Autonomic Nervous System

Lecture-5 :Topics

- Functions of ANS
- Effect of Sympathetic & Parasympathetic stimulation
- Overall difference between 2 divisions of ANS

Learning Objectives

- Effects of sympathetic and parasympathetic neurotransmitters on target organs and tissues.

Sympathetic Effects

- Fight, Fright or flight response
- Release of Neurotransmitters (NT)-
  - Norepinephrine (NT) from postganglionic fibers
  - Epinephrine (NT) from adrenal medulla

Sympathetic Effects

- Mass activation prepares for intense activity
  - Heart rate (HR) increases
  - Bronchioles dilate
  - Blood [glucose] increases

Sympathetic Effects

- GI motility decreases
- Contraction of sphincters
- Relaxation of
  - Detrusor muscle
  - Ciliary muscle
- Mydriasis

Parasympathetic Effects

- Normally not activated as a whole
  - Stimulation of separate parasympathetic nerves.
- Release ACh as NT
- Relaxing effects-
  - Decreases HR.
  - Dilates visceral blood vessels.
  - Increases digestive activity.

Parasympathetic Effects

- Bronchonstriction
- GI motility increases
- Relaxation of sphincters
- Contraction of
  - Detrusor muscle
  - Ciliary muscle
- Miosis

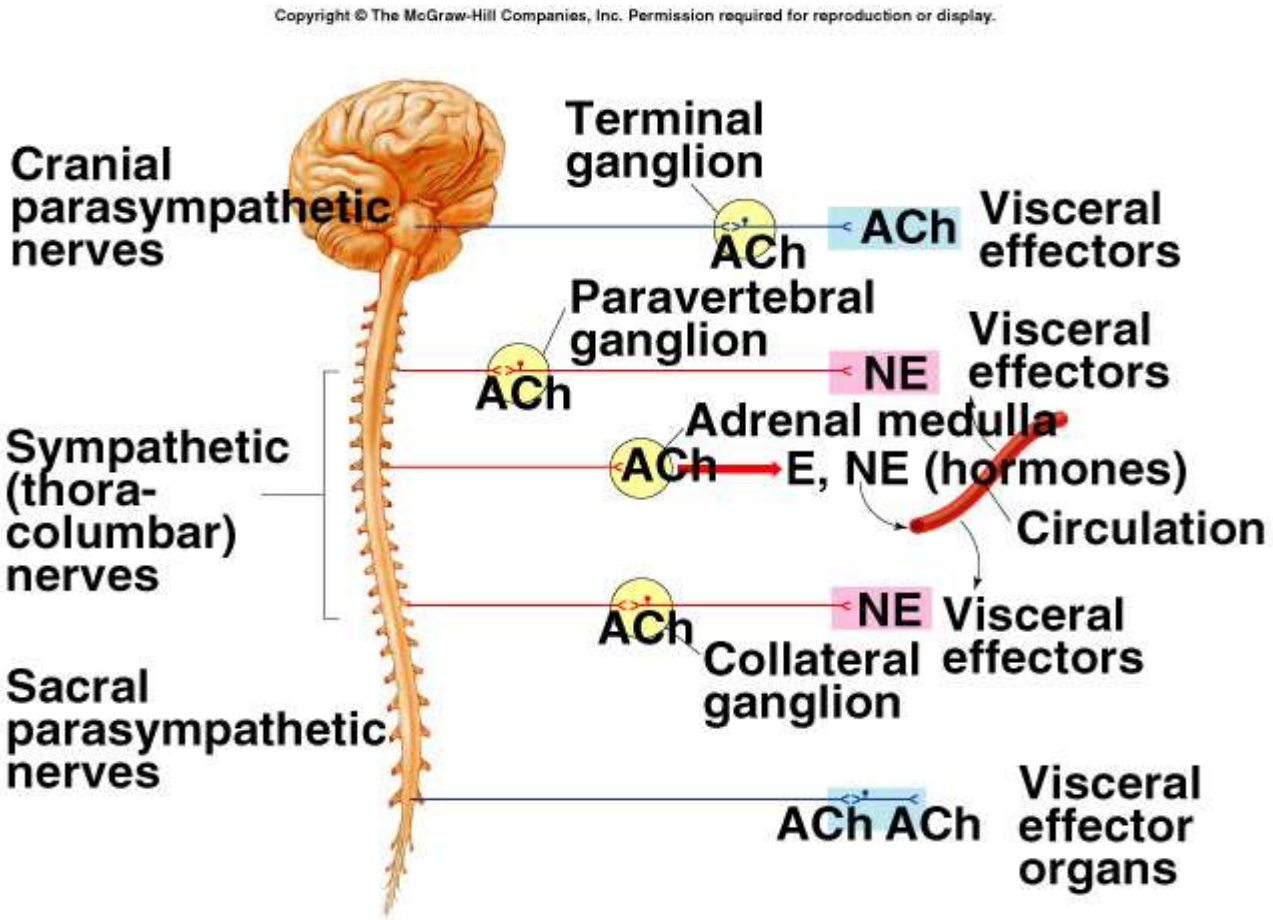
Adrenergic and Cholinergic Synaptic Transmission

- ACh is NT for all preganglionic
  - Sympathetic fibers
  - Parasympathetic fibers
- Transmission at these synapses is termed cholinergic
- All preganglionic fibers terminate in autonomic ganglia

Adrenergic and Cholinergic Synaptic Transmission

- ACh is NT released by -
  - Most postganglionic parasympathetic fibers
  - Some postganglionic sympathetic fibers
- Postganglionic autonomic fibers innervate the target tissue

Adrenergic and Cholinergic Synaptic Transmission



Adrenergic Synaptic Transmission
(continued)

- Transmission at these synapses is called adrenergic:
  - Norepinephrine
    - released by most postganglionic sympathetic nerve fibers.
  - Epinephrine,
    - released by the adrenal medulla
- Collectively called Catecholamines

Responses to Adrenergic Stimulation

- Beta adrenergic receptors:
  - Produce their effects by stimulating production of cAMP
  - NE binds to receptor
  - G-protein dissociates.

Responses to Adrenergic Stimulation

- Depending upon tissue, either α subunit or $\beta\gamma$–complex produces the effects
  - Alpha subunit-
    - Activates adenylate cyclase
    - Producing cAMP
      - cAMP activates protein kinase
      - Opening ion channels

Responses to Adrenergic Stimulation
(continued)

- **Alpha$_1$ adrenergic receptors:**
  - Produce their effects by the production of Ca^{2+}
  - Epi binds to receptor
  - Ca^{2+} binds to calmodulin
  - Calmodulin activates protein kinase, modifying enzyme action

Responses to Adrenergic Stimulation
(continued)

- **Alpha$_2$ adrenergic receptors**:

1. Located on Presynaptic terminal
   - Decreases release of NE.
     - Negative feedback control.
2. Located on postsynaptic membrane.
   - When activated, produces vasoconstriction

Responses to Adrenergic Stimulation
(continued)

- Has both excitatory and inhibitory effects.
- Responses due to different membrane receptor proteins.
  - α_1 : constricts visceral smooth muscles.
  - α_2 : contraction of smooth muscle.
  - β_1 : increases HR and force of contraction.
  - β_2 : relaxes bronchial smooth muscles.
  - $\beta 3$: adipose tissue, function unknown

Responses to Cholinergic Stimulation

- Cholinergic fibers-.
  - Release ACh as NT
  - All somatic motor neurons,
  - All preganglionic neurons
  - Most postganglionic parasympathetic neurons
  - Some postganglionic sympathetic neurons

Responses to Cholinergic Stimulation (continued)

• Somatic motor neurons	• Excitatory
• All preganglionic autonomic neurons	• Excitatory
• Postganglionic axons	• Excitatory or • Inhibitory

Responses to Cholinergic Stimulation (continued)

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- **Muscarinic receptors**
  - Ach binds to receptor
  - Requires the mediation of G-proteins
  - βγ-complex affects-
    - Opening a channel or
    - Closing a channel or
    - Activating enzymes

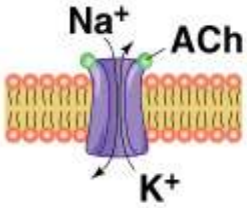
Responses to Cholinergic Stimulation (continued)

- Nicotinic receptors (ligand -gated)
  - ACh binds to 2 nicotinic receptor binding sites.
  - Causes ion channel to open within the receptor protein.
    - Opens a Na^+ channel.
- Always excitatory

Responses to Cholinergic Stimulation (continued)

Nicotinic ACh receptors

Postsynaptic membrane of
- All autonomic ganglia
- All neuromuscular junctions
- Some CNS pathways



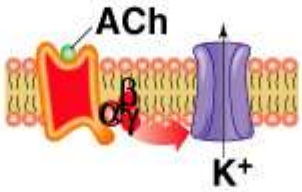
Ligand-gated channels (ion channels are part of receptor)

Depolarization

Excitation

Muscarinic ACh receptors

- Produces parasympathetic nerve effects in the heart, smooth muscles, and glands
- G-protein-coupled receptors (receptors influence ion channels by means of G-proteins)

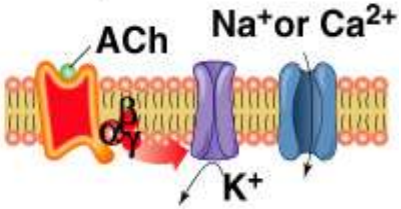


Hyperpolarization

(K^+ channels opened)

Inhibition

Produces slower heart rate



Depolarization

(K^+ channels closed)

Excitation

Causes smooth muscles of the digestive tract to contract

Other Autonomic NTs

- Certain nonadrenergic, noncholinergic postganglionic autonomic axons produce their effects through other NTs
  - ATP
  - NO

Organs With Dual Innervations

- **Dual innervations**
  - Innervations by both
    - Sympathetic fibers
    - Parasympathetic fibers
- Most visceral organs receive dual innervations
- Effects of dual innervations
  - Antagonistic
  - Complementary
  - Cooperative

Organs With Dual Innervations

- Antagonistic :
  - Sympathetic and parasympathetic fibers innervate the same cells.
    - Actions counteract each other.
      - Heart rate.
- Complementary:
  - Sympathetic and parasympathetic stimulation produces similar effects.
    - Salivary gland secretion.
- Cooperative:
  - Sympathetic and parasympathetic stimulation produce different effects that work together to produce desired effect.
    - Micturition.

Organs Without Dual Innervations

- Regulation achieved by increasing or decreasing firing rate.
- Organ receive only sympathetic innervations-
  - Adrenal medulla
  - Arrector pili muscle
  - Sweat glands
  - Most blood vessels.

Applied

Horner's syndrome

- Characterized by-
  - Constriction of the pupil
  - Enophthalmos
  - Drooping of eye lid
  - Anhydrosis on affected side of face
- Occurs due to-
  - Damage of stellate ganglia
  - Paralysis of Cervical Sympathetic nerve trunk

Horner's syndrome

Figure 1: Left pupillary miosis, marked hypochromia of the left iris, ipsilateral mild ptosis and left hemifacial anhidrosis

Drugs acting on autonomic ganglia

Increases activity

- Direct effect
  - Acetylcholine
  - Nicotine (Low doses)
- Indirect effect

(ACE inhibitors)

  - Physostigmine
  - Neostgmine
  - Parathion
  - DFP

Decreases activity

- Ganglion blockers-
  - Hexamethonium
  - Macamylmamine
  - Pentolinum
  - Trymethaphan

Drugs acting on Postganglionic sympathetic nerve endings

Increases activity

- Release NE (TEA)
  - Tyramine
  - Ephedrine
  - Amphetamine

Decreases activity

- Block NE Synthesis
  - Metyrosine
- Block Storage
  - Reserpine
  - Guanethidine
- Prevent Release
  - Bretylium
- False transmitters
- Methyldopa

Drugs acting on Muscarinic receptors

Increases activity

- Acetylcholine

Decreases activity

- Atropine
- scopolamine

Drugs acting on Beta adrenergic receptor

Increases activity

- **β stimulators**
  - Isoproterenol
- **$\beta_2$stimulators**
  - Salbutamol
  - Terbutaline

- Decreases activity
- **β blockers**
  - Propranolol
  - Metaprolol
- **β_1 blockers**
  - Atenolol
- **β_2 blockers**
  - Butoxamine

Drugs acting on Alpha adrenergic receptors

Increases activity

(α_1 stimulators)

- Methoxamine
- Phenylepinephrine

Decreases activity

(α blockers)

- Phenoxybenzamine
- Phentolamine
- Prazocin (α_1 blockers)
- Yohimbine ($\alpha_2$blockers)

Thank You!!!