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The clinical importance of the non-recurrent inferior laryngeal nerve

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Abstract

The importance of the recurrent laryngeal nerve to maintenance of the airway and for the production of voice has long been recognised. This fact is no more evident than during surgery of the head and neck where the recurrent nerve requires specific identification and preservation. This can be difficult in the rare instance of a non-recurrent nerve, which is at risk if not recognised early during the surgical dissection. This review discusses the embryological principles underlying development of a non-recurrent nerve and expands upon the clinical importance of this anatomical aberration during head and neck surgery.

Introduction

The importance of the inferior laryngeal nerve to the production of voice has been known since the second century A.D., when Galen demonstrated the effect of transecting the inferior laryngeal nerve in pigs. This resulted in functional laryngeal incompetence and a loss of phonation.(1) It is now known that the inferior laryngeal nerves supply most of the motor and sensory function of the larynx, and are essential for the production of voice.

The need to identify the inferior laryngeal nerve during thyroid and related surgery to prevent its injury is well established.(2) As part of this operative strategy it is essential for surgeons to be aware of the possibility of a non-recurrent inferior laryngeal nerve (nRLN) to allow its identification and preservation. This review will not only clarify nRLN embryology and anatomy, but will also expand upon the clinical strategies employed to avoid its injury during head and neck surgery.
Anatomy of the Recurrent Laryngeal Nerve

In its usual, recurrent form, the nerve originates from the vagal trunk and is consistent on both sides. From here however, the recurrent laryngeal nerve (RLN) maintains a distinctly different course between the right and left.

With the normal descent and formation of the heart and great vessels, the right RLN branches from the right vagus nerve at the level of the first or second thoracic vertebrae. It travels further inferiorly before coursing over and posterior to the right subclavian artery and ascends behind the right common carotid artery in the right tracheo-oesophageal groove. More superiorly, the right RLN becomes invested in the tracheo-oesophageal fascia.

The left RLN branches from the left vagus nerve in the thorax at the level of the fourth or fifth thoracic vertebrae; approximately at the level of the aortic arch. It travels over the anterior surface of the arch before looping around the ligamentum arteriosum and ascends supero-medially. Both nerves then travel to the larynx in close approximation to the tracheo-oesophageal groove and within the investing tracheo-oesophageal fascia.

As the recurrent nerves ascend, extra-laryngeal branches are given off to the deep part of the cardiac plexus as well as branches to the mucous membrane and muscular wall of the oesophagus and trachea. The right RLN is often described as coursing through the various branches of the right inferior thyroid artery and has an equal chance of being anterior or posterior to it. The left RLN is more often described as passing posterior to the left inferior thyroid artery, but can also be traced passing through the arterial branches as they supply the thyroid gland.
At the level of the upper border of the thyroid isthmus, the RLN often branches into an anterior motor branch and posterior sensory branch. The terminal portions of the RLN pass deep to the inferior constrictor and cricopharyngeas muscles in the region of the cricothyroid joint. It then enters the larynx and pharynx to supply the intrinsic laryngeal muscles (except for the cricothyroid muscle, which is supplied by the external laryngeal nerve) and provides a sensory component to the laryngeal mucosa below the vocal folds.

The anastomosis of Galen (ramus anastomoticus) is a connection between the posterior branch of the RLN with the internal branch of the superior laryngeal nerve (SLN) and is believed to be predominantly sensory and autonomic in function. It has been described in cadaveric dissections as consisting of a single communicating nerve, or alternatively as several branches which form a plexus of communicating fibres.

**Incidence of the Non-Recurrent Laryngeal Nerve**

The existence of the non-recurrent inferior laryngeal nerve (nRLN) was first described in the 19th century and was seen to pass straight from the vagus to the larynx. The nRLN is rare and most often seen on the right side. The incidence of clinically relevant nRLN identified during thyroid surgery has been found to be 0.3-1% in a number of large series. Left sided non-recurrent laryngeal nerves are exceptional, with a incidence of 0.04% reported in a single series of 4673 left sided thyroid and parathyroid operations.

**Anatomy of the Non-Recurrent Laryngeal Nerve**

The development of a non-recurrent laryngeal nerve can be explained by anomalies in embryonic development. The inferior laryngeal nerves are derived from the sixth aortic arch. In the case of the recurrent nerve, as the heart and great vessels descend during embryologic
life and the arches regress, the RLN is dragged down by the lowest persisting aortic arch; the subclavian artery on the right (fourth arch), and on the left the aortic arch and ductus arteriosus (sixth arch).

A nRLN can form on the right side, when an aberrant right subclavian artery (known as the *arteria lusoria*) is formed due to regression of the fourth right aortic arch. This regression means that the normal right subclavian artery does not develop, which allows the nerve to be undisplaced during development. The direct course from vagal trunk to larynx is therefore seen in such cases (Figure 1). An aberrant right subclavian artery is ultimately formed from the distal part of the right dorsal aorta and seventh segmental artery. This leads to an origin on the aortic arch at a point distal to the left subclavian artery. This aberrant right subclavian artery usually follows a retro-oesophageal or “lusoria” course to the right upper limb (Figure 2).(8)

A left nRLN is exceptional as it requires the development of three vascular anomalies during development. They include situs inversus viscerum (with the aortic arch on the right side), a left subclavian artery with a ‘lusoria’ course and the absence of the ductus arteriosus on the left side.(8,11)

Due to the exceptional nature of the left nRLN, most reports involve the right nerve. The right nRLN passes from the vagus in a direct course and passes behind the common carotid artery to the larynx. The origin is always cervical and can take place anywhere from the superior to the inferior pole of the thyroid.(8)
Three variations of the nRLN have been described depending on the take-off and relationship with the inferior thyroid artery: (9,10)

- **Type 1**: characterised by a high take-off from the vagus and descends into the larynx at the level of the superior thyroid pole along with vessels of the superior thyroid pedicle.
- **Type 2A**: arises from the cervical vagus at the level of the laryngo-tracheal junction and follows a transverse path parallel to, and over the trunk of the inferior thyroid artery, at the level of the isthmus (as seen in Figure 1).
- **Type 2B**: also arises from the vagus at the level of the laryngo-tracheal junction and follows a downward looping course to and under the trunk of inferior thyroid artery before it extends up to the usual laryngeal entry point.

Type 2A is the most common variant reported, occurring in 64-82% of reported series.(9,12)

A nRLN enters the larynx in a constant position; beneath the inferior constrictor muscles at the same level as seen with the usual recurrent nerve.(8) During its course, and as with the recurrent nerve, the nRLN can also give off collateral branches. In a series of 33 nRLN Henry et al. reported a bifurcation rate of 36%, which is comparable to rates of 34% reported for the RLN.(8,13) Further investigation of true recurrent nerve branches has shown that anterior fibres are generally motor, and posterior fibres are typically sensory.(13,14) As to whether or not this is consistent in the case of the nRLN is unknown. Regardless, all branches should be preserved in during surgical dissection to avoid any loss of laryngeal motor function.
**Coexisting non-recurrent and recurrent laryngeal nerves**

The presence of co-existing ipsilateral non-recurrent and recurrent laryngeal nerves has been reported in a number of operative series but remains controversial.(7,15,16) The presence of this abnormality is rare, with a reported incidence of 0.2-0.36% of right sided nerve dissections.(7,15)

Co-existing nerves have been reported on both on the right and left sides.(15) The presence of this abnormality is disputed however, as it has no clear embryological explanation and it has been suggested that some of these cases of co-existing nerves may be due to misidentification. Divisions of the sympathetic inferior laryngeal anastomotic branches may be misinterpreted as the laryngeal nerve.(11,17)

Similarly, the presence of non-recurrent nerves without associated vascular anomalies has also been reported. Again, the possibility of this combined anatomical aberration is questionable given the lack of an embryological basis for its cause.(11,18,19)

**Surgical significance and pre-operative diagnosis**

It is essential that surgeons are aware of the possibility of a nRLN, as its presence greatly increases the risk of injury during thyroid surgery. For instance, in a series of over 6000 thyroid operations, four of 31 patients (12.9%) with non-recurrent nerves sustained a persistent vocal cord palsy following surgery. This compared to 1.8% of patients with normal recurrent nerve anatomy.(9) In this series, only five of the patients were suspected pre-operatively to possess a non-recurrent nerve.
Pre-operative suspicion of a nRLN is the most effective way of avoiding injury. This knowledge allows the surgeon to adopt an alternative operative strategy that facilitates early identification of a laryngeal nerve which may not be travelling along its usual course. Historically, only a minority of patients with non-recurrent nerves have been suspected pre-operatively, which reflects the difficulty of identifying this important anatomical variation before surgery. An older series reported that 6-16% of patients with a nRLN were suspected pre-operatively.(8,9)

Unfortunately, there are few aspects of a patient’s history that may be a clue to the presence of a nRLN. For example, dysphagia may be a guide (due to the pressure of an aberrant losoria subclavian artery on the oesophagus), but these symptoms are unreliable and can be difficult to differentiate from complaints related to primary thyroid pathology; a large goitre for example.(8)

If identified early (ie. pre-operatively), the associated vascular anomalies are the best predictor of the possibility of a nRLN. Left non-recurrent nerves can be predicted by the presence of situs inversus viscerum (which can be detected by clinical examination and erect chest radiography), and right sided by the presence of an aberrant right subclavian artery.

There has been considerable interest in the use of ultrasound as a screening tool to identify the loss of the bifurcation of the brachiocephalic trunk, and the lack of the innominate artery which are both associated with an aberrant right subclavian artery.(20,21) Ultrasound has also been shown to be an effective non-invasive investigation to identify possible non-recurrent nerves. Huang et al. in a series using ultrasound preoperatively in 2330 patients, found thirteen suspected cases, of which eleven were confirmed cases of a nRLN at
surgery.(12) The increasing use and low cost of surgeon operated ultrasound makes this technique particularly attractive and has been shown to significantly decrease the rate of injury to the non-recurrent nerve generally.(11)

Other imaging modalities such as computed tomography and barium swallow have also been found to be useful in detecting aberrant right subclavian arteries.(22) However, given the low incidence of the nRLN it is not justifiable to perform such investigations routinely for patients undergoing thyroid, or other head/neck surgery. When performed for an alternative indication (eg. cancer staging), and where head or neck surgery is planned, these investigations should be examined carefully to confirm normal RLN anatomy.(20)

During surgery, intra-operative nerve monitoring of the inferior laryngeal nerve can also help identify a non-recurrent nerve due to differences in distal and proximal vagal stimulation. (23,24) As with all resections around the inferior laryngeal nerve however, it is important to remember the surgical dictum – ‘no structure passing medially from the carotid sheath (except the middle thyroid veins) should be divided until after the nerve is identified’. (7) During dissection, if the nerve cannot be identified, then the vagus must be identified, preserved and followed to look for a non-recurrent nerve.

**Conclusion**

Non-recurrence of the inferior laryngeal nerve is a rare but important clinical entity that nearly always occurs on the right side and is associated with an aberrant right subclavian artery. The rate of non-recurrent nerve injury is greater when it is not suspected and pre-operative suspicion is possible with the use of ultrasound. The greater awareness and
availability of surgeon-focused ultrasound will hopefully decrease the rate of non-recurrent nerve injury in the future.

References


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Figure Legends

**Figure 1:** computed tomography angiogram of an aberrant right subclavian artery in a patient found to have a right sided nRLN; incidental note is made of pathological aneurysmal dilatation at the origin of this aberrant vessel (LCCA: left common carotid artery; LSub.: left subclavian artery; RCCA: right common carotid artery; RSub.: right subclavian artery).

**Figure 2:** Type 2A variant of a right nRLN identified at the tip of surgical forceps; visualised at operation following a right thyroid lobectomy (RCCA: right common carotid artery).
Figure 1: Figure 1.TIF
Figure 2: Figure 2.TIF