Autonomic nervous system

**Laboratory exercise and seminar in medical physiology**

Home preparation, study materials and learning objectives

**Learning goals**

This seminar will introduce the students to the organization and functioning of the autonomic nervous system (ANS), which is critically involved in the maintenance of body homeostasis through regulation of body physiology and behavior. We will discuss the mechanisms by which the ANS regulates peripheral tissues, including autonomic reflexes and regulatory functions, as well as the effect of drugs modulating ANS activity. We will learn how to tests our body’s autonomic functions. The role of ANS in regulating homeostasis and behavior will be addressed in the context of autonomic neuropathy, intoxication, stress response and spinal cord injury-induced dysreflexia. At the end of the seminar we will try to activate our parasympathetic system to attenuate stress reaction using simple breathing techniques.

**Learning objectives – what you should learn?**

* To describe the two divisions of the ANS and their main functions.
* To explain how sympathetic (S) and parasympathetic (PS) nerves interact with each other to regulate organ functions and maintain homeostasis.
* To list the main effects of PS stimulation in different organs.
* To describe the fight-or-flight reaction and explain how sympathetic activation affects the activities of different organs.
* To describe the function of different neurotransmitter receptors in S and PS.
* To describe signaling mechanisms together with basic pharmacology and toxicology of ANS receptor subtypes.

**Study materials**

* Lecture
* Textbook Guyton and Hall
  + Chapter 60 (729-741)

<https://www.ninjanerd.org/lecture/autonomic-nervous-system>

<https://www.ninjanerd.org/lecture/sympathetic-nervous-system>

<https://www.ninjanerd.org/lecture/parasympathetic-nervous-system>

<https://www.ninjanerd.org/lecture/adrenergic-receptors>

<https://www.ninjanerd.org/lecture/cholinergic-receptors>

**Home preparation**

The whole group will split into 4 smaller groups. Each small group will choose one of the 4 case studies. As home preparation each small group will study and prepare answers to questions related to the chosen case study. To find the answers you can use textbooks or online resources. You can prepare a presentation or just explain and draw on a board. Presentations should be max 5-10 minutes long. In the presentation try to mention only aspects relevant to the task. Presentations will be followed by discussion. Bonus task might be prepared by a group of max 3 students and it will be rewarded by special credits.

**Part 1: Case study – diabetic autonomic neuropathy and basic tests of autonomic functions**

A 42-year-old male serving soldier, a known case of Type 2 diabetes mellitus on Oral Anti-Diabetic’s since past 4 years, irregular with treatment with inadequate control of blood glucose levels. He visited his doctor with history of tingling numbness in hand and feet & postural giddiness of few months’ duration. Dizziness was present on getting up from supine position associated with palpitations and near black out sensations. This was not associated with any chest pain, tremors, stiffness & seizures, no tinnitus. He also presented with history of early satiety, bloating sensation, constipation and occasional diarrhea. The patient further complained about genitourinary symptoms of difficulty in initiating micturition & straining during voiding, poor urinary stream with erectile dysfunction. No history of any associated fever present.

The patient was sent for examination of autonomic reflexes with suspected autonomic neuropathy.

***Questions for home preparation (group 1):***

What are the basic tests of autonomic functions? Explain them to your colleagues so that we can perform some of them during the seminar.

To find the answer use especially online resources, for example: <https://medlineplus.gov/lab-tests/autonomic-testing/>

**Part 2: Case study - Organophosphate intoxication**

CD is a 44-year-old woman who had spent much of the day working in her garden. A blustery wind caused her to unintentionally inhale the insecticide that she was spraying throughout the garden. When she began wheezing severely, she was taken to the emergency room. The attending physician observed other symptoms including constricted pupils and a slowed heart rate. CD was treated with the intravenous administration of atropine sulfate.

***Questions for home preparation (group 2):***

1. What are organophosphates?
2. What is their mechanism of action in the body? What is the function of acetylcholinesterase?
3. Which types of autonomic receptors are excessively stimulated as a result of this inhibition?
4. Which division of the ANS has been primarily affected, the sympathetic or the parasympathetic?
5. Under what conditions does this division of the ANS normally predominate?
6. Explain how the insecticide resulted in her presenting symptoms.
7. What effects may the insecticide have on the gastrointestinal system? Explain.
8. What effect may the insecticide have on generalized or localized sweating in this patient? Explain.
9. If exposed to high enough doses, what effect might the insecticide have on the patient’s skeletal muscles?
10. Would the administration of a β-adrenergic receptor antagonist be useful in the treatment of this patient? Why or why not?
11. Why is atropine an appropriate treatment? Justify your ideas.
12. The ‘‘nerve gas,’’ sarin, is a potent, irreversible organophosphate. What is the likely cause of death resulting from exposure to this extremely toxic agent?

**Part 3: Case study - Fight-or-flight response – acute stress reaction**

A thirty-five year-old woman has witnessed a road traffic accident. In the days following the incident, she experiences palpitations, muscle weakness and feels nauseous. She has not been sleeping and is finding it increasingly difficult to concentrate in her office administrator’s job. The woman visits her GP, who diagnoses acute anxiety. He has prescribed a course of the beta-blocker drug propranolol to alleviate symptoms.

***Questions for home preparation (group 3):***

1. What is fight-or-flight response?
2. Which anatomical structures and homeostatic functions participate in the fight-or-flight response?
3. What are the catecholamines? Which is the predominant compound? How are catecholamines normally eliminated from the blood?
4. Describe the relationship of the adrenal medulla to the autonomic nervous system. Under which conditions are catecholamines typically released?
5. Explain the symptoms of palpitations, muscle weakness and nausea.
6. List other symptoms you have experienced when you have been feeling anxious.
7. Is heart rate slower or faster than average in this patient? Why? Which autonomic receptors are involved with this change in heart rate?
8. Is blood pressure likely to be lower or higher than average in this patient? Why? Which autonomic receptors are involved with this change in blood pressure?
9. Describe the mechanism of excessive sweating in the patient. What autonomic receptors are involved with this sweating?
10. Would you expect the patient’s pupils to be constricted or dilated when her other symptoms are at a peak? What is the clinical term used to describe this condition?
11. How does the duration and breadth of activity of the circulating catecholamines compare to that of neuronally released norepinephrine? Explain.
12. Explain how the beta-blocker propranolol may help to alleviate the physical symptoms associated with anxiety.
13. What is the difference between acute and chronic stress response?

**Part 4: Case study - Spinal cord injury and autonomic dysreflexia**

Autonomic dysreflexia is a life-threatening condition affecting patients with spinal cord lesions T6 level and above. A 51-year-old male with history of paraplegia due to C6 spinal cord injury (30 years prior) presented with recurrent debilitating episodic of excessive sweating, hypertension, low body temperature, and bradycardia. Previous hospitalizations presumed sepsis from urinary tract infection to be the etiology; however, on further evaluation his symptoms were consistent with undiagnosed autonomic dysreflexia.

***Questions for home preparation (group 4):***

1. Which part of the autonomic nervous system is over-activated in this patient?
2. What would be the heart rate of this patient? Slower or faster? Why? Explain.
3. What are the most pronounced symptoms?
4. What pathophysiological mechanisms lead to these symptoms?
5. What other diseases might show similar symptoms?

**Bonus task**

Chronic stress accompanied by long time activation of the sympathetic nervous system can lead to many secondary health issues, such as dysfunction of the immune system, digestion problems, high blood pressure, etc.. This can be prevented by several ways – either by avoiding stress caused for example by overwork, which is often not possible; or by learning how to attenuate the effects of chronic stress on your health by increasing the parasympathetic function. These techniques are very popular nowadays and often used.

***Questions for home preparation (max 3 students):***

1. In which way is it possible to actively increase the parasympathetic function in our body?
2. How do these techniques work? Explain the mechanism.
3. When would you use these techniques?