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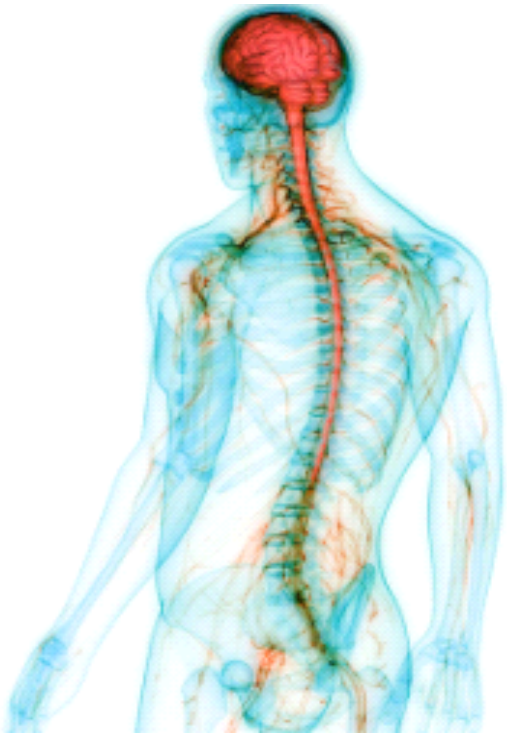

SHEET NO. 28

LECTURE DATE: 1.4.2021

LECTURE TITLE: Parasympathetic Nervous System

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EDITTED BY: Mira Sharayri

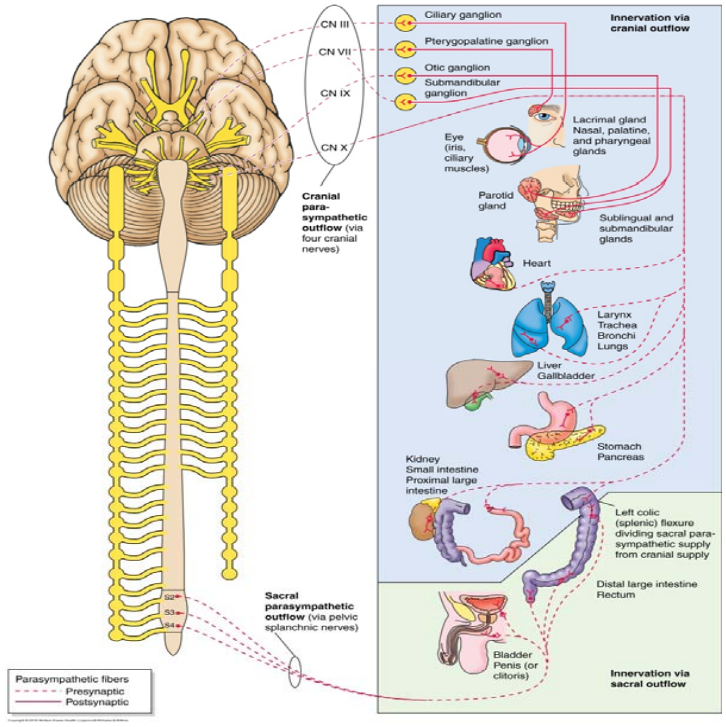
اللهم إن رشيد عبدك يحتاج إلى رحمتك وأنت غني عن عذابه فارحمه برحمتك يا أرحم الراحمين

Structure of the Parasympathetic Division

- Craniosacral division: Preganglionic neurons originate from:
  - ✓ Cranial part: Brainstem through cranial nerves III, VII, IX and X (they innervate all the structures in the head, neck, thorax & most of the abdomen till the midgut)
  - ✓ Sacral part: Within intermediolateral cell column. Sacral spinal nerves S2-S4 (they innervate all the structures in the abdomen from the hindgut and the pelvic organs)

- Parasympathetic ganglia (autonomic ganglia) called terminal ganglia because the connection between the pre & post ganglion is near the organ and mostly is within the walls of the organ (ex. Stomach) except the ganglia in the head and neck that innervates the eye & the exocrine glands. The connection can also occur within the plexuses preceding the organ. Will be discussed shortly.

- Presynaptic neuron usually synapses with 4-5 postsynaptic neurons all of which supply a single visceral effector (targeted innervation) while in the sympathetic ns the preganglionic neuron synapse with 20 postganglionic, near the spinal cord & supply multiple different visceral effectors.



Autonomic Plexuses in the Thorax, Abdomen and Pelvis

- A network of sympathetic (post ganglionic) and parasympathetic (preganglionic) axons
- ✓ Cardiac plexus: Heart.
- ✓ Pulmonary plexus: The bronchial tree.
- ✓ Pleural plexus: Lung
- ✓ Esophageal Plexus: Esophagus
- ✓ Celiac plexus- largest: -upper abdomen-supplies the stomach, spleen, pancreas, liver, gallbladder, and adrenal medullae.

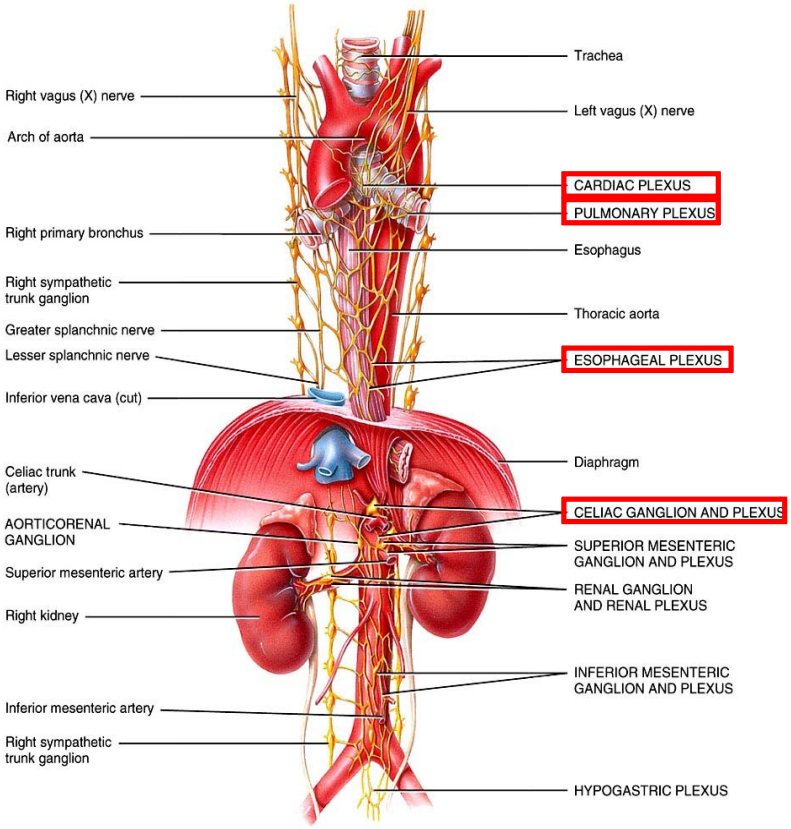
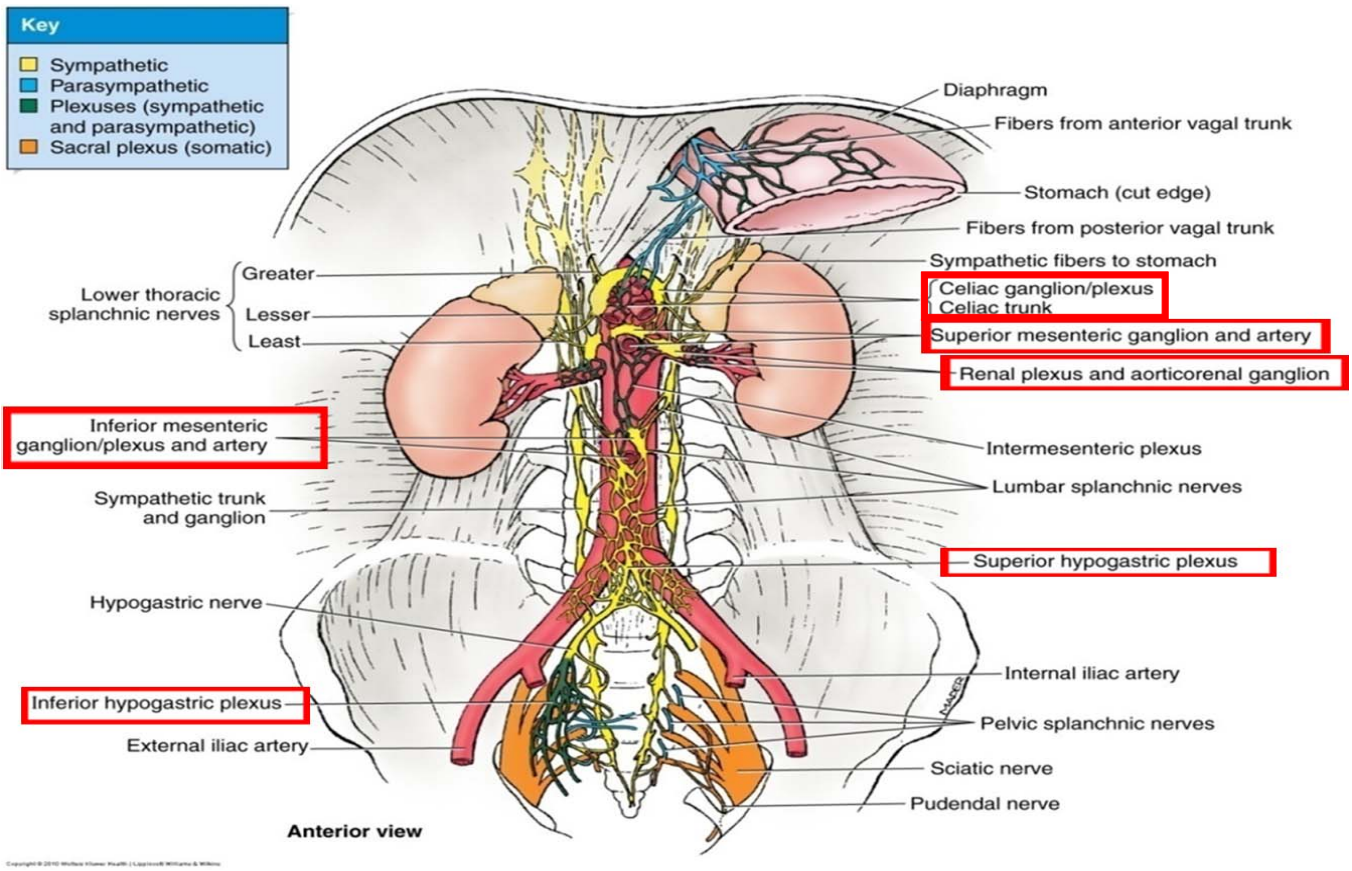


Figure 15.05 Tortora - PAP 12/e



- ✓ Superior mesenteric plexus: midgut-small intestine and proximal colon.
- ✓ Inferior mesenteric plexus: hindgut-distal colon and rectum.
- ✓ Hypogastric plexus: pelvic organs urinary bladder and genital organs.
- ✓ Renal plexus: kidneys and ureters

Cranial Parasympathetic Outflow

- Preganglionic neurons:

III – Edinger-Westphal nucleus – rostral midbrain

VII – superior salivatory/lacrimal nucleus – caudal pons

IX – inferior salivatory nucleus – rostral medulla > submandibular, sublingual, parotid salivary glands, glands of the nasal cavity and the pharynx

X – dorsal nucleus of Vagus -- medulla

- Vagus nerve carries nearly 80% of the total craniosacral flow. (thoracic and abdominal viscera)

- Postganglionic neurons:
  - ✓ In Head and Neck

Reside in four pairs of ganglia:

Ciliary ganglia (III) (located within the orbit) - ciliary muscles (lens adaptation) & iris (constrictor)
Pterygopalatine ganglia (VII)- lacrimal gland/ salivary glands of the nasal cavity and pharynx…
Submandibular ganglia (VII) (within the floor of the mouth) - submandibular and sublingual glands
Otic ganglia (IX) (infratemporal fossa) - parotid gland
In Thorax and Abdomen

Terminal ganglia (walls of visceral organs or within the plexuses in a lesser extent)

Associated with the Vagus nerve

Sacral Parasympathetic Outflow

- Consists of S2-S4.
  Sacral parasympathetic fibres leave the anterior horn spinal cord through the ***pelvic splanchnic nerves*** → preganglionic parasympathetic sacral neurons (joining the inferior hypogastric plexus or walls of viscera)
- ✓ Distal GIT (distal colon, sigmoid colon, rectum) supplied by inferior mesenteric plexus
- ✓ Urinary bladder (voiding)
- ✓ Penis or clitoris (erection)

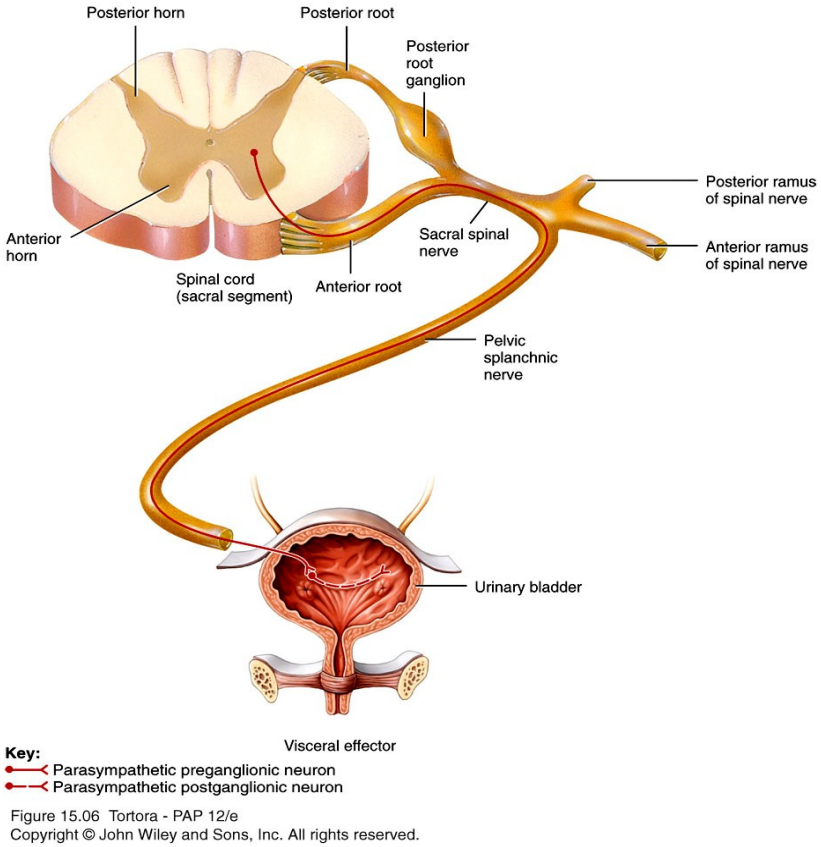
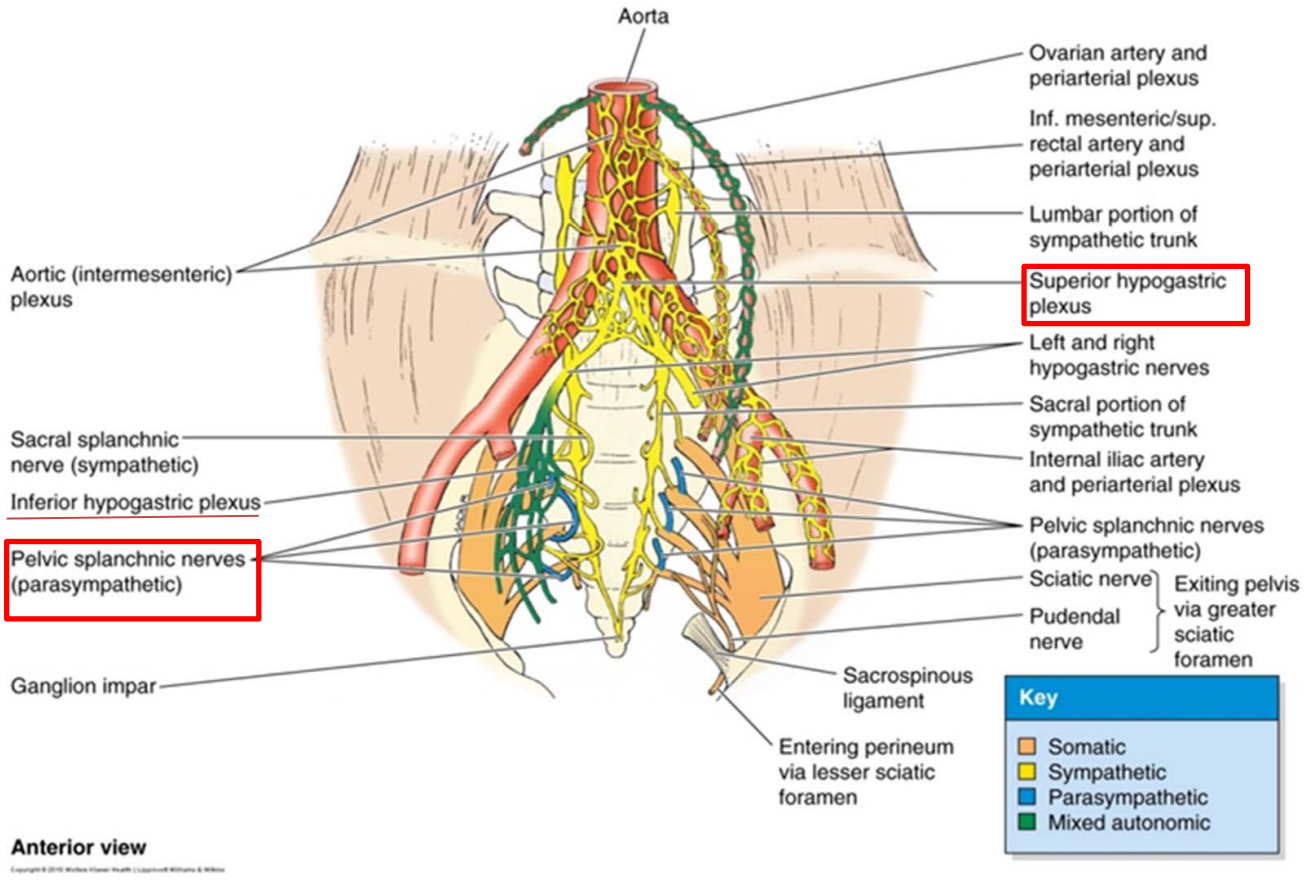


Figure 15.06 Tortora - PAP 12/e

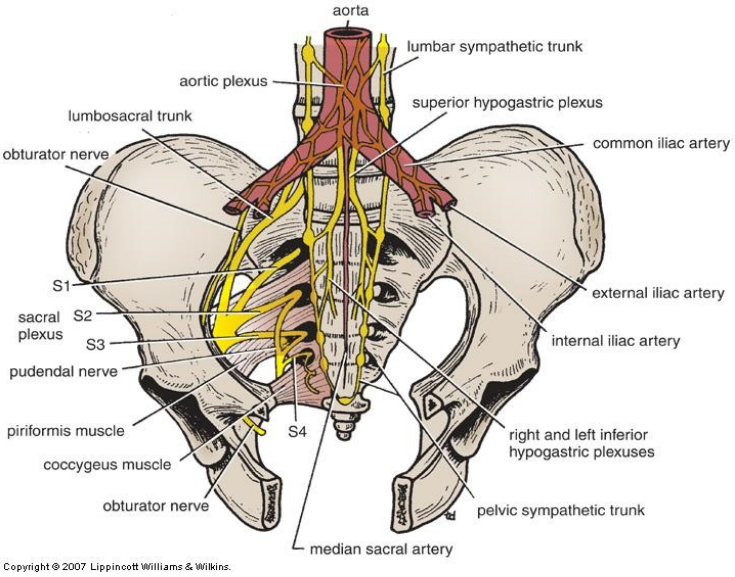
Pelvic splanchnic nerves

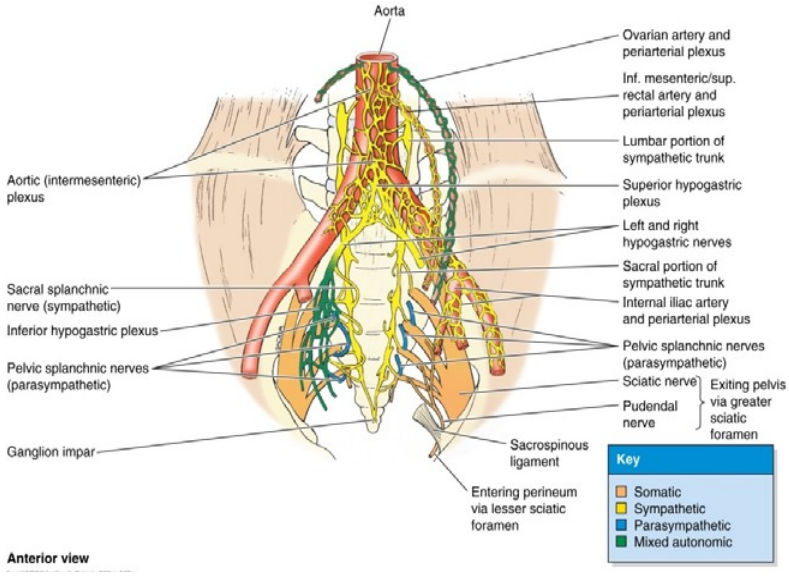


- ✓ **Parasympathetic (S2-S4)**
- ✓ **Inferior hypogastric plexus** within the pelvis
- ✓ Superior hypogastric plexus is located against the promontory of the sacrum/bifurcation of the aorta and is associated with the **Inferior mesenteric plexus** that supplies the hindgut (distal git in the past slide)
- ✓ The parasympathetic fibres of the inferior mesenteric plexus originate from the sacral region, **how**?
    - Preganglionic neurons of pelvic splanchnic nerves that supply the hindgut will ascend from inferior mesenteric plexus towards superior hypogastric plexus through right & left superior hypogastric nerves, toward inferior hypogastric plexus, to finally reach the organs of the hindgut.

Hypogastric Plexuses

- ➢ Superior hypogastric plexuses
    - ✓ In front of promontory
    - ✓ Forms right & left hypogastric nerves
- ➢ Inferior hypogastric plexuses
    - ✓ Hypogastric nerves (sympathetic) + pelvic splanchnic nerves (parasympathetic)
    - ✓ Suspended in the middle of the pelvis, lateral to rectum, bladder & vagina





Parasympathetic Afferent Fibers

- Cell bodies

  Cranial part --- sensory ganglia of cranial nerves

  VII ---- geniculate ganglion ---- temporal bone

  IX ---- inferior (petrosal) ganglion ---- jugular foramen

  X ---- inferior (nodose) ganglion ---- jugular foramen

- Sacral part --- dorsal root ganglia of sacral spinal nerves (S2-S4)
  The organs that are supplied by the sacral afferent fibers, their pain refers to the somatic dermatomes of S2, S3, and S4.

Sympathetic Responses

- Stress ↑ sympathetic system ↑ fight-or-flight response.
  - ✓ ↑ production of ATP.
  - ✓ Dilation of the pupils.
  - ✓ ↑ heart rate and blood pressure.
  - ✓ Dilation of the airways.
  - ✓ Constriction of blood vessels that supply the kidneys and gastrointestinal tract.
  - ✓ ↑ blood supply to the skeletal muscles, cardiac muscle, liver and adipose tissue
  - ✓ ↑ glycogenolysis ↑ blood glucose.
  - ✓ ↑ lipolysis.

Parasympathetic Responses

- Rest-and-digest response.
  - ✓ Conserve and restore body energy.
  - ✓ ↑ digestive and urinary function.
  - ✓ ↓ body functions that support physical activity.

Integration and Control of Autonomic Functions

- ✓ Direct innervation- brain stem and spinal cord.
- ✓ Hypothalamus is the major control and integration center of the ANS.
- ✓ It receives input from the limbic system.

Autonomic or Visceral Reflexes

- ➢ Autonomic reflexes occur over autonomic reflex arcs. Components of that reflex arc:
  - ✓ sensory receptor
  - ✓ sensory neuron
  - ✓ integrating center
  - ✓ pre & postganglionic motor neurons
  - ✓ visceral effectors
- ➢ Unconscious sensations and responses
  - ✓ changes in blood pressure, digestive functions etc
  - ✓ filling & emptying of bladder or defecation

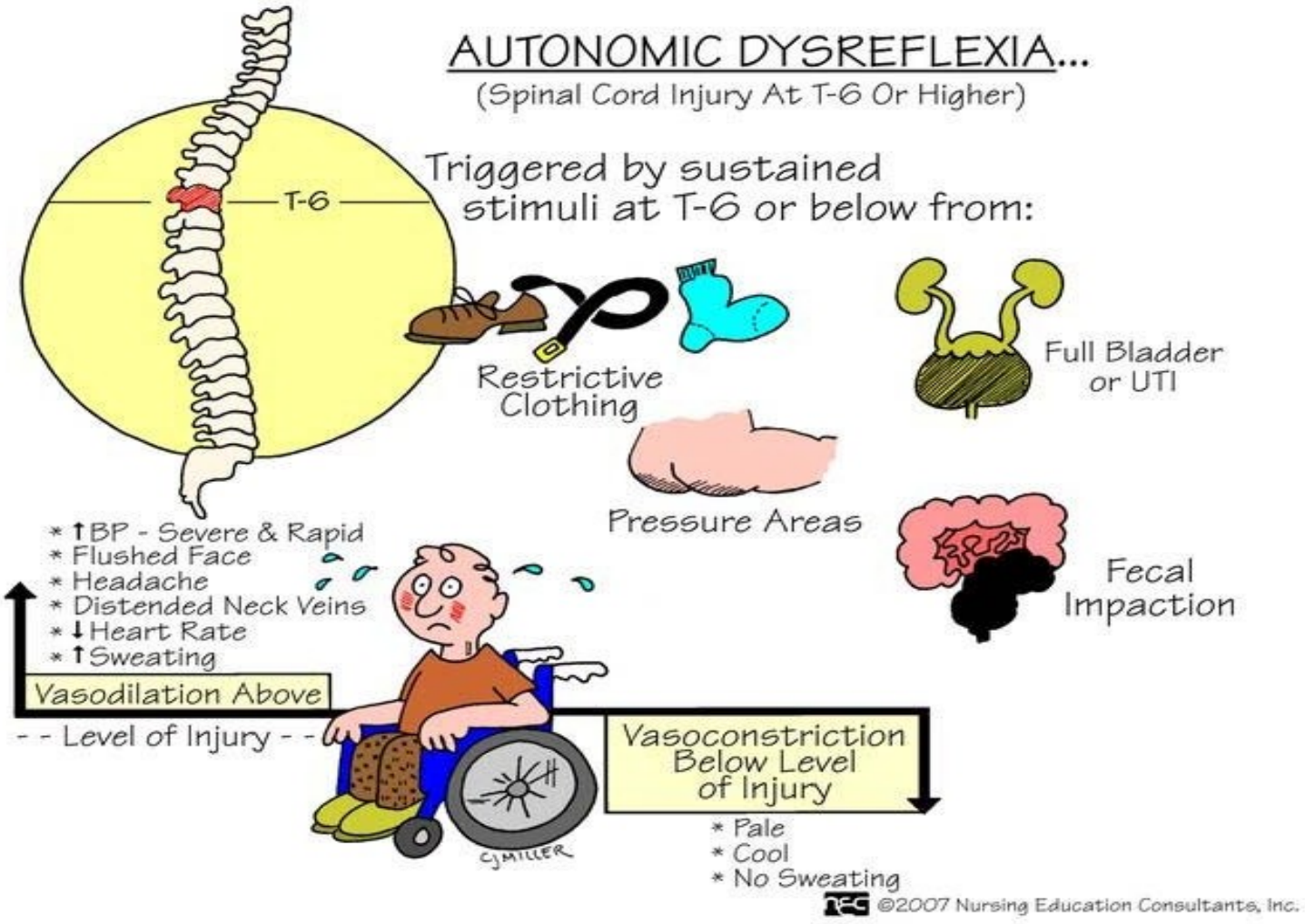
Control of Autonomic NS

- ➢ Not aware of autonomic responses because control center is in lower regions of the brain
- ➢ Hypothalamus is major control center
  - ✓ input: emotions and visceral sensory information
    - o smell, taste, temperature, osmolarity of blood, etc
  - ✓ output: to nuclei in brainstem and spinal cord
  - ✓ posterior & lateral portions control sympathetic NS
    - o increase heart rate, inhibition GI tract, increase temperature
  - ✓ anterior & medial portions control parasympathetic NS
    - o decrease in heart rate, lower blood pressure, increased GI tract secretion and mobility

Autonomic Dysreflexia

- Exaggerated response of sympathetic NS in cases of spinal cord injury **above T6**
  - Why above T6? (mostly related to the heart and CVS) sympathetic innervation of the heart is from cervical ganglia of the sympathetic trunk and upper part of thoracic ganglia. Injury at a level below T6: no autonomic dysreflexia, because it will not affect sympathetic innervation of the heart.
  - Multiple explanations for AD
    - separation of preganglionic fibers innervating the heart.
    - Interrupted supraspinal control from the hypothalamus for innervations of areas below the level of injury.
    - exaggerated response of sympathetic nervous system stimuli from areas above the level of injury; and blockage of sympathetic stimulation below the level of injury say urination or fecal impaction or reproductive functions.
    - In other words, a discontinuation between the upper part and lower part of sympathetic nervous system makes the stimuli below level of lesion/injury present reflexes independent from the supraspinal center, which results in the triggers shown in the figure below.
    - direct reflexes without supraspinal effect
  - still under ongoing research, debatable, part of the symptoms presented cannot be explained through reflexes but with local/hormonal effects
- Certain sensory impulses trigger mass stimulation of sympathetic nerves below the injury
- Result (it could be fatal)
  - ✓ vasoconstriction which elevates blood pressure
  - ✓ parasympathetic NS tries to compensate by slowing heart rate & dilating blood vessels above the injury
  - ✓ pounding headaches, sweating warm skin above the injury and cool dry skin below
  - ✓ can cause seizures, strokes & heart attacks

✓ Above the injury the opposite happens (increase supraspinal control)



Example of Spinal and Supraspinal Control of AN: Urinary Bladder Function

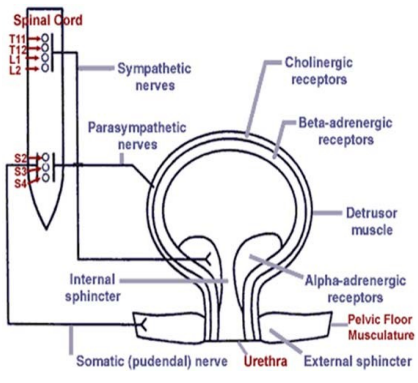
➢ Urinary bladder function

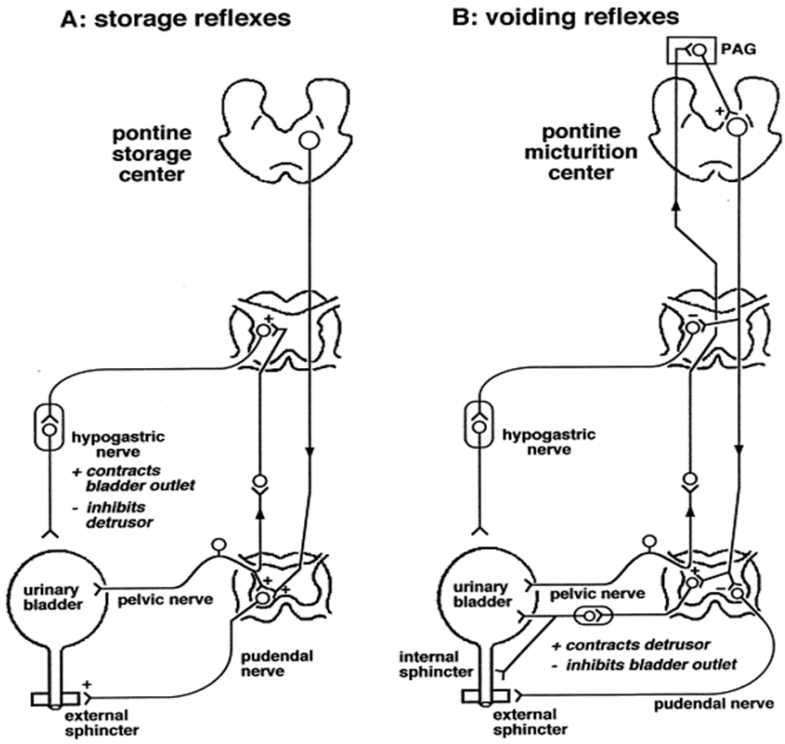
✓ Storage phase (relaxation of internal urinary bladder smooth muscle and contraction of the internal urethral sphincter)

- Example of spinal reflex control on the AN

✓ Voiding phase (contraction of urinary bladder smooth m. and relaxation of internal urethral sphincter)

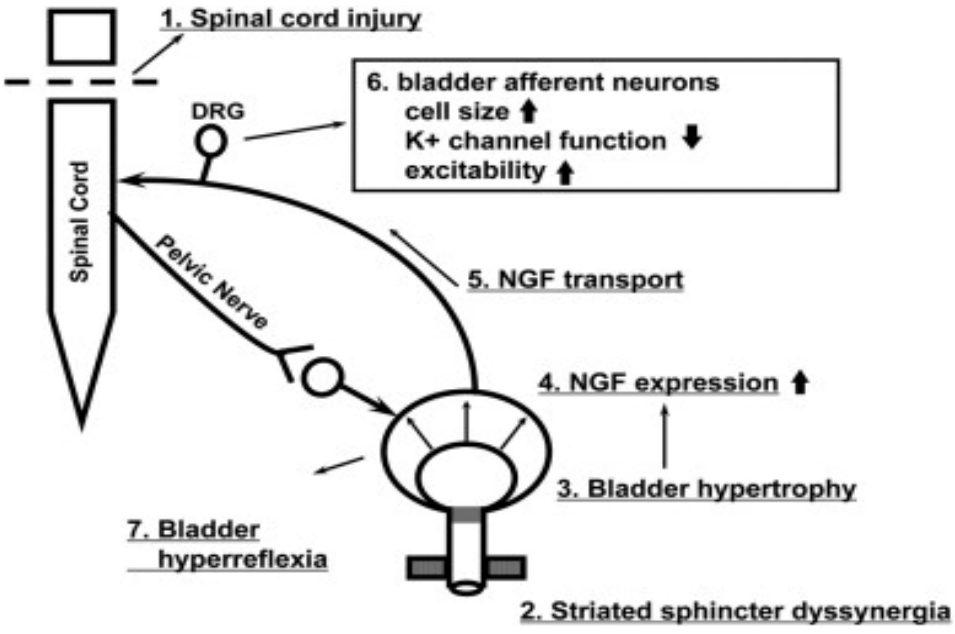
- Example of supraspinal control on the AN





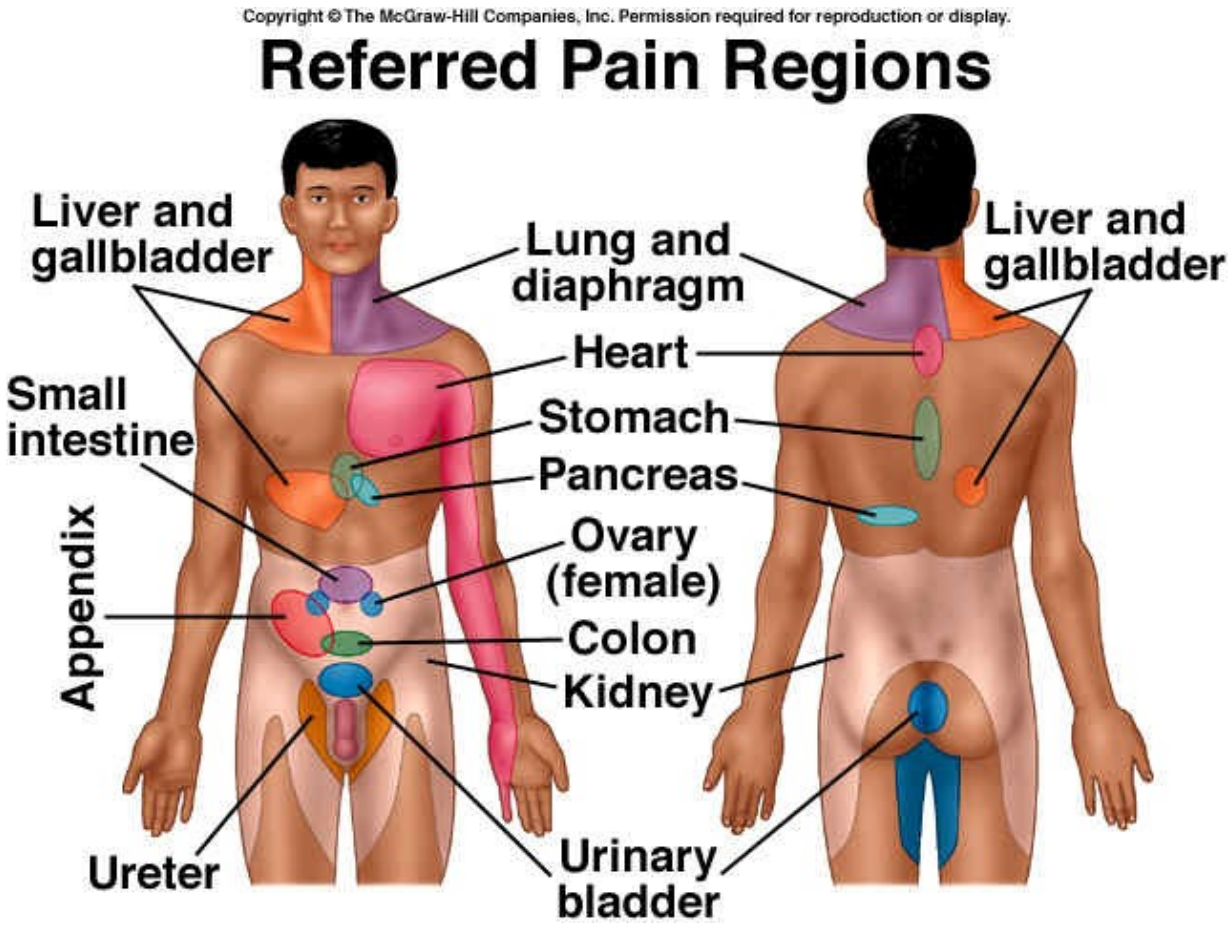
Effect of SCI on the Urinary Bladder Function

- Spinal cord injury (SCI) eliminates the supraspinal control leading to Urinary bladder dysfunction/dyssynergia (no coordination between the different structures of the urinary bladder) leading sometimes to bladder hypertrophy, bursts, infections, renal failure.
    - Now we use a catheter to empty the urinary bladder in case of spinal cord injury to avoid renal failure because of urinary bladder dysfunction



Visceral Pain

- Vague and poorly localized – somatic pain is very specific and highly localized, different modalities, fibers and tracts-.
- Referral pain: centrally located, bilaterally innervated. Afferent fibers get back toward the dorsal root ganglion and they meet the somatic ganglion, the CNS disperses, so the pain is felt next to other dermatomes innervated by that same dorsal root ganglion, so referral pain depends on the spinal segment receiving the afferents.



- Referral pain for liver and gallbladder is sometimes in the neck and shoulders in case of severe injury (ex. severe inflammation) that reaches the parietal peritoneum that is innervated by the phrenic nerve from the cervical plexus causes a referral pain in the neck and shoulder

Referred pain overview

Organ	Afferent pathway	Spinal cord level	Referral area
Heart	Thoracic splanchnic nerves	T1 to T4	Upper thorax and medial arm
Foregut (organs supplied by celiac trunk)	Greater splanchnic nerve	T5 to T9 (or T10)	Lower thorax and epigastric region
Midgut (organs supplied by superior mesenteric artery)	Lesser splanchnic nerve	T9,T10 (or T10,T11)	Umbilical region
Kidneys and upper ureter	Least splanchnic nerve	T12	Flanks (lateral regions) and pubic region
Hindgut (organs supplied by inferior mesenteric artery)	Lumbar splanchnic nerves	L1,L2	Left and right flanks and groins, lateral and anterior thighs

Good luck