

**Adrenal Gland**  
**Physiology of adrenal medulla and pheochromocytoma**  
**(Lecture-4)**  
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**Objectives**

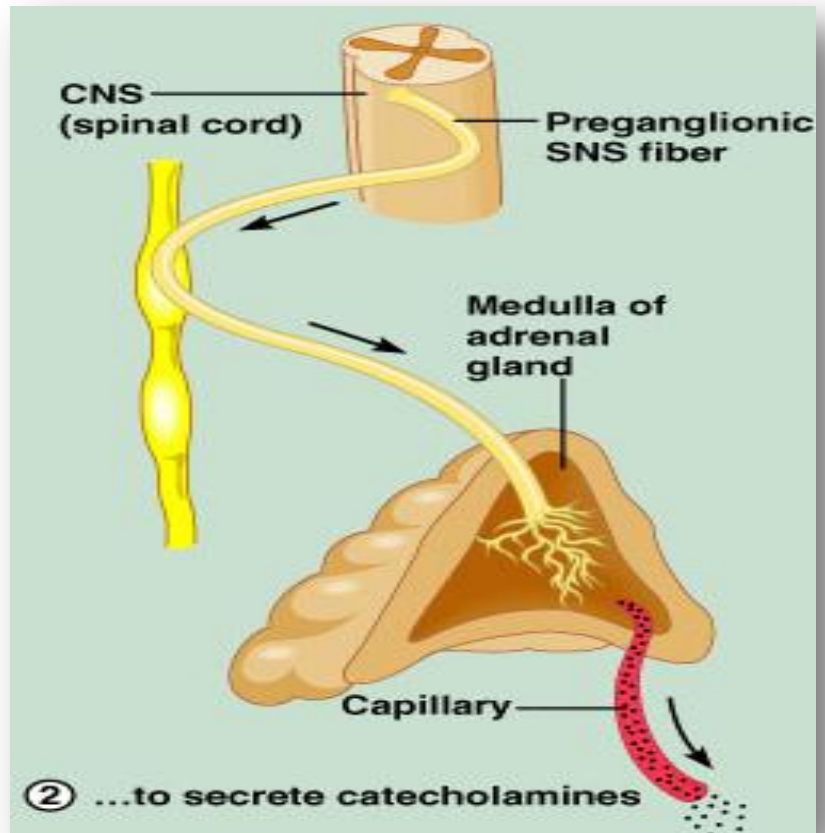
By the end of this lecture, students should be able to describe:

- Structure of adrenal medulla.
- Adrenal medulla and sympathetic nervous system.
- Structure and functions of adrenal medullary hormones.
  - Catecholamines: Epinephrine and norepinephrine
  - Dopamine
- Regulation of adrenal medullary secretions
- Adrenal medullary tumors (pheochromocytomas)

**Keywords:** epinephrine, norepinephrine, dopamine, catecholamines, pheochromocytoma.

## *Function of the Adrenal Medullae*

- The adrenal medulla is a modified sympathetic ganglion in which the postganglionic neurons have lost their axons and become secretory cells (chromaffin cells).
- The cells secrete when stimulated by the preganglionic nerve fibers that reach the gland via the splanchnic nerves.



The main secretions of the adrenal medulla are:

- ❖ Catecholamines:
  - ✓ Epinephrine (80 %)
  - ✓ Norepinephrine (20 %)
- ❖ Dopamine.

### *Biosynthesis of catecholamines*

Norepinephrine is formed by hydroxylation and decarboxylation of tyrosine, and epinephrine by methylation of norepinephrine.

The catecholamines have a half-life of about 2 min in the circulation.

For the most part, they are methoxylated and then oxidized and excreted in the urine.

### ***Secretion of catecholamines from adrenal medulla***

In the medulla, norepinephrine and epinephrine are stored in granules with ATP.

Secretion is initiated by Ach released from the preganglionic neurons that innervate the secretory cells.

Ach activates cation channels allowing  $\text{Ca}^{++}$  to enter the cells from the ECF and trigger the exocytosis of the granules.

In this fashion, catecholamines, ATP, and proteins from the granules are all released into the blood together.

### **Value of the Adrenal Medullae to the Function of the Sympathetic Nervous System.**

Epinephrine and norepinephrine are almost always released by the adrenal medullae at the same time that the different organs are stimulated directly by generalized sympathetic activation. Therefore, the organs are actually stimulated in two ways:

directly by the sympathetic nerves and indirectly by the adrenal medullary hormones. The two means of stimulation support each other, and either can, in most instances, substitute for the other.

Another important value of the adrenal medullae is the capability of epinephrine and norepinephrine to stimulate structures of the body that are not innervated by direct sympathetic fibers. For instance, the metabolic rate of every cell of the body is increased by these hormones, especially by epinephrine, even though only a small proportion of all the cells in the body are innervated directly by sympathetic fibers.

## **Effects of epinephrine & norepinephrine**

Catecholamines are secreted mainly in emergency conditions to prepare the body for the "fight or- flight" responses, and have almost the same effects throughout the body as direct sympathetic stimulation.

*They exert the following effects:*

- Vasoconstriction of essentially all the blood vessels of the body which increase both systolic and diastolic blood pressure.
- Increase both heart rate and force of contraction.
- Splenic contraction and add concentrated blood to the general circulation.
- Vasoconstriction to renal blood vessels which may decrease urine volume.
- Stimulation of glycogenolysis in liver and skeletal muscle so blood glucose level increases.
- Mobilization of free fatty acids (FFA) from adipose tissue.
- Increase the metabolic rate and O<sub>2</sub> consumption leading to increase heat production.
- Increase the rate and depth of respiration by direct excitation of respiratory centre and by increased metabolic rate.
- Potentiation of skeletal muscle contraction and delay onset of its fatigue. They also cause vasodilatation of skeletal muscle blood vessels.
- Excitation of the CNS and increase the mental activity and alertness.
- Dilation of the pupils and increase the visual fields

## ***Differences between actions of epinephrine and norepinephrine***

Epinephrine has a greater effect on cardiac stimulation than does norepinephrine. Epinephrine causes only weak constriction of the blood vessels in the muscles, in comparison with much stronger constriction caused by norepinephrine. Therefore,

epinephrine raises the arterial pressure to a lesser extent but increases the cardiac output more.

Epinephrine has 5 to 10 times as great a metabolic effect as norepinephrine.

### **EFFECTS OF DOPAMINE**

The physiologic function of the dopamine in the circulation is unknown. However, injected dopamine produces the following:

- Renal vasodilation and vasodilation in the mesentery, elsewhere, it produces vasoconstriction.
- It has a positively inotropic effect on the heart, increases systolic pressure and has no effect on diastolic pressure. Because of these actions, dopamine is useful in the treatment of traumatic and cardiogenic shock.
- Dopamine made in the renal cortex causes natriuresis and may exert this effect by inhibiting renal  $\text{Na}^+ - \text{K}^+$  ATPase.

### **Regulation of adrenal medullary secretion: Neural control**

- ❖ Catecholamine secretion is low in basal states, but the secretion of epinephrine and, to a lesser extent, that of norepinephrine is reduced even further during sleep.
- ❖ Increased adrenal medullary secretion is part of the diffuse sympathetic discharge provoked in emergency situations, which is called the "emergency function of the sympatho-adrenal system.
- ❖ Catecholamines are essential for preparing the body to withstand emergencies as in muscular exercise, hemorrhage, hypoglycemia and exposure to cold.system.

### ***Effect of adrenomedullary insufficiency***

Unlike adrenal cortex, the adrenal medulla does not appear to be essential to life because most of its vital functions can be done by the activity of SNS.

### ***Pheochromocytomas***

Tumors of adrenal medulla which lead to increase secretion of catecholamines. Manifestations may be intermittent bouts of palpitations, headache, glycosuria, extreme systolic hypertension and increased metabolic rate.