

Autonomic Nervous System (2)

- Autonomic nervous system is divided into 2 divisions: sympathetic and parasympathetic.
- To have an ideal daily activity there must be a balance between the sympathetic and the parasympathetic.
- * We need our **sympathetic** to be excited when we need to **increase the activity** of the body like in exercising, emotional involvement with a certain person or situation, fighting or fighting conditions.

And the **parasympathetic** is excited on the **resting and digestion conditions**. Like when your kidneys get rid of the waste substances, clear your blood and decrease the urea and toxic substances.

Parasympathetic division:

The parasympathetic originates from the **cranial and sacral** nerves.

- From T1 up to L2 is sympathetic innervation.
- In the brain we have 24 cranial nerves (12 pairs) and part of four cranial nerves carry parasympathetic fibers.

Cranial Region:

The Four cranial nerves are:

- 1- The third cranial nerve (Oculomotor nerve): it's responsible for the pupil of the eye and causes its constriction and this is called myosis.

2- The seventh cranial nerve (the facial nerve): responsible for various facial expressions so it gives motor supply to the face muscles.

Remark: parasympathetic innervations mostly increase the secretion of the glands like the lachrymal, nasal and submandibular glands and salivary and GI glands.

3- The ninth cranial nerve (glossopharyngeal nerve): it gives very slight parasympathetic innervation to the parotid gland which is found in front of the ear and enlarges when you get viral infection: Mumps. (النكاف)

4- **The tenth cranial nerve (the vagus nerve):** Vagus means the lost nerve because it has many branches and it's the most important nerve of all the parasympathetic nerves (mostly when we talk about the parasympathetic we are mainly talking about the vagus nerve because it covers almost 75% of the parasympathetic innervations). It is the major and the main innervations of parasympathetic system. It innervates the heart and decrease the heart rate and it also innervates the GI tract.

Bradycardia: decrease in the heart rate less than the normal range. (Vagus effect)

Tachycardia: Increase in the heart rate more than the normal range.

The normal range: (65-75), the average (68-70)

* In old days they used to cut the vagus nerve in order to treat peptic ulcers(exp, gastric and duodenal ulcers) Why?

Firstly, this is called Vagotomy (the suffix – ectomy denotes the surgical removal of a specified part of the body) and Vagotomy means the cutting of the vagus from both sides at the lower esophageal area. And as previously denoted, parasympathetic is responsible for gland secretion and HCl acid that is secreted in the stomach was thought to be the major cause of ulcers.

Because like when you are under stress, depressed and disappointed, the parasympathetic activity is very high and they concluded that the HCl will be very high and will lead to ulcers so they must do Vagotomy.

But nowadays they discovered that the majority of ulcers are due to bacteria (H-pylori) so they stopped total Vagotomy operations . Instead, they only do (Endoscopic highly selective Vagotomy), where they don't cut the whole vagus and cause side effects but only highly selective cut for a specific region and this is used as treatment for obesity and other things.

Sacral Region:

- Mostly from S2 and S3

These nerves regulate the urination and defecation reflexes (means that they control the urine and the stool output) majorly affecting the urinary bladder and the lower part of the rectum and anus and they also control the sexual act in males.

So we see that the parasympathetic is actually completing what the sympathetic has already started and both of them they make a beautiful harmony and regulation together in our body.

Neurotransmitters:

-Internal organs are supplied by sympathetic and parasympathetic divisions, and each of them contains preganglionic and postganglionic fibers. What are the neurotransmitters released in the four sites?

This is important for our next studying years in the pharmacology and physiology of the heart and blood pressure regulation and GI.

Preganglionic is usually within the spinal cord and it ends at the ganglia(prevertebral or paravertebral in either sympathetic or parasympathetic), then we reach the synapses, there is then a neurotransmitter to be released, and the postganglionic neuron will continue until it reaches the target tissue(heart, stomach, blood vessel) then it gives them response.

Major Neurotransmitters that are released from these fibers (pre and post ganglionic) of the sympathetic and parasympathetic :

1-In the sympathetic pathway the **preganglionic** release **Acetylcholine** and the postganglionic release norepinephrine or we can call it noradrenalin.

Which means that the Majority of sympathetic fibers(postganglionic) release norepinephrine EXCEPT the sweat glands and very few blood vessels and piloerector muscles .(muscles that give you goose bumps when you are emotionally involved and all the hair stands up).

Sweat glands are actually innervated by sympathetic fibers that's why we sweat when we are under stress but the postganglionic neurotransmitter is the ACETYLCHOLINE not norepinephrine(except in the palms of the hands and the soles of the feet).

2-In parasympathetic pathway the pre and postganglionic both release acetylcholine.

In conclusion, all preganglionic and postganglionic release acetylcholine except: The postganglionic sympathetic fibers that releases norepinephrine except the cholinergic sweat glands.

Sweat Glands:

We have two types of sweating:

1- Sensible sweating: When the weather is hot you start sweating to the extent that you feel it.

2- Insensible: All people have this type even in the north pole, winter or summer.

What is the function/ physiology of these two types of sweating?

1- Insensible sweating: We move our skin aggressively for example ,the skin over the elbow , if it is hard it will crack during flexion or extension. So we need to keep our skin very moist and that's by insensible sweating which is all over the body and it is released all the time regardless of the weather to keep the moisture and elasticity of the body.

2- Sensible sweating: that we feel in hot weather is due to vasodilatation and it becomes excessive sweating to evaporate

the water and eventually you feel cooler and the core temperature of the body is decreased.

So, the insensible sweating is to keep the elasticity of the skin, to prevent cracking when you flex your joints and the sensible is to regulate the body temperature .

How to treat axillary hyperhidrosis (excessive sweating):

1- Antiperspirants(body deodorants) that contain aluminum chloride- $AlCl_3$ - that can inhibit the release of sweat .It hasn't yet proven but it may cause breast cancer. It is a temporary relief.

2- Injection of Botox that prevents the release of acetylcholine.

3-Anticholinergic drugs to body acetylcholine receptors.(competitive antagonist and it can really stop the sweating).

4- Hypnosis (التنويم المغناطيسي): It depends on biofeedback which means trying to control activities in the human body that were usually automated(like sweating, heart or respiration rate)so they are taught techniques to reduce the sweating and it really gives good results and it is invasive with no risks.

5- Surgical Removal :Endoscopic thoracic sympathetocmy (cutting the sympathetic innervations by endoscope to the chest and it's very dangerous procedure and deaths are recorded because you might puncture the lung or cause a severe bleeding to the chest and kill the patient so it's not usually used because it's very dangerous).

Receptors:

Acetylcholine have two different types of cholinergic receptors: nicotinic and muscarinic.

Norepinephrine have also two types of adrenergic receptors alpha and beta and nowadays there is $\alpha_1, \alpha_2, \alpha_3$ and β_1, β_2 .

Many drugs are highly specific for these receptors.

1- If we have a somatic pathway, that is the motor nerve that innervates the skeletal muscles, the nerves releases acetylcholine and the type of receptors located on the muscles is called NICOTINIC.

2- Preganglionic fibers in the parasympathetic and sympathetic pathways all receptors for the acetylcholine are nicotinic .

3- Postganglionic in the parasympathetic pathway that goes for example to the heart have muscarinic receptors and any other sympathetic post ganglionic that release acetylcholine is also muscarinic.

4- Sympathetic fibers that release norepinephrine has two receptors alpha and beta .

Very Important:

Because it is very important to regulate the circulation during emergency, we have two types of neurotransmitters are released in the sympathetic pathway. When the preganglionic reaches the adrenal medulla , here we don't have postganglionic

neurons and immediately there will be a release of epinephrine and norepinephrine.

- Sympathetic postganglionic fibers, when they innervate the heart and the vascular system, they usually release norepinephrine (referred to as sympathetic adrenergic) that affects the α receptors much more than the β receptors.
- When you have this stimulation vascular system which is peripheral resistance will be affected more than the heart because heart majorly has β receptors.
- When you need more sympathetic stimulation, adrenal medulla is stimulated and starts releasing both, epinephrine and norepinephrine but 80% of its secretion is epinephrine.
- Epinephrine works on α and β receptors equally so it will affect the heart more than the norepinephrine. (And the β will become highly activated)

In conclusion, the stimulation of adrenal medulla to release epinephrine will increase the heart contractility much more than the sympathetic postganglionic fibers and both of them affect the peripheral resistance and increase the blood pressure. Sympathetic fibers are instant within a fraction of a second.

How do we remove acetylcholine and norepinephrine?

- Acetylcholine and norepinephrine once they are released, they have to be broken down.
- Acetylcholine is broken down majorly by esterase enzyme the same way as neuromuscular junction. Esterase enzyme breaks it instantly and whatever is left will dissipate to the tissues.

- Noerpinephrine is precious and we need it in changing posture and the activity so 50%-80% of it will be reuptaken and reused. Part of it will diffuse to the blood and other part will be degraded by enzymes:

1- MAO= monoamine oxidase enzyme which is found in the nerve terminals in postganglionic sympathetic fibers.

2- Catechol- o-methyl transferase which is found in all body tissues and whenever they want to end instantly the sympathetic stimulation, they can do it.

Major regulation of the CNS by sympathetic and parasympathetic nerves:

- The centers of the cardiovascular control are located in the brainstem but the major control is from your emotional brain and cerebral cortex.

Example: If you want to exercise, the sympathetic innervations will be increased. But if there is someone who really bothers you and you have to compete with him and win over him, your cerebral cortex will force you to the limit, it is majorly cerebral cortical control and hypothalamic control on parasympathetic and sympathetic during competitions and other situations.

That's why sometimes when it is not under your control, the sympathetic becomes overactive and this causes tachycardia especially in our age, when we are under stress or causes tremor.

Sympathetic stress begins with tremor and tachycardia and ends as insomnia.

Although cardiovascular, sympathetic and parasympathetic controls are at the lower part of the brain (brain stem, emotional brain) the cerebral cortex can control them completely.

The input comes from higher centres ,from the cerebral cortex and limbic system and from the hypothalamus and from the other receptors.

Cardiovascular centre response:

we have sympathetic and parasympathetic fibers. sympathetic increases the heart rate and blood pressure and the parasympathetic decreases them.

Some of the widely spread diseases: is peptic ulcers and they are called anatomic induced diseases.

Many students will start suffering from stomachache and this ends as ulcer, because of the over activity of the autonomic nervous system (parasympathetic) when you get depression or feel that you are trapped, the parasympathetic will work more, acid will increase, and have bad dietary habits and this can eventually lead to gastric or duodenal ulcers or consipation (امسالك) or the irritable bowel syndrome (القولون) (القلق). All this is due to excessive parasympathetic stimulation.

Also people our age who are anxious suffer from tachycardia and heart palpitation.

Lesions of the brain at the level of the cardiovascular center , will keep the arterial pressure but you can't modulate your arterial pressure.

Lesion below the medulla, it is the physician job to regulate the heart rate and the blood pressure and this occurs for example in a car accident or a head trauma, the arterial pressure immediately goes to zero and the respiration stops and the whole cardiovascular system will be disturbed and you have to remaintain it.

Sometimes people face disastrous conditions and this state is called the vasovagal response or the emotional syncope, emotional fainting. Immediate fainting when they hear unexpected news out of sudden, some people because the parasympathetic controls the unification and defecation they might urinate and defecate on themseleves or get immediate heart inhibition. 😊

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