Autonomic Nervous System III
Adrenal medulla & Autonomic reflexes

Physiology lecture 30

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Lecture Objectives:

- Distinguish the function of the adrenal medulla.
- Understand the sympathetic and parasympathetic tone.
- Identify the autonomic reflexes.
- Describe the stress and alarm response of the SNS.
The Adrenal Medulla:

- Stimulation of the sympathetic nerves to the adrenal medullae causes release of large quantities of the hormones epinephrine (E) and norepinephrine (NE) into the circulating blood.

- On average, about 80% of the secretion is epinephrine and 20% is norepinephrine, although the relative proportions can change considerably under different physiological conditions.

- The circulating E and NE have almost the same effects on the different organs as the effects caused by direct sympathetic stimulation, except that the effects last 5 to 10 times as long because both of these hormones are removed from the blood slowly over a period of 2 to 4 minutes.
The Adrenal Medulla (cont.):

- Epinephrine causes almost the same effects as those caused by norepinephrine, but the effects differ in the following respects:
  1. Has a greater effect on cardiac stimulation than does norepinephrine.
  2. Causes only weak constriction of the blood vessels in the muscles, in comparison with much stronger constriction caused by norepinephrine.
  3. On tissue metabolism, Epinephrine has 5 to 10 times as great a metabolic effect as norepinephrine. Example; glycogenolysis in the liver and muscle and glucose release into the blood.
Advantage of Adrenal Medullary Secretion:

- The simultaneous organ stimulation directly by sympathetic nerves and indirect by the adrenal medullary hormones support each other. And each mechanism can compensate for the other.

- The capability of adrenal medullary epinephrine and norepinephrine to stimulate structures of the body that are not innervated by direct sympathetic fibers.
Sympathetic and Parasympathetic Tone:

- Unlike the state in skeletal muscle, only one nerve impulse every few seconds suffices to maintain normal sympathetic or parasympathetic effect, and full activation occurs when the nerve fibers discharge 10 to 20 times per second.

- Normally, the sympathetic and parasympathetic systems are **continually active**, and **the basal rates of activity** are known, respectively, as **sympathetic tone and parasympathetic tone**.

- The increase or decrease in the tone → increase or decrease in the activity of the stimulated organ. Example; vasoconstriction and vasodilation of arterioles (sympathetic), and basic gastric motility (parasympathetic).
Under specific circumstances, the activity of one autonomic nervous system subdivision can dominate the other. The sympathetic system dominates during stress response, while, in quiet and restful circumstances, the parasympathetic system dominates.

The tone in the sympathetic system is achieved by basal secretion of epinephrine and norepinephrine by the adrenal medulla (0.2 μg/kg/min of E and about 0.05 μg/kg/min of NE).

Removal of the sympathetic or parasympathetic tone by denervation → denervation supersensitivity. This mechanism is believed to be due to up-regulation of the adrenergic or cholinergic receptors.
The Autonomic Reflexes:

- Many visceral functions of the body are regulated by autonomic reflexes. Examples of such reflexes are the cardiovascular autonomic reflexes and gastrointestinal autonomic reflexes.

- Emptying of the urinary bladder is another example of the autonomic reflex. Stretching of the bladder sends impulses to the sacral cord, which in turn causes reflex contraction of the bladder and relaxation of the urinary sphincters, thereby promoting micturition.

- The autonomic reflexes contribute to the regulation of pancreatic secretion, gallbladder emptying, kidney excretion of urine, blood glucose concentration, and many other visceral functions.
Local Vs. Mass Stimulation of the Sympathetic and Parasympathetic Systems:

- In some instances, almost all portions of the sympathetic nervous system discharge simultaneously as a complete unit, a phenomenon called **mass discharge**. The result is a widespread reaction throughout the body called the **alarm** or **stress response**.
- At other occasions, activation occurs in isolated portions of the sympathetic nervous system. Important examples are:
  2. Gastrointestinal reflexes. Gastric sensory receptor stimulation → reflex arc through paravertebral ganglia → back to the gut through sympathetic nerves to control motor or secretory activity.
- The parasympathetic system usually causes specific localized responses. Example is the salivation in the mouth upon stimulation of touch receptors. However, there is often **association** between closely allied parasympathetic functions. Example; urinary bladder and rectal emptying reflexes.
The Alarm or Stress Response of the Sympathetic Nervous System:

- The stress response increases the ability of the body to perform vigorous muscle activity in many ways, including:
  1. Increased arterial pressure.
  2. Increased blood flow to active muscles concurrent with decreased blood flow to organs such as the gastrointestinal tract and the kidneys that are not needed for rapid motor activity.
  3. Increased rates of cellular metabolism throughout the body.
  4. Increased blood glucose concentration.
  5. Increased glycolysis in the liver and in muscle.
  6. Increased muscle strength.
  7. Increased mental activity.
  8. Increased rate of blood coagulation.

- The sympathetic system is especially strongly activated in many emotional states. For instance, in the state of rage.

- The sympathetic alarm reaction is also called the fight-or-flight reaction.
Test Question:

Q. Which of the following statements regarding the alarm response is false?

A. Contraction of the radial muscle that dilate the pupil
B. Increased urinary excretion of catecholamines
C. Lipolysis in adipose tissue
D. Decreased cholinergic tone in the heart
E. Relaxation of sphincteric smooth muscle in the alimentary tract