetic (Pelvic nerve)(S2-S4)
 - i. Afferent: sensation of bladder fullness, reflex micturition and pain.
 - ii. Efferent: motor to detrusor muscle and inhibitory to the internal urethral sphincter.
2. Somatic nerves:
 - a. Pudendal nerve (S2-S4)
 - i. Afferent: sensation of urethra distention and passage of urine through the urethra.
 - ii. Efferent: motor to the external urethral sphincter.

MCQ & SAQ

Q1: if the conditions for emptying were favourable :

- A. Pudendal nerves are stimulated
- B. Pudendal nerves are inhibited
- C. Inhibition of sacral micturition center
- D. External urethral sphincter contracts

Q4: Which of the following nerves is motor to the internal urethral sphincter :

- A. hypogastric nerve
- B. pudendal nerve
- C. pelvic nerve
- D. phrenic nerve

Q2: In a 2 months old infant, the micturition reflex :

- A. Controlled by supraspinal CNS centers
- B. Voluntary
- C. Not controlled by supraspinal CNS center
- D. The nerve tracts for the process are myelinated

Q3: The wall of urinary bladder is lined by :

- A. pseudostratified columnar epithelium
- B. simple squamous epithelium
- C. transitional epithelium
- D. stratified columnar epithelium

1- Define the bladder tone.

2- What is the trigone ?

A1: the relationship between bladder volume and pressure (intravesical pr.)

A2: A triangular area in the internal urinary bladder bounded by 2 ureteric orifice and internal urethral orifice. Its mucous membrane is elastic (not folded).

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