Chapter 5
Neural Control of the Laryngopharynx

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The Laryngopharynx and the Vagus Nerve

The laryngopharynx, including the hypopharynx, is a cavity that is part of the pharynx. It acts as a point of division between the larynx and esophagus and is a crucial structural component that allows swallowing of food and water as well as the production of speech. Its main structures include the posterior pharyngeal wall, pyriform sinuses, and post-cricoid area [1].

The laryngopharynx is innervated by the vagus nerve (also referred to as cranial nerve X or the vagal nerve) [2]. The vagus nerve is a significant physiological component of the parasympathetic nervous system [3]. It is the tenth of 12 pairs of cranial nerves that originate in the brain and pass through apertures in the skull to supply sense organs and muscles of the head, neck, and viscera [4, 5]. The vagus nerve contains both afferent and efferent fibers. The efferent fibers originate from motor neurons of the vagus nerve, which have their cell bodies in the medullary

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nuclei and carry neural impulses from the central nervous system to different muscles in the human body for movement production. Afferent fibers of the vagus nerve originate from sensory neurons, which have their cell bodies in the vagus nerve ganglia, and carry neural impulses from sensory organs to the central nervous system. These signals travel to the thalamus, which further projects to the cortex.

The vagus nerve is the longest and most widely distributed of the cranial nerves and is unique in its asymmetrical structure. It is comprised of several branches that spread extensively throughout the face, thorax, and abdomen to supply the laryngopharynx, larynx, ear, epiglottis, tongue, trachea, bronchi, heart, and gastrointestinal tract [5]. In this chapter, we will focus on the branches of the vagus nerve innervating the neck that are important for the function of the laryngopharynx. These branches include the superior laryngeal nerve, recurrent laryngeal nerve, and pharyngeal nerve [6, 7]. These nerve fibers originate in different nuclei within the medulla and can be motor, sensory, and secretomotor [8]. We will first provide an overview of the structure and function of pertinent nuclei in the medulla. Then, we will examine the neural pathways of the three vagus nerve branches present, from their origins in the medulla to their presence in the vagus ganglia.

Vagus Nerve Nuclei

The fibers that comprise the vagus nerve have endings in different nuclei within the medulla. These nuclei include the dorsal motor nucleus, nucleus solitarius, nucleus ambiguus, and the spinal trigeminal nucleus. Each of these nuclei is a paired, bilateral, and symmetrical structure located in the vagal complex of the medulla oblongata [9].

Dorsal Motor Nucleus

The dorsal motor nucleus is located in the dorsomedial caudal part of the medulla which is a general visceral, motor, and sensory mixed center [9, 10]. It sends parasympathetic signals to the viscera, heart, bronchi, and alimentary tract via general visceral efferent fibers and receives sensory signals from the larynx, lungs, pharynx, heart, and alimentary tract. The dorsal motor nucleus also receives input from the brainstem and higher brain regions, including reticular formation, nucleus solitarius, hypothalamus, and olfactory system.

Solitary Tract Nucleus (Nucleus of the Tractus Solitarius)

The solitary tract nucleus is a vertical agglomeration of sensory nuclei embedded in the dorsomedial medulla. It serves as a primary sensory recipient of sensorimotor, viscerosensory, autonomic, and gustatory inputs. The nucleus is intersected by the solitary tract, which expands longitudinally through the medulla and is composed of fibers from the glossopharyngeal, facial, and vagus nerves [11]. The solitary tract nucleus receives sensory information from mechano- and chemoreceptors in the peripheral nervous system and is responsible for the gastrointestinal, cardiovascular, and respiratory functions [12]. After these reflexes have been initiated, signals are sent to other medullary nuclei to coordinate the action of emesis.

Additionally, the solitary tract nucleus receives information from other peripheral nerves, brainstem structures, spinal cord, and cerebellar structures. The solitary tract nucleus projects to the central nucleus of the amygdala, hippocampus, thalamus, nucleus accumbens, and the bed nucleus of stria terminalis [13]. These connections provide the solitary tract nucleus with direct influence over higher autonomic systems, the amygdala-hippocampus-entorhinal cortex pathway of the limbic system, and extrapyramidal motor systems [14, 15].

Nucleus Ambiguus

The nucleus ambiguus is located in the medullary reticular formation and contributes to the efferent portion of the vagus and glossopharyngeal nerves. The nucleus ambiguus provides motor innervation to the pharynx, palate, and larynx for phonation and swallowing [16, 17].

Spinal Trigeminal Nucleus

The spinal trigeminal nucleus is located in the dorsal pons and receives sensory information regarding deep touch, temperature, and pain from the ear, the posterior cranial fossa, and the mucosa of the larynx [16]. It is a minor contributor to the vagus nerve and receives information from the trigeminal, facial, and glossopharyngeal nerves. The spinal trigeminal nucleus projects to the medial thalamus [18].

Cranial Nerve Fibers

There are seven types of cranial nerve fibers that project from nuclei within the medulla. These fibers include general visceral efferents and afferents, special visceral efferents and afferents, and somatic efferents and afferents [19]. Of these seven types of nerve fibers, four are constituents of the vagus nerve: general somatic afferents, general visceral afferents and efferents, and special visceral efferents [18].

The general somatic afferent fibers of the vagus nerve receive sensory information from the pharynx, larynx, trachea, esophagus, external auditory meatus, and auricle [18, 20, 21]. The fibers have their cell bodies in the superior ganglion. Signals travel up through the jugular foramen to the spinal trigeminal nucleus [16, 21].

General visceral afferent fibers relay pain or reflex sensations. They also transmit sensory information from the pharynx, larynx, trachea, esophagus, heart, lungs, stomach, and thoracoabdominal viscera down to the splenic flexure, aortic arch baroreceptors, and aortic body. Information in the vagus transmitted by way of general visceral afferent fibers relays to the solitary tract nucleus through the nodose ganglion [16, 20–22].

General visceral efferent fibers originate in the dorsal motor vagal nucleus and are relevant to visceral autonomic innervation [16]. These fibers send parasympathetic signals to the lungs and heart and innervate gastrointestinal smooth muscles and glands [10]. They also deliver secretomotor innervation to pharyngeal and laryngeal mucosa, the ganglia in the walls of thoracic organs, and esophageal, hepatic, celiac, gastric, and celiac plexus [8, 20].

Special visceral efferent fibers, also called branchiomotor fibers, provide motor innervation for phonation and swallowing. They originate in the nucleus ambiguus, specifically supplying striated musculature of the soft palate, pharynx, larynx, and branchial arches via the vagus nerve [16, 20].

The Vagus Nerve Ganglia

The different nerve fibers emerge from each vagal nucleus at the postero-lateral sulcus and unite to form a single trunk at the lateral aspect of the medulla. This trunk leaves the skull through the jugular foramen [8]. The nerve forms two consecutive ganglia that are exclusively sensory and contain somatic, general visceral, and special visceral afferent neurons [18]. They are separated by the jugular foramen. These ganglia are bilateral structures that create the right and left vagus nerve and are considered part of the peripheral nervous system.

Superior (Jugular) Ganglion

The superior ganglion provides sensory innervation to the auricular and meningeal branches of the vagus nerve [10]. In doing so, the structure communicates with the glossopharyngeal nerve, accessory nerve, the sympathetic trunk, and the superior cervical sympathetic ganglion [18].

Inferior (Nodose) Ganglion

The inferior ganglion is larger than the superior ganglion and is located below the superior ganglion. It contains most of the visceral afferent cell bodies and provides innervation to the visceral branches. This structure communicates with the hypoglossal nerve, the superior sympathetic ganglion, and the loop between the first and second cervical nerves [10, 18].

Neck Branches of the Vagus Nerve

Recurrent Laryngeal Nerve

The recurrent laryngeal nerve contains sensory, motor, and autonomic fibers [23]. Specifically, the recurrent laryngeal nerve is comprised of special visceral efferents and general visceral afferents, and thus it receives innervation from the nucleus ambiguus and sends information from sensory stimuli to the nucleus solitarius. Special visceral afferent fibers innervate laryngeal muscles, while general visceral afferent fibers supply the subglottic mucosa [20, 24].

Superior Laryngeal Nerve

The superior laryngeal nerve is divided up into an internal and external branch. It is comprised of special visceral efferent and general visceral afferent fibers, meaning it receives innervation from the nucleus ambiguus and sends information from sensory stimuli to the nucleus solitarius, respectively. Special visceral efferent fibers comprise the external branch of the superior laryngeal nerve and innervate the cricothyroid muscle. General visceral afferent fibers comprise the internal branch and supply the supraglottic mucosa [20, 24].

Pharyngeal Branches

The pharyngeal branches of the vagus nerve supply the pharynx. They contain both sensory and motor fibers. These branches are made of special visceral efferent fibers and general visceral afferent fibers. Therefore, they receive innervation from the nucleus ambiguus and supply sensory information to the spinal trigeminal nucleus, respectively [18, 20, 25].

Superior Cardiac Nerve

The superior cardiac nerve supplies the heart. It is comprised of general visceral afferent fibers. Therefore, it sends information from sensory stimuli to the nucleus solitarius [18, 20].

Conflict of Interest No authors have any pertinent disclosures or conflicts of interest.

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