Parasympathetic Nervous System
Lecture Objectives

• Make a list of the components of the system.
• Make a list of cranial nerves having parasympathetic activity.
• Describe the parasympathetic ganglia in the head and neck, their locations and target organs.
• Describe the sacral parasympathetic outflow.
• Make a list of its target organs.
Structure of the Parasympathetic Division

- Craniosacral division: Preganglionic neurons originate from
  - Brainstem through cranial nerves III, VII, IX and X
  - Sacral spinal nerves S2-S4
- Parasympathetic ganglia
  - terminal ganglia.
- Presynaptic neuron usually synapses with 4-5 postsynaptic neurons all of which supply a single visceral effector.
Autonomic Plexuses in the Thorax, Abdomen and Pelvis

Figure 15.05 Tortora - PAP 12/a
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Autonomic Plexuses

- A network of sympathetic and parasympathetic axons.
  - Cardiac plexus
    - heart.
  - Pulmonary plexus
    - the bronchial tree.
  - Esophageal Plexus
    - esophagus
  - Celiac plexus- largest.
    - Supplies the stomach, spleen, pancreas, liver, gallbladder, and adrenal medullae.
Autonomic Plexuses Continued..

- Superior mesenteric plexus
  - small intestine and proximal colon.
- Inferior mesenteric plexus
  - distal colon and rectum.
- Hypogastric plexus
  - urinary bladder and genital organs.
- Renal plexus
  - kidneys and ureters.
Cranial Parasympathetic Outflow

- Preganglionic neurons
  - III – Edinger-Westphal nucleus – rostral midbrain
  - VII – superior salivatory nucleus – caudal pons
  - IX – inferior salivatory nucleus – rostral medulla
  - X – dorsal nucleus of vagus – medulla
- Vagus nerve carries nearly 80% of the total craniosacral flow. (thoracic and abdominal viscera)
Cranial Parasympathetic Outflow

• Postganglionic neurons:

• In Head and Neck
  ➢ Reside in four pairs of ganglia
  • Ciliary ganglia (III)- ciliary muscles (lens adaptation) & iris (constrictor)
  • Pterygopalatine ganglia (VII)- lacrimal gland
  • Submandibular ganglia (VII)- submandibular and sublingual glands
  • Otic ganglia (IX)- parotid gland

• In Thorax and Abdomen
  • Terminal ganglia
    • Associated with the vagus nerve
Sacral Parasympathetic Outflow

• Consists of S2-S4.
• Pelvic splanchnic nerves → postganglionic neurons (hypogastric plexus or walls of viscera)
• Distal GIT (distal colon, sigmoid colon, rectum)
• Urinary bladder (voiding)
• Penis or clitoris (erection)
Pelvic splanchnic nerves

- Parasympathetic (S2-S4)
- Inferior hypogastric plexus
- Inferior mesenteric plexus
Hypogastric Plexuses

• Superior hypogastric plexuses
  • In front of promontory
  • Forms right & left hypogastric nerves

• Inferior hypogastric plexuses
  • Hypogastric nerves + pelvic splanchnic nerves
  • Lateral to rectum, bladder & vagina
Parasympathetic Afferent Fibers

• Follow the efferent pathway
• 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
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.
Sympathetic Responses continued..

- ↑ 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
    • smell, taste, temperature, osmolarity of blood, etc
  • output: to nuclei in brainstem and spinal cord
  • posterior & lateral portions control sympathetic NS
    • increase heart rate, inhibition GI tract, increase temperature
  • anterior & medial portions control parasympathetic NS
    • 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
• Certain sensory impulses trigger mass stimulation of sympathetic nerves below the injury

• Result
  • 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
AUTONOMIC DYSREFLEXIA...
(Spinal Cord Injury At T-6 Or Higher)

Triggered by sustained stimuli at T-6 or below from:

- Restrictive Clothing
- Pressure Areas
- Full Bladder or UTI
- Fecal Impaction

* ↑BP - Severe & Rapid
* Flushed Face
* Headache
* Distended Neck Veins
* ↑Heart Rate
* ↑Sweating

Vasodilation Above
--- Level of Injury ---

Vasoconstriction Below Level of Injury

* Pale
* Cool
* No Sweating

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

• Urinary bladder function
  • Storage phase
    • Example of spinal reflex control on the AN
  • Voiding phase
    • Example of supraspinal control on the AN
Effect of SCI on the Urinary Bladder Function

- Spinal cord injury (SCI) eliminates the supraspinal control
  - Urinary bladder dysfunction

![Diagram of bladder function and effects of SCI](image)
Visceral Pain

- Vague and poorly localized
- Referral pain depend on the spinal segment receiving the afferent
## Referred pain overview

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