Mammalian Physiology

Autonomic Nervous System

PHYSIOLOGY, Chapter 11
Berne, Levy, Koeppen, Stanton
Objectives

• Describe the organization of the autonomic nervous system
  – Parasympathetic nervous system
  – Sympathetic nervous system
• Match neurotransmitters with the appropriate receptors
• Describe pharmacology related to ANS
Autonomic Nervous System

Organization of the sympathetic and parasympathetic divisions of the autonomic nervous systems
Autonomic Nervous System

Similar to somatic reflex arcs except there are two motor neurons in efferent pathway

Enteric nervous system:
Reflex arc (sensory, motor, intrinsic neurons) entirely within walls of GI tract
Autonomic Nervous System

Sympathetic subdivision: 
(aka) – Thoracolumbar subdivision based on where the nerves leave the CNS

Parasympathetic subdivision: 
(aka) Craniosacral subdivision again based on where the nerves leave the CNS
Parasympathetic Nervous System

Parasympathetic subdivision: (aka) Craniosacral subdivision again based on where the nerves leave the CNS

Vagus Nerve (CN X) accounts for 75% of parasympathetic innervation

Preganglionic fibers extend to organ innervated and synapse with post-ganglionic fibers in wall of organ
Sympathetic Nervous System

Sympathetic subdivision:
(aka) – Thoracolumbar Subdivision

Pre-ganglionic fibers synapse with post-ganglionic fibers in paravertebral ganglionic chain
Sympathetic Nervous System

Pre-ganglionic fibers arise in intermediolateral horn of spinal cord – neuron passes through anterior root into corresponding spinal nerve – then through white ramus into a ganglion of sympathetic chain
Sympathetic Nervous System

- No presynaptic neurons terminate in ganglia
- One of three routes is followed
  - Synapse with post ganglionic neuron in the ganglion it enters
  - Pass upward or downward and synapse in another ganglion
  - Pass through the chain and synapse in a peripheral ganglion
    - Celiac
    - Hypogastric (superior & inferior mesenteric ganglia)
Sympathetic Nervous System

• Special Cases
  – Some post ganglionic fibers reenter spinal nerves via gray rami and extend to body via skeletal nerves to innervate blood vessels, sweat glands, piloerector muscles

  – Some preganglionic nerves pass through ganglia without synapsing – terminate on adrenal medulla and stimulate secretion of epinephrine and norepinephrine
Neurotransmitters

- Acetylcholine and Norepinephrine
- All preganglionic neurons are cholinergic
- Parasympathetic postganglionic neurons are cholinergic
- Sympathetic postganglionic neurons are adrenergic except
  -Sympathetics innervating sweat glands, blood vessels (?), and piloerector muscles are cholinergic
Receptors

• Specialized receptors on cells mediate actions of neurotransmitter
  – Change membrane permeability to an ion
  – Activate a second messenger – cyclic AMP

• Acetylcholine receptors
  – Muscarinic (muscarine activates)
  – Nicotinic (nicotine activates)

• Norepinephrine/epinephrine receptors
  – $\alpha$, $\beta_1$, $\beta_2$
  – Norepinephrine targets $\alpha$ receptors
  – Epinephrine targets $\beta_1$ (excitatory) and $\beta_2$ (inhibitory)
Receptors

All post synaptic neurons – nicotinic receptors

Parasympathetic fibers – muscarinic tissue receptors

Sympathetic adrenergic fibers - $\alpha$ or $\beta$ tissue receptors

Sympathetic cholinergic fibers – muscarinic tissue receptors
Second Messenger System
Autonomic Nervous System

Parasympathetic

Preganglionic nerves

Ganglion

Postganglionic nerves

ACh

ACh

ACh

ACh

Cholinergic nerves

Effector organs

+ Exocrine glands
+ Smooth muscle of GI tract
- Heart rate

+ Sweat glands
- Blood vessels (some)

+ Heart
+ Spleen
+ Blood vessels (most)

Smooth muscle of
- GI tract
- Lungs

Sympathetic

Nerves

ACh

ACh

ACh

Adrenal medulla

Adrenergic nerves

CNS

Somatic

Cholinergic

ACh

Skeletal muscle
Adrenergic Receptors and Function

• **Alpha Receptor**
  – Vasoconstriction
  – Intestinal relaxation
  – Intestinal and bladder sphincter contraction

• **Beta Receptor**
  – Vasodilatation
  – Cardioacceleration
  – ↑ myocardial strength
  – Intestinal relaxation
  – Uterus relaxation
  – Bronchodilatation
  – Calorogenesis
  – Glycogenolysis
  – Lipolysis
Pharmacology of ANS

• Sympathetic Nervous System
  – Sympathomimetic – stimulate sympathetic receptors
    • Phenylephrine -α agonist
    • Isoproterenol - β agonist
    • Albuterol - β_2 agonist
  – Activate norepinephrine release
    • Ephedrine
    • Amphetamine

• Adrenergic blockers
  – ↓ synthesis & storage of nor-epinephrine in sympathetic nerve endings (reserpine)
  – Block release of nor-epinephrine
  – α blockers (phentolamine)
  – β blockers (propranolol)
  – Block synaptic transmission
Pharmacology of ANS

- Parasympathetic Nervous System
  - Parasympathomimetics – potentiate effect of acetylcholine (neostigmine) or inhibit acetylcholinesterase
  - Anti-muscarinic drugs (atropine, scopolamine)
Pharmacology of ANS

- Postganglionic effectors - Nicotine
  - Activates post ganglionic fibers of both sympathetic and parasympathetic (nicotinic receptors)
  - Result: sympathetic vasoconstriction in abdominal organs and limbs
  - Parasympathetic mediated increase in gastrointestinal activity and decrease in heart rate