EDITORIAL

PHYSIOLOGY OF AFFERENT AND CENTRAL PARTS OF AUTONOMIC NERVOUS SYSTEM

Tehseen Iqbal

RYK Medical College, Rahim Yar Khan

The Autonomic Nervous System (ANS) and the endocrine system control the internal environment of the body. The organization of the ANS is on the basis of the reflex arc. Changes in chemical composition, blood pressure, osmotic pressure, stretch in viscera, and temperature are detected by autonomic receptors. The visceral afferent fibres are myelinated and they accompany the visceral motor fibres. The sensory autonomic neurons are pseudo-unipolar cells located in the dorsal root ganglia of somatic spinal nerves. Once the afferent fibres gain entrance to the spinal cord or the brainstem, they are thought to travel alongside the somatic afferent fibres to the autonomic centres in different parts of the brain. Information reaches the higher autonomic centres from viscera through an ascending system that involves the nucleus tractus solitarius, the parabrachial nucleus, the periaqueductal gray matter, and the hypothalamus. The hypothalamic paraventricular nucleus, pontine A5 cell group, rostral ventrolateral medulla, and medullary raphe nuclei send direct output to the preganglionic autonomic neurons. The amygdala, mesencephalic periaqueductal gray, caudal ventrolateral medulla, nucleus of the tractus solitarius, and medullary lateral tegmental field feed into these direct pathways.

Keywords: Autonomic stimuli, autonomic receptors, nucleus tractus solitarius, hypothalamus

Pak J Physiol 2023;19(4):1–2

The new integrated modular curriculum of University of Health Sciences (UHS) has included the autonomic nervous system (ANS) in the foundation module of the 1st Year class while anatomy of the nervous system and physiology of the somatic nervous system is placed in the 2nd Year MBBS. All senior physiologists agree that ANS is to be taught after the discussion of the somatic nervous system. This is a natural progression of developing a clear concept of the nervous system. Many physiology books describe only the efferent part of the ANS or the autonomic outflows only, and so students cannot comprehend the overall architecture of the autonomic nervous system. It is advantageous to describe our nervous system (including ANS) on the basis of a reflex arc[1], as reflex arc is usually discussed in the premedical classes.

The ANS and endocrine system control the internal environment of the body (homeostasis) and behaviour. The ANS has an afferent limb, efferent limb, and a central integrating system. The afferent component of the autonomic nervous system is identical to the afferent component of the somatic sensory system, and it forms part of the general afferent segment of the entire nervous system. A modern definition of the ANS takes into account visceral afferent pathways, several forebrain and brainstem regions as well as the descending pathways that activate the preganglionic sympathetic and parasympathetic neurons.[2] Because much of the actions of ANS relate to control of the viscera, it is sometimes called the visceral nervous system. The enteric nervous system is also considered part of the ANS.[3] For convenience of our students and teachers, physiological and anatomical aspects of afferent and central parts of the ANS are discussed here.

Stimuli and Autonomic sensory receptors

Chemical changes like arterial oxygen concentration, blood carbon dioxide concentration are detected by chemoreceptors in aortic and carotid bodies. For blood glucose, amino acids, fatty acids, chemoreceptors are in the hypothalamus. Blood pressure changes are detected by baroreceptors present in arch of aorta and carotid sinus. Stretch or mechanical distension in viscera is detected by mechanoreceptors or stretch receptors, e.g., in the urinary bladder or intestines etc. Temperature change in the body is detected by thermoreceptors present in the skin and hypothalamus. Change in osmolality of extracellular fluid is detected by osmoreceptors present in the hypothalamus. Change in H^+ concentration is detected by chemoreceptors present in carotid bodies and medulla oblongata. Although the brain receives such information and utilizes this information for regulatory purposes, we are not consciously aware of these stimuli.[2,3,5] These autonomic sensory receptors should not be confused with the autonomic receptors on the autonomic effectors which are called adrenergic and cholinergic receptors.

Autonomic afferent pathways

General visceral afferent fibres from viscera and blood vessels accompany their efferent counterparts, and are the peripheral processes of neuronal cell bodies located in the sensory ganglia of some cranial nerves and in spinal dorsal root ganglia.[4] The visceral afferent fibres are myelinated fibres and they supply information that originates from autonomic sensory receptors in the viscera. Their peripheral axonal branch extends to one of the viscera and a central axonal branch enters the CNS.[3] Sympathetic (Thoracolumbar) afferent myelinated nerve fibres travel from the viscera through the sympathetic ganglia without synapsing. They pass to spinal nerve via white rami communicantes and reach their cell bodies in dorsal root ganglia of corresponding spinal nerves. The central axons then enter the spinal cord and may form afferent component of a local reflex arc and ascend in spinothalamic tracts to higher centers, such as hypothalamus. Parasympathetic (Craniosacral) afferent myelinated nerve fibres travel from viscera in the head and neck region to their cell bodies, located in the sensory ganglia of the cranial nerves III, VII, IX and X and so to the brain stem. From the pelvic organs to the posterior root ganglia of the Sacro-spinal S2, S3, and S4 nerves. The central axons then enter the CNS and take part in the formation of local reflex arcs, and pass through spinothalamic tracts to higher centers of the ANS, such as the hypothalamus. Once the afferent fibres gain entrance to spinal cord or brainstem, they are thought to travel alongside, or mixed with somatic afferent fibres to autonomic centers in different parts of the brain. Information reaches the higher autonomic centres from viscera through an ascending system that involves the nucleus tractus solitarius, parabrachial nucleus, periaqueductal gray matter, and hypothalamus.[5]

Autonomic control centres in CNS

The hypothalamic paraventricular nucleus, pontine A5 cell group, rostral ventrolateral medulla, and medullary raphe nuclei send direct output to preganglionic autonomic neurons. The amygdala, mesencephalic periaqueductal gray, caudal ventrolateral medulla, nucleus of tractus solitarius, and medullary lateral tegmental field feed into these direct pathways. The rostral ventrolateral medulla is generally considered the major source of excitatory input to preganglionic sympathetic neurons in intermediolateral nuclei of spinal cord.[2,3]

Descending Autonomic Pathways

The pathways that influence preganglionic autonomic neuronal activity include spinal cord and brainstem reflex pathways, as well as descending control systems originating at higher levels of nervous system, such as hypothalamus. The hypothalamus and its closely allied structures send output signals to brain stem, mainly into reticular areas of mesencephalon, pons, and medulla, and from these areas into peripheral nerves of ANS.[6] Pathways that control preganglionic neurons in the intermediolateral nuclei of spinal cord include direct projections from hypothalamic paraventricular nucleus, pontine catecholaminergic A5 cell group, rostral ventrolateral medulla, and medullary raphe nuclei. Many brain regions feed into these direct pathways which include amygdala, mesencephalic periaqueductal gray, caudal ventrolateral medulla, nucleus of tractus solitarius, and medullary lateral tegmental field. The rostral ventrolateral medulla is generally considered the major source of excitatory input to preganglionic sympathetic neurons.[2–5]

Autonomic Reflexes

Visceral sensory and autonomic neurons participate in visceral reflex arcs. These reflexes are pupillary light reflexes (Direct and Consensual), sneeze and cough reflexes, baroreceptor and chemoreceptor reflexes, micturition and defecation reflexes, etc. In some peripheral reflexes, branches from visceral sensory fibres synapse with postganglionic motor neurons within sympathetic ganglia. Complete three neuron reflex arcs (with small sensory, motor, and intrinsic neurons) exist entirely within the wall of digestive tube; these neurons are part of enteric nervous system.[2,3,6]

Can we consciously control our ANS?

Although autonomic nervous system mostly acts at subconscious level, two examples of perceived visceral sensations are pain sensations from damaged viscera and angina pectoris from inadequate blood flow to heart.[2] Though the ANS is not considered to be under direct voluntary control, some people can exert some conscious control over some autonomic functions by developing control over their thoughts and emotions. For example, feelings of extreme calm achieved during meditation[7] are associated with cerebral cortex influence on parasympathetic centres in hypothalamus via various limbic structures. Voluntary sympathetic activation can occur when people decide to recall a frightful experience; in this case the cerebral cortex acts through the amygdala.

REFERENCES

1. Bankenahally R, Krovvidi H. Autonomic nervous system: anatomy, physiology, and relevance in anaesthesia and critical care medicine. BJA Educ 2016;16(11):381–7.
2. Autonomic Nervous System. In: Barrett KE, Barman SM, Boitano S, Brooks HL. (Eds.) Ganong's Review of Medical Physiology (25th ed.). McGraw-Hill Education; 2016.
3. Berne RM, Levy MN. Autonomic Nervous System. In: Medical Physiology (8th ed.). Philadelphia PA: Elsevier; 2018.
4. Autonomic Nervous System. In: Gray's Anatomy; The Anatomical Basis of Clinical Practice. (42nd ed.). Elsevier Limited; 2020.p 394–5.
5. Snell RS, Splittgerber R. Autonomic Nervous System. In: Snell's Clinical Neuroanatomy. (8th ed.). Wolters Kluwer/Lippincott Williams & Wilkins; 2019.
6. Hall JE, Hall ME. Autonomic Nervous System. In: Guyton & Hall Textbook of Medical Physiology (14th ed.). Elsevier; 2021.
7. Chaya MS, Nagendra HR. Long-term effect of yogic practices on diurnal metabolic rates of healthy subjects. Int J Yoga 2008;1(1):27–32.

Address for Correspondence:

Prof Dr Tehseen Iqbal, Head of Physiology Department and Vice Principal, RYK Medical College, Rahim Yar Khan, Pakistan. **Cell:** +92-333-6144799

Email: prof.tehseeniqbal@gmail.com

Received: 30 Dec 2023 **Reviewed:** 31 Dec 2023 **Accepted:** 31 Dec 2023

Conflict of Interest: No conflict of interest declared **Funding:** None