

= Recurrent laryngeal nerve =

The recurrent laryngeal nerve (RLN) is a branch of the vagus nerve (cranial nerve X) that supplies all the intrinsic muscles of the larynx , with the exception of the cricothyroid muscles . There are two recurrent laryngeal nerves , right and left , in the human body . The right and left nerves are not symmetrical , with the left nerve looping under the aortic arch , and the right nerve looping under the right subclavian artery then traveling upwards. They both travel alongside of the trachea . Additionally , the nerves are one of few nerves that follow a recurrent course , moving in the opposite direction to the nerve they branch from , a fact from which they gain their name .

The recurrent laryngeal nerves supply sensation to the larynx below the vocal cords , gives cardiac branches to the deep cardiac plexus , and branches to the trachea , esophagus and the inferior constrictor muscles . The posterior cricoarytenoid muscles , the only muscles that can open the vocal cords , are innervated by this nerve .

The recurrent laryngeal nerves are the nerves of the sixth pharyngeal arch . The existence of the recurrent laryngeal nerve was first documented by the physician Galen .

= = Structure = =

The recurrent laryngeal nerves branch from the vagus nerve , relative to which they get their names ; the term " recurrent " from Latin : re- (back) and currere (to run) , indicates they run in the opposite direction to the vagus nerves from which they branch . The vagus nerves run down into the thorax , and the recurrent laryngeal nerves run up to the larynx .

The vagus nerves , from which the recurrent laryngeal nerves branch , exit the skull at the jugular foramen and travel within the carotid sheath alongside the carotid arteries through the neck . The recurrent laryngeal nerves branch off the vagus , the left at the aortic arch , and the right at the right subclavian artery . The left RLN passes in front of the arch , and then wraps underneath and behind it . After branching , the nerves typically ascend in a groove at the junction of the trachea and esophagus . They then pass behind the posterior , middle part of the outer lobes of the thyroid gland and enter the larynx underneath the inferior constrictor muscle , passing into the larynx just posterior to the cricothyroid joint . The terminal branch is called the inferior laryngeal nerve .

Unlike the other nerves supplying the larynx , the right and left RLNs lack bilateral symmetry . The left RLN is longer than the right , because it crosses under the arch of the aorta at the ligamentum arteriosum .

= = = Nucleus = = =

The somatic motor fibers that innervate the laryngeal and pharyngeal muscles are located in the nucleus ambiguus and emerge from the medulla in the cranial root of the accessory nerve . Fibers cross over to and join the vagus nerve in the jugular foramen . Sensory cell bodies are located in the inferior jugular ganglion , and the fibers terminate in the solitary nucleus . Parasympathetic fibers to segments of the trachea and esophagus in the neck originate in the dorsal nucleus of the vagus nerve .

= = = Development = = =

During human and all vertebrate development , a series of pharyngeal arch pairs form in the developing embryo . These project forward from the back of the embryo towards the front of the face and neck . Each arch develops its own artery , nerve that controls a distinct muscle group , and skeletal tissue . The arches are numbered from 1 to 6 , with 1 being the arch closest to the head of the embryo , and the fifth arch only existing transiently .

Arches 4 and 6 produce the laryngeal cartilages . The nerve of the sixth arch becomes the recurrent laryngeal nerve . The nerve of the fourth arch gives rise to the superior laryngeal nerve . The arteries of the fourth arch , which project between the nerves of the fourth and sixth arches ,

become the left @-@ sided arch of the aorta and the right subclavian artery . The arteries of the sixth arch persists as the ductus arteriosus on the left , and is obliterated on the right .

After birth , the ductus arteriosus regresses to form the ligamentum arteriosum . During growth , these arteries descend into their ultimate positions in the chest , creating the elongated recurrent paths .

= = = Variation = = =

In roughly 1 out of every 100 ? 200 people , the right inferior laryngeal nerve is nonrecurrent , branching off the vagus nerve around the level of the cricoid cartilage . Typically , such a configuration is accompanied by variation in the arrangement of the major arteries in the chest ; most commonly , the right subclavian artery arises from the left side of the aorta and crosses behind the esophagus . A left nonrecurrent inferior laryngeal nerve is even more uncommon , requiring the aortic arch be on the right side , accompanied by an arterial variant which prevents the nerve from being drawn into the chest by the left subclavian .

In about four people out of five , there is a connecting branch between the inferior laryngeal nerve , a branch of the RLN , and the internal laryngeal nerve , a branch of the superior laryngeal nerve . This is commonly called the anastomosis of Galen (Latin : ansa galeni) , even though anastomosis usually refers to a blood vessel , and is one of several documented anastomosis between the two nerves .

As the recurrent nerve hooks around the subclavian artery or aorta , it gives off several branches . There is suspected variability in the configuration of these branches to the cardiac plexus , trachea , esophagus and inferior pharyngeal constrictor muscle .

= = Function = =

The recurrent laryngeal nerves control all intrinsic muscles of the larynx except for the cricothyroid muscle . These muscles act to open and close the vocal cords , and include the posterior cricoarytenoid muscles , the only muscle to open the vocal cords . The nerves supply muscles on the same side of the body , with the exception of the interarytenoid muscle , which is innervated from both sides .

The nerves also carry sensory information from the mucous membranes of the larynx below the lower surface of the vocal fold , as well as sensory , secretory and motor fibres to the cervical segments of the esophagus and the trachea .

= = Clinical significance = =

= = = Injury = = =

The recurrent laryngeal nerves may be injured as a result of trauma , during surgery , as a result of tumour spread , or due to other means . Injury to the recurrent laryngeal nerves can result in a weakened voice (hoarseness) or loss of voice (aphonia) and cause problems in the respiratory tract . Injury to the nerve may paralyze the posterior cricoarytenoid muscle on the same side . This is the sole muscle responsible for opening the vocal cords , and paralysis may cause difficulty breathing (dyspnea) during physical activity . Injury to both the right and left nerve may result in more serious damage , such as the inability to speak . Additional problems may emerge during healing , as nerve fibres that re @-@ anastomose may result in vocal cord motion impairment , uncoordinated movements of the vocal cord .

= = = Surgery = = =

The nerve receives close attention from surgeons since during neck surgery , especially thyroid and

parathyroid surgery , the nerve is at risk for injury . Nerve damage can be assessed by laryngoscopy , during which a stroboscopic light confirms the absence of movement in the affected side of the vocal cords . The right recurrent laryngeal nerve is more susceptible to damage during thyroid surgery because it is close to the bifurcation of the right inferior thyroid artery , variably passing in front of , behind , or between the branches . The nerve is permanently damaged in 0 @. @ 3 ? 3 % of thyroid surgery , and transiently in 3 ? 8 % of surgeries , and is one of the leading causes of medicolegal issues for surgeons .

= = = Tumors = = =

The RLN may be compressed by tumors . Studies have shown that 2 ? 18 % of lung cancer patients develop hoarseness because of recurrent laryngeal nerve compression , usually left @-@ sided . This is associated with worse outcomes , and when found as a presenting symptom , often indicates inoperable tumors . The nerve may be severed intentionally during lung cancer surgery in order to fully remove a tumor .

= = = Other disease = = =

In Ortner 's syndrome or cardiovocal syndrome , a rare cause of left recurrent laryngeal nerve palsy , expansion of structures within the heart or major blood vessels impinges upon the nerve , causing symptoms of unilateral nerve injury .

= = Other animals = =

Horses are subject to equine recurrent laryngeal neuropathy , a disease of the axons of the recurrent laryngeal nerves . The cause is not known , although a genetic predisposition is suspected . The length of the nerve is a factor since it is more common in larger horses , and the left side is affected almost exclusively . As the nerve cells die , there is a progressive paralysis of the larynx , causing the airway to collapse . The common presentation is a sound , ranging from a musical whistle to a harsh roar or heaving gasping noise (stertorous) , accompanied by worsening performance . The condition is incurable , but surgery can keep the airway open . Experiments with nerve grafts have been tried .

Although uncommon in dogs , bilateral recurrent laryngeal nerve disease may be the cause of wheezing (stridor) when middle @-@ aged dogs inhale .

In sauropod dinosaurs , the vertebrates with the longest necks , the total length of the vagus nerve and recurrent laryngeal nerve would have been up to 28 metres (92 ft) long in Supersaurus , but these would not be the longest neurons that ever existed : the neurons reaching the tip of the tail would have exceeded 30 metres (98 ft) .

= = = Evidence of evolution = = =

The extreme detour of the recurrent laryngeal nerves , about 4 @. @ 6 metres (15 ft) in the case of giraffes , is cited as evidence of evolution . The nerve 's route would have been direct in the fish @-@ like ancestors of modern tetrapods , traveling from the brain , past the heart , to the gills (as it does in modern fish) . Over the course of evolution , as the neck extended and the heart became lower in the body , the laryngeal nerve was caught on the wrong side of the heart . Natural selection gradually lengthened the nerve by tiny increments to accommodate , resulting in the circuitous route now observed .

= = History = =

Roman physician Galen demonstrated the nerve course and the clinical syndrome of recurrent laryngeal nerve paralysis , noting that pigs with the nerve severed were unable to squeal . Galen

named the nerve the recurrent nerve , and described the same effect in two human infants who had undergone surgery for goiter . In 1838 , five years before he would introduce the concept of homology to biology , anatomist Richard Owen reported upon the dissection of three giraffes , including a description of the full course of the left recurrent laryngeal nerve . Anatomists Andreas Vesalius and Thomas Willis described the nerve in what is now regarded as an anatomically standard description , and doctor Frank Lahey documented a way for its intraoperative identification during thyroid operations .