Functional neuroanatomy
the visceral nervous system (ANS)

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How do you evaluate the ANS in your neurological examination?
Visceral Nervous System

– Efferent system, afferents use the same pathways

– Visceral afferent system
  • Receptors
    – Pressure, stretch and chemical changes
  • Single neuron with peripheral ganglion
  • Axons – cranial and spinal nerves
    – CNN ganglia – geniculate (VII), petrosal (IX), distal (X)
    – Spinal ganglia
Visceral afferent system

- Input via cranial nerves
  - Brainstem – Solitary nucleus (CN VII, IX, X) – GVA, SVA (taste)
    » Reflex function via reticular formation e.g. respiratory, CVS
    » Conscious perception – solitarothalamic tract
- Input via spinal nerves
  - Reflexes – sympathetic or parasympathetic
    » e.g. tachy- or bradycardia
  - Conscious perception to thalamus
Referred Pain

– Dermatomal distribution of referred pain
  • Visceral afferent stimulation
    – Stretch, distension, ischaemia
  • Confusion with exteroception synapsing on same dorsal horn
    – Low density innervation
    – Infrequent stimulation

– Viscerovisceral reflex
  • causing cutaneous vasospasm and local mediators?

– Occurrence in vet med?
What is the visceral motor system?

• Autonomic nervous system ANS
  – Purely efferent system (?)
  – Innervates smooth and cardiac muscle and glands
  – Two functional components
    • Differentiated morphologically, pharmacologically and physiologically
    • Parasympathetic NS
      – Housekeeping system ‘rest and digest’
    • Sympathetic NS
      – Prepares the body for flight or to fight
  – Dual innervation all body systems
What is anatomical arrangement of the VNS?

- **Central nervous system (CNS) components**
  - Brain
    - Forebrain (diencephalon) and brainstem
  - Spinal cord
    - Thoracic, lumbar, sacral

- **Peripheral nervous system (PNS)**
  - Cranial and spinal nerves
  - Efferent – two neuron system with peripheral ganglia
  - (Afferent – single neuron and peripheral (spinal) ganglia)
What are the anatomical concepts of the ANS?

• How many neurons?
  – One CNS neuron
    • Brain or spinal cord
  – Two neurons in the PNS (p106)
    • 1\textsuperscript{st} neuron cell body in CNS
    • 2\textsuperscript{nd} neuron cell body in ganglion
    • May pass through several ganglia without synapsing
  – Terminology – pre and post \textit{synaptic} neurons

• Where do ANS fibres leave CNS?
  – Parasympathetic NS = craniosacral NS
  – Sympathetic NS = thoracolumbar NS
What are the central controls for VNS?

- **Hypothalamus**
- **Central regulator**
  - Receives input
    - From viscera
      - Via **CN VII, IX and X**
        » **To nucleus solitarius** in myelencephalon = principal visceral sensory nucleus
      - Via **segmental spinal nerves**
        » To **spinal cord**
      - From **telencephalon**
        » Emotional input
  - Output
    - Neural via brainstem and spinal cord
    - Humoral via hypophysis

Dog brain, median section
Where are ANS NCB located?

Fig 1.7 Thomson and Hahn, functional nuclear columns, spinal cord and brainstem

From Fig A23, Thomson and Hahn, Dog, TS myelencephalon
- **Spinal cord grey matter**
  - **Dorsal horn**
    - Sensory/afferent NCB
  - **Ventral horn**
    - Motor/efferent NCB to striated muscle
  - **Intermediate horn**
    - Motor/efferent NCB of ANS
    - Thoracolumbar and sacral cord only
Peripheral components of the ANS

- 2-neuron + ganglion
- Location of ganglion PS vs Symp
- Neurotransmitter

- Terminology
- Pre and post ganglionic???
- Pre and post synaptic

Fig 12.2 Thomson and Hahn
Fig 12.1 Thomson and Hahn, ANS
How do sympathetic fibres innervate all viscera?

- **Thoracolumbar outflow from CNS**
  - C8/T1 to L4/5
  - Thoracic cavity
    - Sympathetic chain of nerves and *paravertebral* ganglia
  - Abdominal and pelvic cavities
    - Fusion of fibres to form *prevertebral* ganglia
      - e.g. celiac, cranial and caudal mesenteric ganglia
  - Head
    - Supplied by spinal nerves from C8-T7
    - Via vagosympathetic trunk
Sympathetic trunk and ganglia

Fig 12.3 Thomson and Hahn
How do parasympathetic fibres innervate all viscera?

- **Craniosacral** outflow from CNS
  - Cranial nerves from **brain**
    - To head region
      - CN III, VII, IX, X
    - To cervical, thoracic and abdominal viscera
      - CN X via vagosympathetic trunk
  - Segmental spinal nerves from **sacral spinal cord**
    - S1, S2, S3
    - To pelvic viscera
Vagus N.

Fig 12.4 Thomson and Hahn
Thoracic portion of the vagus nerve
Autonomic innervation of the eye

Pupillary light reflex

• Signs of dysfunction
  – Afferent lesion
    • Other signs?
  – Efferent lesion
    • Other signs?
Fig 12.5 Thomson and Hahn, Sympathetic innervation of the head
Pupillary Function in Acute Brain Disease

• Miosis
  – Compression of mesencephalon
  – Mechanism?
    • parasympathetic nucleus of CN III
      – facilitation or loss of inhibition?
    • Loss of sympathetic function?

• Mydriasis
  – Loss of parasympathetic nucleus of CN III function
  – Unfavourable prognosis
Innervation of pelvic viscera

Fig 12.7 Thomson and Hahn
Innervation of the Urinary Bladder

• Micturition
  – Primarily reflex function but controlled by higher areas

• Brainstem centres
  – Affect LMN and autonomic outflow

• Cerebrum
  – Initiates learned toileting behaviour
# Urinary Bladder Function

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<thead>
<tr>
<th></th>
<th>Storage</th>
<th>Voiding</th>
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<tbody>
<tr>
<td><strong>Parasympathetic</strong></td>
<td>- detrusor relaxation</td>
<td>+ detrusor contraction</td>
</tr>
<tr>
<td><strong>Sympathetic</strong></td>
<td>+ $\beta$ receptors bladder wall inhibition of detrusor</td>
<td>- $\beta$ receptors in the bladder wall</td>
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<tr>
<td></td>
<td>+ $\alpha$ bladder neck sm muscle contracts</td>
<td>- $\alpha$ bladder neck muscle</td>
</tr>
<tr>
<td><strong>Somatic</strong></td>
<td>+ striated sphincter contracts</td>
<td>- striated sphincter relaxes</td>
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Lesions affecting urinary bladder

Fig 12.8 Thomson and Hahn
Defaecation

• Primarily reflex
  – Local enteric plexus
  – Ascending paths for conscious perception
    • which funiculus?
      – dorsal funiculus
  – Sphincters
    • Striated muscle
    • Origin and nerve?
      – pudendal nerve from S1-S3
The Neuro Exam

• Aim to assess:
  1) Mentation/arousal and behaviour
  2) Posture and gait
     Sensory function – proprioception, tactile
     Motor function – gait, spinal reflexes
     Coordination
     Balance
  4) Cranial nerves
  5) Visceral function
  6) Spinal pain-hyperpathia