Chapter 15

Autonomic Nervous System (ANS) and Visceral Reflexes

- general properties
- Anatomy

Autonomic effects on target organs

Central control of autonomic function

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ANS - General Properties

• **Motor** - controls glands, cardiac and smooth muscle
  – also called visceral motor system
• **Regulates visceral processes**
  – Blood pressure, body temperature, respiratory airflow
• **ANS actions are automatic**
Visceral Reflexes

• Unconscious, automatic responses to stimulation of glands, cardiac or smooth muscle
  1. Receptors
     – detect internal stimuli -- stretch, blood chemicals, etc.
  2. Afferent neurons
     – connect to interneurons in the CNS
  3. Efferent neurons
     – carry motor signals to effectors
     – ANS is the efferent neurons of these reflex arcs
  4. Effectors
     – glands, smooth or cardiac muscle
• ANS modifies effector activity
Visceral Reflex to High BP

- High blood pressure detected by arterial stretch receptors (1), afferent neuron (2) carries signal to CNS, efferent (3) signals travel to the heart (4), heart slows reducing BP
Divisions of ANS

• Two divisions innervate same target organs
  – may have cooperative or contrasting effects

1. Sympathetic division
  – Backup for physical activity
    • increases heart rate, BP, airflow, blood glucose levels, etc

2. Parasympathetic division
  – Favors energy acquisition, storage
  – digestion and waste elimination

• Autonomic tone -balance of the two systems
• Effects of each depend upon neurotransmitters released
Somatic versus Autonomic Pathways

ANS = 2 neurons from CNS to effectors
  • presynaptic neuron cell body in CNS
  • postsynaptic neuron cell body in peripheral ganglion
Sympathetic Nervous System

• Origin of presynaptic neurons
  – lateral horns of spinal cord (T1-L2)

• Sympathetic chain ganglia (paravertebral)
  – 3 cervical, 11 thoracic, 4 lumbar, 4 sacral and 1 coccygeal ganglia

• Neuronal divergence predominates
  – each preganglionic cell branches and synapses on multiple postganglionic cells
  – produces widespread effects on multiple organs
Efferent Pathways
Preganglionic Pathways
Ganglia and Abdominal Aortic Plexus
Sympathetic Innervation

- Effectors in body wall are innervated by sympathetic fibers in spinal nerves.
- Effectors in head and thoracic cavity are innervated by fibers in sympathetic nerves.
- Effectors in abdominal cavity are innervated by sympathetic fibers in splanchnic nerves.
  - celiac, superior and inferior mesenteric ganglion.
Adrenal Glands

- Paired glands sit on superior pole of each kidney
- Cortex (outer layer)
  - secretes steroid hormones
- Medulla (inner core)
  - a modified sympathetic ganglion
    - stimulated by preganglionic sympathetic neurons
  - secretes neurotransmitters (hormones) into blood
    - catecholamines (85% epinephrine and 15% norepinephrine)
- Sympathoadrenal system is the closely related functioning adrenal medulla and sympathetic nervous system
Parasympathetic Nervous System

• Origin of preganglionic fibers
  – pons and medulla (for cranial nerve nuclei)
  – sacral spinal cord segments S2-S4

• Pathways of preganglionic fibers
  – cranial nerves III, VII, IX and X
  – arising from sacral spinal cord
    • pelvic splanchnic nerves and inferior hypogastric plexus

• Terminal ganglia in/near target organs
  – long preganglionic, short postganglionic fibers
Efferent Pathways
Parasympathetic Cranial Nerves

- Oculomotor nerve (III)
  - narrows pupil and focuses lens
- Facial nerve (VII)
  - tear, nasal and salivary glands
- Glossopharyngeal (IX)
  - parotid salivary gland
- Vagus nerve (X)
  - viscera as far as proximal half of colon
  - Cardiac, pulmonary, and esophageal plexus
Enteric Nervous System

- Nervous system of the digestive tract
- Composed of 100 million neurons found in the walls of the digestive tract (no components in CNS)
- Has its own reflex arcs
- Regulates motility of viscera and secretion of digestive enzymes and acid in concert with the ANS
Neurotransmitters and Receptors

• Effects of ANS
  – determined by types of neurotransmitters released and types of receptors on target cells

• Sympathetic has longer lasting effects
  – neurotransmitters persist in synapse and some reach the bloodstream

• Many substances released as neurotransmitters
  – enkephalin, substance P, neuropeptide Y, neotensin, nitric oxide (NO)
  • NO inhibits muscle tone in BV walls (vasodilation)
Dual Innervation

• Most of viscera receive nerve fibers from both parasympathetic and sympathetic divisions
• Both divisions do not normally innervate an organ equally
Dual Innervation

• Antagonistic effects
  – oppose each other
  – exerted through dual innervation of same effector
    • heart rate decreases (parasympathetic)
    • heart rate increases (sympathetic)
  – exerted because each division innervates different cells
    • pupillary dilator muscle (sympathetic) dilates pupil
    • constrictor pupillae (parasympathetic) constricts pupil
Dual Innervation

• Cooperative effects seen when 2 divisions act on different effectors to produce a unified effect
  – parasympathetics increase salivary serous cell secretion
  – sympathetics increase salivary mucous cell secretion
Dual Innervation of the Iris

- Brain
- Superior cervical ganglion
- Spinal cord
- Ciliary ganglion
- Sympathetic (adrenergic) effect
- Parasympathetic (cholinergic) effect

Pupil dilated
Pupil constricted
Without Dual Innervation

• Some effectors receive only sympathetic
  – adrenal medulla, arrector pili muscles, sweat glands and many blood vessels

• Sympathetic tone
  – a baseline firing frequency
  – vasomotor tone provides partial constriction
    • increase in firing frequency = vasoconstriction
    • decrease in firing frequency = vasodilation
    • can shift blood flow from one organ to another as needed
      – sympathetic stimulation increases blood to skeletal and cardiac muscles -- reduced blood to skin
Sympathetic and Vasomotor Tone

Sympathetic division prioritizes blood vessels to skeletal muscles and heart in times of emergency.

Blood vessels to skin vasoconstrict to minimize bleeding if injury occurs during stress or exercise.
Control of Autonomic Function

• ANS regulated by several levels of CNS
  – cerebral cortex has an influence
  – hypothalamus (major visceral motor control center)
    • nuclei for primitive functions – hunger, thirst
  – midbrain, pons, and medulla oblongata
    • nuclei for cardiac and vasomotor control, salivation, swallowing, sweating, bladder control, and pupillary changes
  – spinal cord reflexes
    • defecation and micturition reflexes integrated in cord
    • brain can inhibit these responses consciously