A VARIANT NERVE THAT MIMICS THE LEFT RECURRENT LARYNGEAL NERVE: A CASE STUDY IN HUMAN ANATOMY

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ABSTRACT

We describe a variant nerve in a human cadaver patient that parallels the course of the left recurrent laryngeal nerve (RLN). Like the normal left RLN, the variant nerve branches from the vagus nerve and wraps around the arch of the aorta, but it passes anterior and medial to the ligamentum arteriosum (= fetal ductus arteriosus) instead of behind it like the normal RLN. After recurring around the aorta, the variant nerve joins the esophageal plexus and also appears to connect to the cervical sympathetic chain. The bilaterally paired RLNs supply innervation not only to the larynx but also to the upper parts of the trachea and esophagus, in particular those parts derived from the 4^{th}-6^{th} pharyngeal arches. We hypothesize that in this case, some of the nerve fibers to the trachea and esophagus were pulled down into the torso by the 4^{th} embryonic aortic arch (= the arch of the aorta in adults), but passed cranial to the 6^{th} embryonic aortic arch (= fetal ductus arteriosus). From where it recurs around the aorta to join the esophageal plexus, the variant nerve is very similar to the pararecurrent nerve in dogs, so there is at least a partial precedent in another placental mammal. Understanding the relationships of the embryonic pharyngeal and aortic arches and their adult derivatives is crucial for correctly identifying the RLN, especially when imposter nerves, like the one documented here, are present.

INTRODUCTION

The recurrent laryngeal nerve is one of the most interesting gross structures in the human body. It is equally famous in evolutionary biology and in clinical practice. In an evolutionary context, the nerve is commonly referenced as an example of a morphological inefficiency caused by a developmental constraint (Berry and Hallam, 1986; Darwen and Yao, 1993; Forsdyke, 1993; Coyne, 2009; Dawkins, 2009; Kinsella and Marcus, 2009; Wedel, 2012). During early development, the nerves that link the brainstem to the 6th pharyngeal arches pass caudal to the embryonic aortic arches. When the head and the heart are separated by the formation of the neck later in development, the great vessels derived from the caudal aortic arches descend into the thorax. The nerves to the 6th pharyngeal arches are dragged along by these vessels and forced to assume a recurrent course back up the neck to their innervation targets in the pharynx and larynx; they are referred to recurrent laryngeal nerves (RLNs), or, less commonly, recurrent pharyngeal nerves. The long, inefficient pathway of the RLNs is present in all tetrapods, even long-necked taxa such as ostriches and giraffes (Owen, 1841), and it appears to be an unbreakable developmental constraint.

Clinically, physicians have known for two millennia that the RLNs must be identified and protected during thyroid surgery to avoid deinnervating the patient’s larynx (Kaplan et al., 2009). Despite this long history of knowledge and study, injury to the RLNs is still one of the most common complications from thyroid surgery. In a meta-analysis involving 16,448 operations and 29,998 RLNs at risk, Dralle et al. (2004: table 3) found permanent RLN paralysis in 0.84% of cases overall, and in 5%-25% of patients in certain subgroups and treatments. Even electromyographic monitoring of the RLN during surgery did not reduce the incidence of paralysis below 0.8%. Other recent studies have found similar incidences of RLN paralysis following thyroid surgery (e.g., Chan et al., 2008). The high rate of RLN injury even at the hands of competent, knowledgeable surgeons is a product of two factors: first, the delicacy of the RLNs themselves, which can experience physiological damage even if they are apparently intact at the gross level (Crile 1932), and second, the high frequency of extra-laryngeal branching as the RLN approaches the larynx (Sun et al., 2002; Yalcin et al., 2006, 2008), which led Cernea et al. (2009) to suggest that the RLN should be referred to as a plexus rather than a nerve.

Occasionally overlooked is the fact that the RLNs innervate not only the larynx but also other parts of the pharynx. In general, the portions of the pharynx that pass through the embryonic pharyngeal arches are innervated by the nerves that serve each pair of arches. The RLNs serve the 6th pharyngeal arches, so in addition to innervating much of the larynx, they also innervate the upper portions of both the esophagus and trachea (Kuo and Urma, 2006). Of the extra-laryngeal branches of the RLNs, branches to the esophagus are typically prominent (Sun et al., 2002; Yalcin et al., 2006, 2008),

Our goals in this work are to review the normal anatomy of the RLN, and to describe and illustrate a variation related to the RLN that we have not seen documented previously: a second large nerve on the left side that takes a recurrent course around the aorta, mirroring the path of the left RLN, albeit on the opposite side of the ligamentum arteriosum.

BACKGROUND

The earliest surviving description of the RLN comes from the 2nd century writings of the Roman physician Galen. To demonstrate the nerve's involvement in vocal activity, Galen famously exposed the RLNs in a live, squealing pig, and then severed both nerves, rendering the pig mute. In the 1500s, Vesalius produced the oldest surviving drawings that map out the course of RLN and its major branches. Throughout the post-Roman history of Western medicine, knowledgeable surgeons have attempted to avoid damage to the RLNs during thyroid surgery, thereby preserving their patients' voices (Kaplan et al., 2009).

The following description of the paths of the RLNs is based on Steinberg et al. (1986). The RLN originates from the vagus nerve (cranial nerve X). In the middle and lower part of the neck, the vagus nerve courses bilaterally alongside the common carotid artery and internal jugular vein, typically inside the posterior wall of the carotid sheath. On the right side, the right RLN branches from the vagus nerve at the level of the right subclavian artery. The right RLN loops below and around the proximal end of the right subclavian artery to ascend up the neck in the right tracheo-esophgeal groove. The right RLN may cross superficially, deep, or between the branches of the inferior thyroid artery as it proceeds superiorly. The left RLN arises lateral to the arch of the aorta, and passes below it lateral to the ligamentum arteriosum (= fetal ductus arteriosus), and ascends in the left tracheo-esophageal groove.

There are typically two divisions of the RLN: the cricopharyngeal nerve, which innervates part of the inferior pharyngeal constrictor muscle, and the laryngeal nerve, which innervates much of the larynx. The laryngeal branch of the RLN further divides into an anterior motor branch and a posterior sensory branch. The sensory branch supplies sensory filaments to the laryngeal mucosa below the vocal folds. Occasionally the sensory branch blends with the internal laryngeal nerve, itself a branch of the superior laryngeal nerve (SLN). If present, this interweaving of nerve fibers from the internal laryngeal nerve (SLN) and the laryngeal branch of the RLN is known as the ramus anastomoticus or Galen’s anastomosis (Sanders et al., 1993). Sanders et al. (1993) also found other, finer connections between the SLN and RLN, particularly in the area of the interarytenoid muscle, where fibers of both nerves form a tiny plexus.

The motor branches of the RLNs supply all of the intrinsic muscles of the larynx except the cricothyroids. In particular, the RLNs innervate the posterior cricoarytenoid muscles, which are the only muscles to abduct the vocal folds (Standring, 2008). Unilateral RLN palsy will cause hoarse speech, and if both RLNs are compromised, the patient will be left mute and may experience difficulty breathing since there will be no way to abduct the vocal folds, as Galen demonstrated to the elders of Rome by vivisecting a pig and severing its RLNs (Kaplan, et al. 2009). King and Gregg (1948) suggested that variant vocal cord paralysis could be explained by the presence of adductor (anterior) and abductor (posterior) branches of the recurrent laryngeal nerve. Furthermore, Nemiroff and Katz (1982) found that the posterior branches were frequently smaller than the anterior branches; this in turn increases the possibility that these smaller branches—which innervate the all-important posterior cricoarytenoid muscles—can be overlooked or inadvertently injured during thyroid surgery, potentially leading to transient or permanent vocal cord paralysis (Nemiroff and Katz, 1982). The small but crucial posterior branches of the RLN will be especially vulnerable if they originate outside the larynx; as early as 1948, King and Gregg noted that the branches of the RLN were relatively safe from surgical injury above the inferior margin of the thyroid cartilage.

The inferior thyroid artery is sometimes used as an anatomic landmark in search for the RLN (Sun et al., 2001), but this is problematic, because the relationship of the RLNs to the inferior thyroid arteries is so variable, not only from patient to patient but even between the left and right sides in a single individual. Reed (1943) reported that the right and left recurrent laryngeal nerve were alike in only 43 of 253 cadavers (17%). Reed also identified three possible paths for the RLN relative to the inferior thyroid artery: (a) superficial to the artery and its branches (18.6%), (b) deep to the artery and its branches (39.1%), and (c) between the branches of the artery (36.5%). Yalcxin (2006) and Bergman (2011) both found that the right RLN more commonly lies anterior or superficial to the inferior thyroid artery, whereas the left RLN frequently passes posterior or deep to the artery.

As noted in the Introduction, the RLNs also innervate portions of the esophagus and trachea. The development and innervation of the esophagus are complex; in the following summary we have drawn from the works of Goyal et al. (1999) and Kuo and Urma (2006). The esophageal plexus contains parasympathetic fibers from the vagus nerve and sympathetic fibers from the cervical and thoracic sympathetic trunks. Parasympathetic innervation comes from the nucleus ambiguous and dorsal motor nucleus of the vagus nerve. Both nuclei serve as the origin of the motor functions of the upper esophagus. The esophagus can be divided into three portions: cervical, thoracic, and abdominal. The cervical esophagus extends from the pharyngoesophageal junction to the suprasternal notch, and is bordered anteriorly by the trachea, posteriorly by the vertebral column, and laterally by the carotid sheaths. The upper portion of the esophagus consists of striated muscle, and is derived from mesenchyme of pharyngeal arches 4 and 6 (Kuo et al., 2006); the 5th arch is rudimentary in humans and has no known adult derivatives (O'Rahilly and Tucker, 1973). The middle and lower portions of the esophagus are smooth muscle, and are derived from the mesenchyme of somites surrounding the foregut. The upper esophageal sphincter is derived in part from the 6th pharyngeal arch, and it is therefore innervated by the RLNs, which serve that arch. The RLNs therefore supply the upper esophageal sphincter (in part) and the cervical portion of the esophagus, and the vagus nerves contribute to the esophageal plexus that innervates the remainder of the esophagus.

MATERIALS AND METHODS

The variant nerve described herein was discovered by the students at Table 30 in the Medical Gross Anatomy laboratory at Western University of Health Sciences in the fall of 2011, most of whom are now authors of this work. The cadaver patient is an 82-year-old male who died of adenocarcinoma of the pancreas, and whose remains were donated to the anatomy program at Western University of Health Sciences through the university's willed body program. All of the dissections were performed by the student authors, using standard surgical dissection tools. The work was reviewed and approved by the Institutional Review Board at Western University of Health Sciences (protocol 14/RFD/006).

RESULTS

Description

The variant nerve was discovered by the students at Table 30 in the Medical Gross Anatomy laboratory at Western University of Health Sciences in the fall of 2011, most of whom are now authors of this work. During a routine dissection of the heart and mediastinum of our cadaver patient, we noticed a large nerve that descended from the superior thorax to wrap around the aorta on its anterior aspect (Fig. 1). We will refer to this nerve herein as the variant nerve. The cadaver patient also had a variation in the branching of the great vessels near the heart: the left vertebral artery branched directly from the aortic arch, between the left common carotid and left subclavian arteries (Fig. 2). We identified this extra branch of the aortic arch as the vertebral artery based on subsequent dissections. Although the variant origin of the left vertebral artery is interesting in itself, it is fairly common and well-understood (Uchino et al., 2013) and is probably not related to the variant nerve.

The variant nerve branched from the vagus nerve above the level of the subclavian artery (Fig. 2). It wrapped around the aorta anteriorly and inferiorly, taking a similar course to that of the recurrent laryngeal nerve, with one important difference: whereas the recurrent laryngeal nerve passed posterior to the ligamentum arteriosum, the variant nerve passed medially to it and was not closely related to the ligament (Fig. 1, 2, and 3). As the variant nerve passed around the aorta, it contributed branches to the cardiac plexus (Fig. 3). Posterior to the aorta, the variant nerve contributed to and essentially disappeared within the dense and complex esophageal plexus (Fig. 4). At this point, it became impossible to trace all of the possible connections of the variant nerve, although at least one prominent strand of nervous tissue (highlighted in Fig. 4) connected the variant nerve to the stellate ganglion of the left cervical sympathetic chain. We were unable to detect any connections between the esophageal plexus and the larynx, so although the variant nerve did recur around the aorta, it probably did not supply any structures other than the esophagus and trachea.

In contrast to the variant nerve, the left recurrent laryngeal nerve passed mostly posterior to the esophageal plexus and appeared to share few connections with it (Fig. 4). We did not find any significant extralaryngeal branches of the left recurrent laryngeal nerve. Superiorly it passed posterior to the inferior thyroid artery before entering the larynx (Fig. 5). The branches of the left recurrent laryngeal nerve inside the larynx were normal and the ramus anastomoticus or Galen's anastomosis (between the recurrent laryngeal nerve and the internal branch of the superior laryngeal nerve) was not present on the left.

The right recurrent laryngeal nerve contributed many small branches to the esophagus, and passed anterior to the inferior thyroid artery before entering the larynx (Fig. 6). As on the left, we did not note any significant extralaryngeal divisions other than those to the esophagus. Inside the larynx, the right recurrent laryngeal nerve was joined with the internal laryngeal nerve to form Galen's anastomosis (Fig. 7).

DISCUSSION

Identity of the Variant Nerve

In the absence of neuronal tracing, any identification of the variant nerve can only be a hypothesis based on its gross anatomy. This necessarily tentative identification is subject to further test if similar patterns of nerves are found in living patients or laboratory organisms in the future.

Cardiac branches from the vagus nerve and cervical sympathetic trunk commonly course anteriorly over the aortic arch, medial to the left recurrent laryngeal nerve (see, e.g., Mizeres, 1963; Standring, 2008: fig. 56.20) or occasionally joined with it (Lemere, 1932). These cardiac nerves typically form a dense plexus on the anterior aspect of the aortic arch, with individual nerves that are quite small (< 1mm in diameter). One possibility is that our variant nerve is simply this group of cardiac nerves, fused into a single connective sheath instead of distributed into a plexus of many fine branches. This is unlikely to be a complete explanation, however, because a comparatively thick trunk of the variant nerve passed around the aorta and took a short recurrent course into the esophageal plexus (Figs. 3 and 4).

Proximally, the variant nerve was clearly connected to the vagus nerve, and first appeared to us a branch of the vagus nerve above the subclavian artery (Fig. 2). It also appeared to share a connection to the stellate ganglion of the cervical sympathetic chain—at least, a prominent band of nervous tissue connected the stellate ganglion to the portion of the variant nerve that wrapped around the aorta inferiorly (Fig. 4). Distally (i.e., closer to innervation targets) the variant nerve contributed to both the cardiac plexus (Fig. 3) and the esophageal plexus (Fig. 4). Given this pattern of connections, it is likely that the variant nerve carried both preganglionic parasympathetic fibers derived from the vagus nerve, and postganglionic sympathetic fibers from the stellate ganglion, to both the esophageal plexus and the cardiac plexus. The portion of the nerve that wrapped around the aorta inferiorly might have contained parasympathetic and sympathetic nerve fibers running in opposite directions—parasympathetic fibers from the vagus nerve to the esophageal plexus wrapping around the aorta from front to back, and sympathetic fibers from the cervical sympathetic chain to the cardiac plexus running around the aorta from back to front.

Although we have not found any previous reports of a similar division of the recurrent nerves to the pharynx from the rest of the RLN in humans, this division is present in dogs. Lemere (1932: p. 422) described it as follows:

> “In the dog, immediately after its origin, [the RLN] divides into the recurrent proper and what might be termed the pararecurrent. The first courses without

> interruption to the muscles of the larynx. The pararecurrent supplies the trachea, esophagus, and infracordal mucosa of the larynx posteriorly. In man, of course, this component remains within the recurrent. The pararecurrent may rarely be included in the recurrent in dogs, but it usually runs as a separate nerve or as a plexus."

This description and the accompanying illustration (Lemere 1932: fig. 1) match very closely the variant nerve documented here. It is interesting that Lemere (1932) found the pararecurrent nerve as a separate branch in most cases in dogs, but apparently blended with the RLN. The opposite situation apparently holds in humans, where normally the esophageal and tracheal branches remain with the RLN, but—at least in this case, and possibly in others not yet documented—they branch off as a separate, pararecurrent nerve. Possibly the pararecurrent nerve is a latent developmental possibility in most mammals, which is expressed at different frequencies in various mammalian lineages.

Developmental Basis

The upper part of the esophagus is derived from pharyngeal arches 4 and 6. In humans, these arches and their derivatives are innervated by the vagus nerve: the 4th arch is served by the superior laryngeal nerve and the pharyngeal plexus, the 5th arch is entirely resorbed and has no persistent derivatives, and the 6th arch is innervated by the recurrent laryngeal nerve (O'Rahilly and Tucker, 1973; Standring, 2008). In early development the pharyngeal arches are located just ventral to the brain and brainstem, and the nerves take a straight path from the central nervous system to the muscles, glands, and other innervation targets in the pharyngeal arches. At this early stage, the nerves that serve the pharyngeal arches become entwined with the embryonic aortic arches, which also serve the pharyngeal arches. Later in development the head and the heart are separated by the formation of the neck, and the heart and the great vessels descend into the thorax—specifically, the great vessels derived from the 4th and 6th aortic arches. When these vessels move down into the thorax, they drag along the nerves that serve the 6th arch. These nerves are forced to grow in length to maintain the connections between brainstem and the pharynx, and take on a recurrent course. These nerves serve all of the derivatives of the 6th pharyngeal arches, including not only the larynx and its muscles and mucosa but also the portions of the esophagus and trachea associated with the 6th arch. The name 'recurrent laryngeal nerve' does not reveal the full scope of the activities of this nerve, because it omits the innervation of the relevant portions of the esophagus and trachea. 'Recurrent pharyngeal nerve' would be more accurate, and indeed the nerve in question is occasionally referred to by that name, but mostly in older literature (e.g., Hooper, 1885; Messerklinger and Propst, 1953).

The function of the recurrent laryngeal nerve in innervating part of the esophagus is relevant to current case. In all humans and indeed in all vertebrates, we would expect that some of the neurons innervating the proximal third of the esophagus would be forced to take a recurrent course around the great vessels near the heart. Normally these neurons are bundled by connective tissue into the gross structure that we recognize as the recurrent laryngeal (or recurrent pharyngeal) nerve. On the right side, this can hardly fail to happen; the only remnant of embryonic aortic arches 4-6 is the right subclavian artery (4th arch), so there is one vascular 'hook' to pull the nerves to pharyngeal arches 4-6 down into the chest. But on the left, there are two such 'hooks': the arch of the aorta (4th embryonic arch), and the ductus arteriosus (6th arch).

So it is at least theoretically possible that vagal branches to portions of the pharynx other than those derived from the 6th arch could pass distal to the 4th embryonic aortic arch (= arch of the aorta in adults), but proximal to the 6th aortic arch (= ductus arteriosus, or ligamentum arteriosum in adults). We suspect that this happened in the current case; it seems to be the only explanation that is fully consistent with embryology that also explains all of the morphological features of the variant nerve.

Clinical Implications

The main clinical implication of the variant nerve documented here is that it is so large and its course is so similar to that of the left RLN that the two could potentially be confused. The variant nerve differs from the left RLN in three respects: (1) it branches from the vagus much farther superiorly, near the root of the neck, whereas the normal RLN branches from the vagus as the latter nerve passes the arch of the aorta; (2) the variant nerve passes anterior and medial to the ligamentum arteriosum, instead of behind it; and (3) the variant nerve apparently innervated only portions of the esophagus and trachea, but not the larynx, whereas the left RLN in this case served the larynx but had few connections to the esophageal plexus (in contrast to the numerous esophageal branches of the right RLN—see Figure 6). The number and fineness of the nerve fibers in the esophageal plexus on both sides (see Figures 4 and 6) should be of interest to all students of anatomy, especially surgeons.

Of the three visual criteria for distinguishing the variant nerve from the normal RLN, the relationship of the RLN to the ligamentum arteriosum is the most important, because it is apparently invariant. Non-recurrent inferior laryngeal nerves occur reasonably frequently on the right side, in 0.3%-1.6% of patients. Non-recurrent nerves on the left are much less frequent (0.04%), and they are always associated with situs inversus, in which the normal bilateral asymmetry of the internal organs is reversed from left to right (Toniato et al., 2004). In cases where the inferior laryngeal nerve is non-recurrent, it is always the case that the right subclavian artery (or left subclavian artery, in patients with situs inversus) is formed by a segmental branch from the descending aorta, distal to the contralateral subclavian artery. What this means is that the 4th embryonic aortic arch on the right side (or the left, in situs inversus) was completely resorbed during development, and there was no remaining vascular 'hook' to drag the inferior laryngeal nerve down into the torso (Henry et al., 1988). But even in these cases, the RLN that passes under the arch of the aorta and the ligamentum arteriosum (normally the left RLN, but the right RLN in situs inversus) is still present; there are no known cases of bilaterally non-recurrent inferior laryngeal nerves. Therefore the ligamentum arteriosum is the most crucial landmark for identifying the left RLN (or the right one, in situs inversus). This is particularly important in cases like the one documented here, in which an imposter nerve is also present and takes a recurrent course around the aorta, but not around the ligamentum arteriosum.

CONCLUSIONS

In this work we have shown that nerves to other portions of the pharynx (including for our purposes the esophagus and trachea) can also take a recurrent course around the aorta and visually mimic the RLN. In this case, the variant nerve could be distinguished from the normal RLN by its path anterior and medial to the ligamentum arteriosum, rather than posterior and lateral to it. Innervation to the esophagus is complex and involves both recurrent and nonrecurrent fibers of the vagus nerve. Normally the recurrent fibers to the larynx, esophagus, and trachea are all bundled into the RLNs, but in this case some may have passed caudal to the 4^{th} embryonic aortic arch (the arch of the aorta in adults) but proximal to the 6^{th} aortic arch (the ductus arteriosus, or ligamentum arteriosum in adults), producing the variant nerve. This variant nerve is very similar to the pararecurrent nerve of dogs, which also recurs around the great vessels to serve the esophagus and trachea. Despite almost 2000 years of study, the RLN remains a challenging structure for anatomists and surgeons because of its complexity, fragility, and variability.

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FIGURES AND FIGURE CAPTIONS

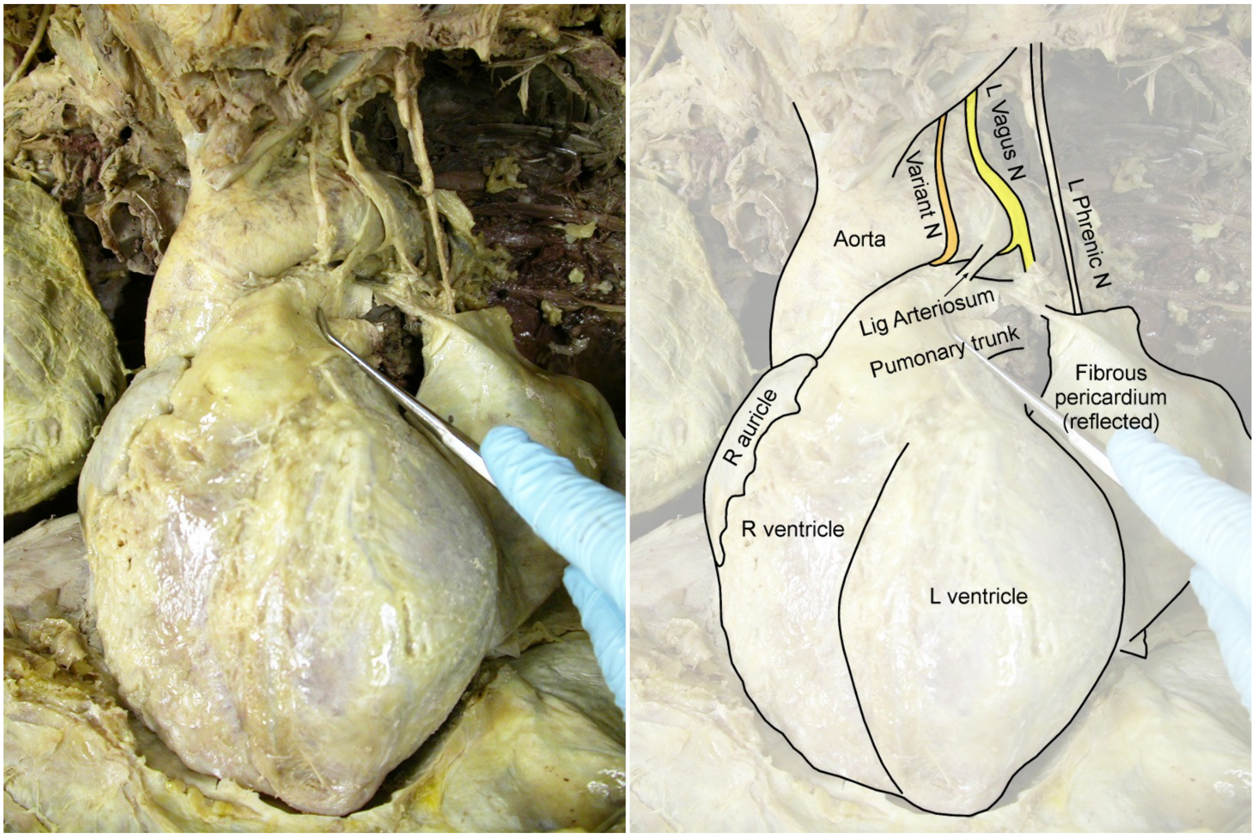

Figure 1: Discovery photo showing the variant nerve curving around the aorta.

Photograph in ventral view showing the relationship of the variant nerve (orange) to the left vagus nerve (yellow) and the great vessels. The left RLN is just visible branching from the vagus nerve and passing behind the ligamentum arteriosum. The lungs have been removed and the fibrous pericardium opened and laterally reflected.

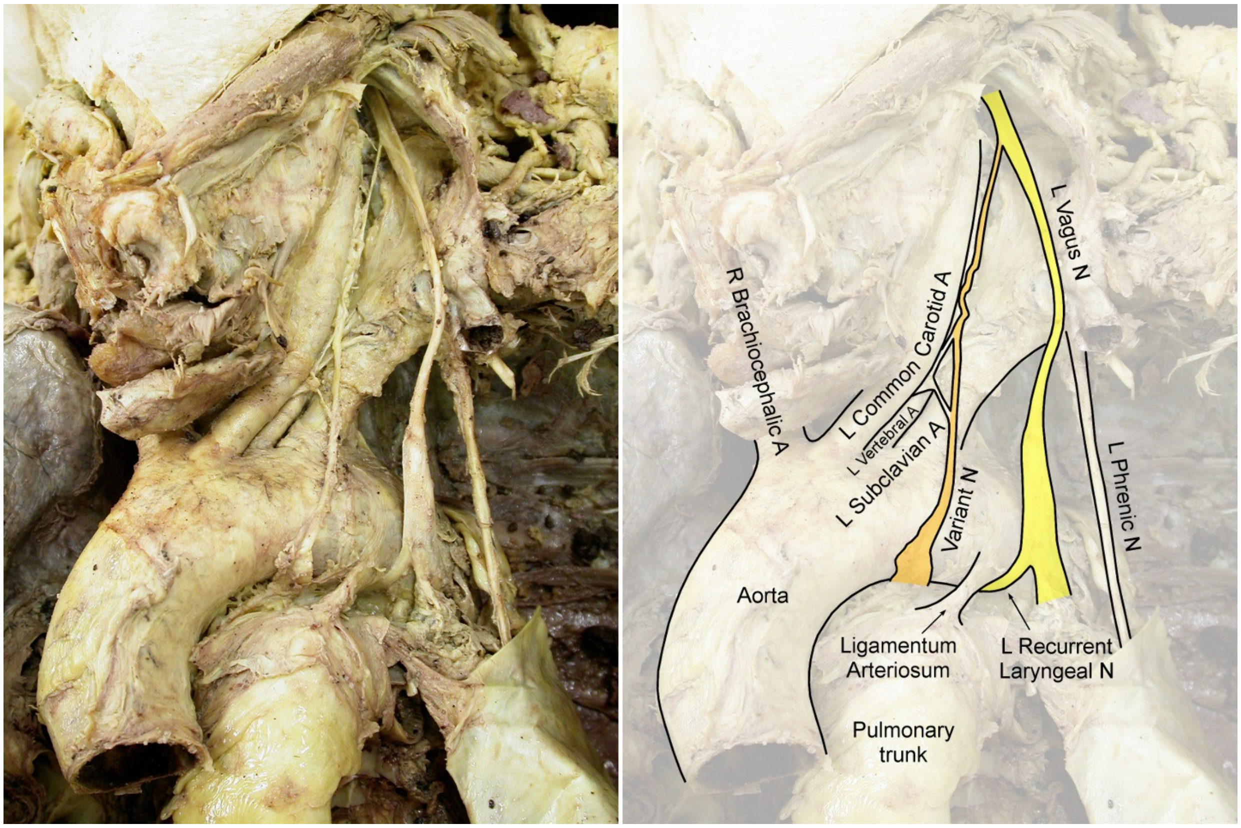

Figure 2: The arch of the aorta, the variant nerve, and the normal RLN. Photograph in ventral view showing the proximal connection of the variant nerve (orange) to the left vagus nerve (yellow). In addition to the variant nerve, a minor vascular anomaly is also visible: the left vertebral artery branches directly from the arch of the aorta, between the left common carotid and left subclavian arteries. The heart has been removed.

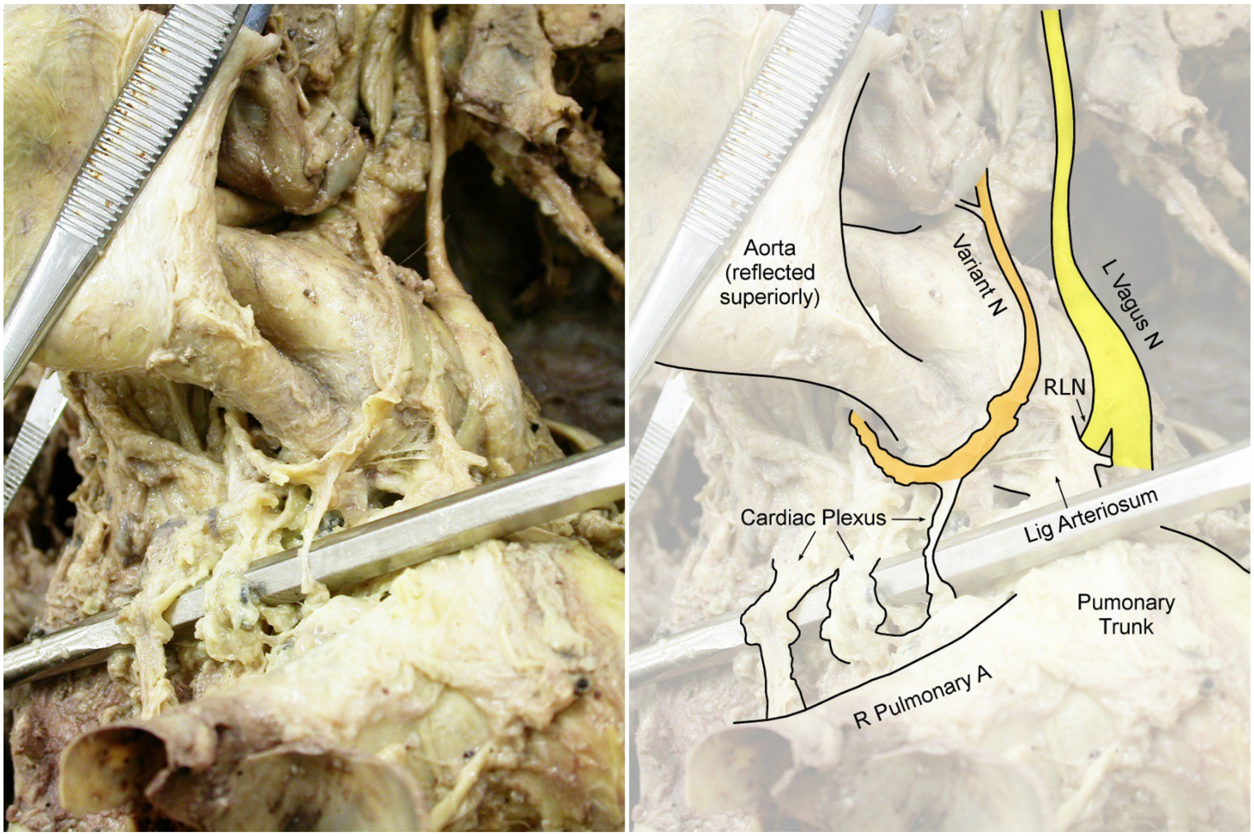

Figure 3: The recurrent course of the variant nerve around the aorta.

Photograph in ventral view with the aorta reflected upward to show the variant nerve wrapping around it. The probe is passing under nerve fibers of the cardiac plexus, at least one of which is originating from the variant nerve (in this and other figures, only the main trunk of the variant nerve is highlighted in orange in the interpretive diagram on the right).

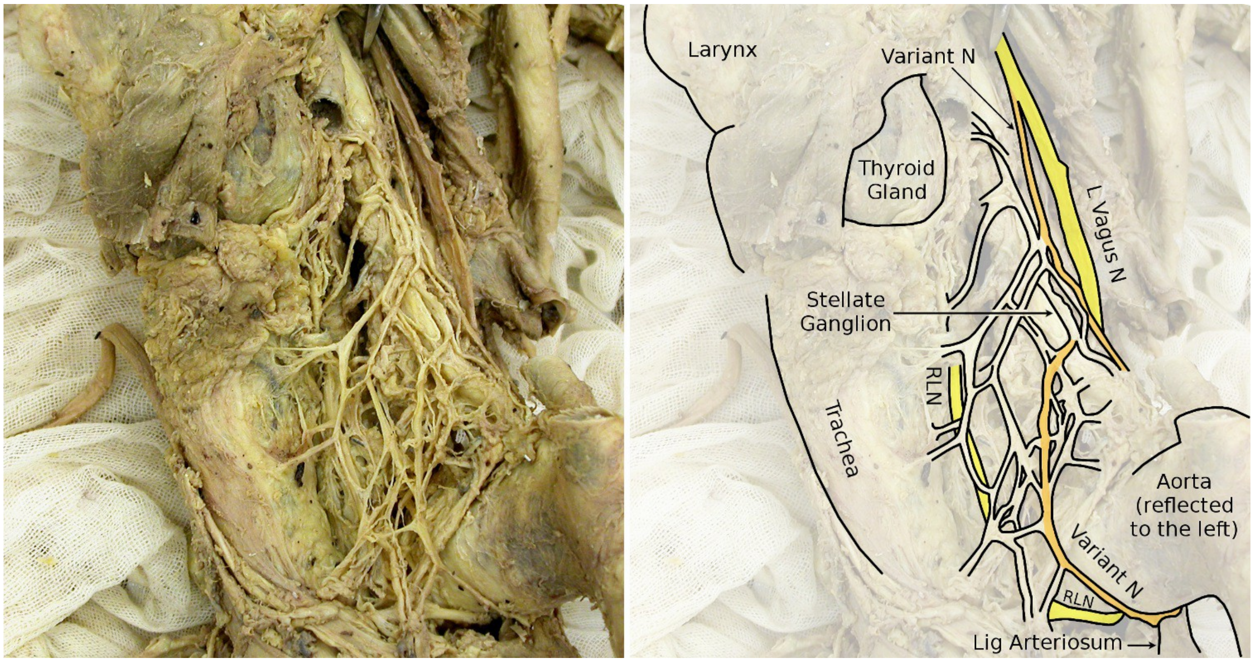

Figure 4: Connections of the variant nerve to the esophageal plexus.

Photograph of the root of the neck in left ventrolateral view showing the esophageal plexus. The variant nerve appears twice here: on the far right, descending from the left vagus nerve, and on the middle right, wrapping around the aorta to join the esophageal plexus. Also shown here is the connection of the variant nerve to the stellate ganglion (this pathway is highlighted in orange), and the normal left RLN (yellow) coursing behind the esophageal plexus on its ascending path to the larynx.

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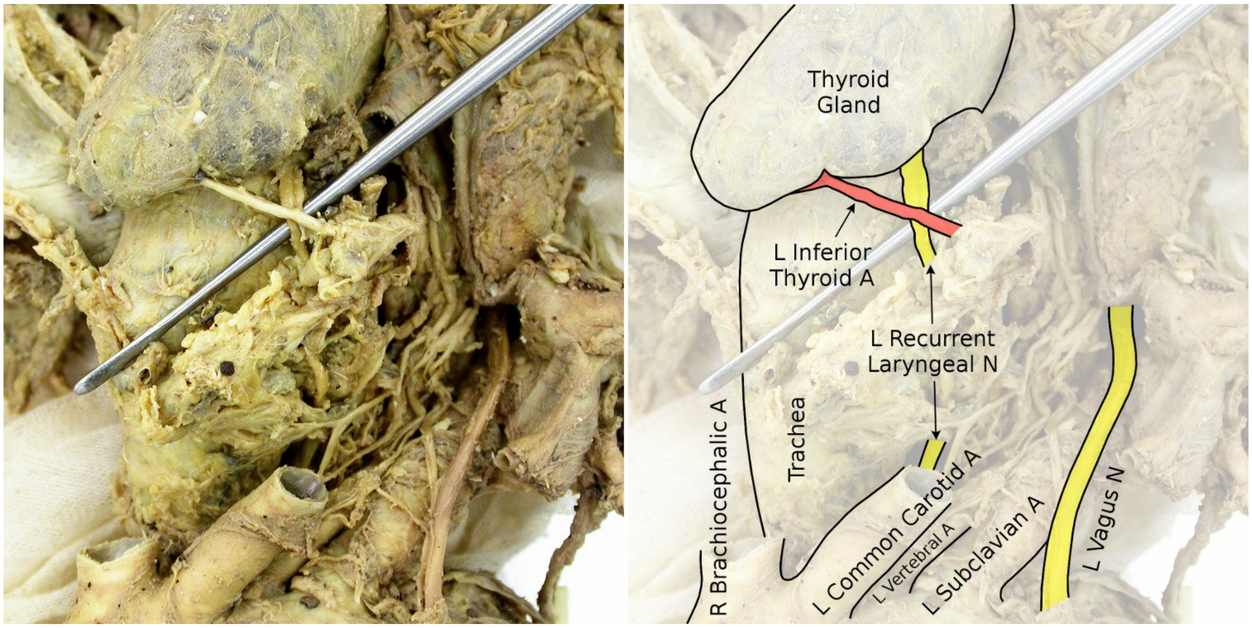

Figure 5: The left RLN passing behind the inferior thyroid artery.

Close-up photo of the root of the neck in left ventrolateral view. Compare the relationship of the artery and the nerve on the left, as shown here, with their reversed relationship on the right, shown in Fig. 6.

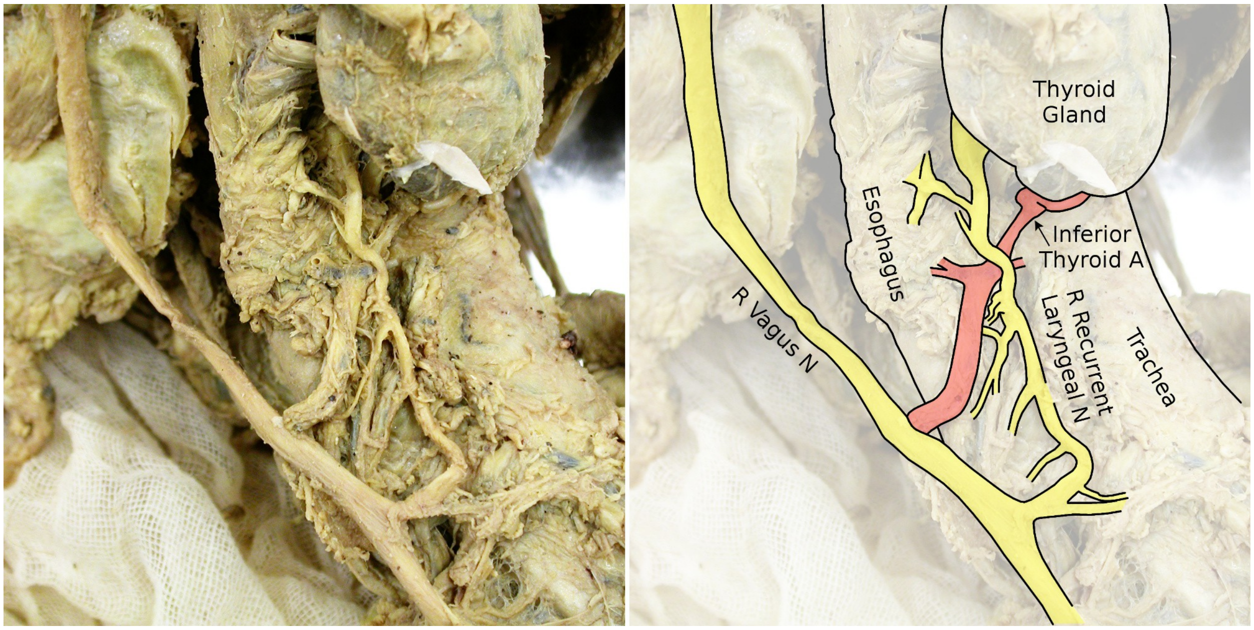

Figure 6: The course of the right RLN.

Close-up photo of the root of the neck in right ventrolateral view, showing the course of the right RLN from the right vagus nerve to the point where it passes behind the thyroid gland. The subclavian artery (which the right RLN wraps around before coursing superiorly) has been removed; originally it sat at the bottom of the U-shape formed by the right vagus nerve and right RLN. Note the numerous branches from the right RLN to the esophagus. Also note that on this side the RLN passes in front of the inferior thyroid artery, in contrast to their relationship on the left, shown in Fig. 5.

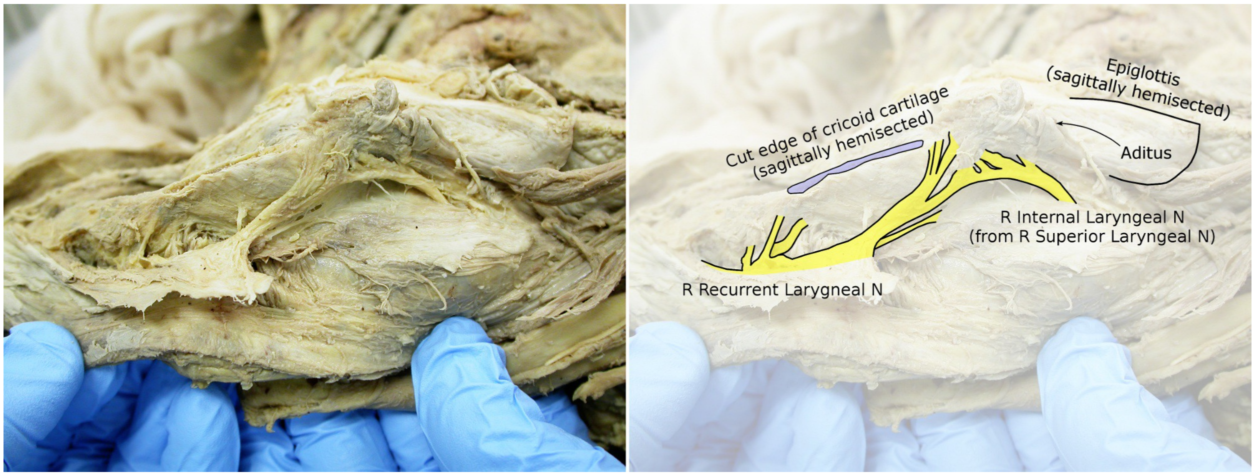

Figure 7: The anastomosis of Galen between the superior and recurrent laryngeal nerves on the right.

Close-up photo of the piriform recess inside the larynx in posterior view; superior is to the right. On the far right, the internal laryngeal nerve pierces the muscular wall of the larynx and enters the piriform recess, where its fibers become intertwined (middle) with those of the internal branch of the recurrent laryngeal nerve (left). This connection is known as the ramus anastomoticus or Galen's anastomosis. In this individual it was only present on the right side of the larynx; the left SLN and RLN did not share any visible connections.

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