

The recurrent laryngeal nerve does not usually lie within the tracheo-oesophageal groove

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ABSTRACT

Background: Traditionally, it has been taught that the recurrent laryngeal nerve (RLN) is anatomically located within the tracheo-oesophageal groove (TEG). However, a recent paper concluded that the RLN does not lie in the TEG. Notably, in this mentioned study, all data were taken intra-operatively in patients with pathological findings with a preponderance of thyromegaly or parathyroid disease.

Aim: Accurate identification of the RLN is essential during surgical management of neck disease as nerve injury carries significant disability. We sought to examine the course of the RLN in necks devoid of pathology, to define the true anatomical course of the nerve.

Materials and Methods: Neck dissections were performed on 26 cadavers, to expose a total of 52 RLNs. The angle of the RLN to the TEG was measured bilaterally in each neck. This was done by way of photography of each nerve in relation to the trachea, followed by digital measurement of the RLN: TEG angle (RTA). Any cases with neck pathology or previous surgery were excluded from this study.

Results: In only 3 cases, all found on the left side, did the RLN run within the TEG. One non recurrent laryngeal nerve was found and in all other 48 cases, the RLNs coursed cranially and medially toward the TEG with a mean RTA of 27.9 and 21.5° on the right and left sides respectively.

Conclusion: Our findings indicate that the RLN most often does not lie in the TEG but runs well lateral to it. Thus, during intraoperative neck dissection, in order to minimise RLN injury, the surgeon should expect to find the nerve well lateral to the TEG as it ascends to the cricothyroid joint.

Keywords: Anatomy of recurrent laryngeal nerve, recurrent laryngeal nerve, recurrent laryngeal nerve injury, tracheo-oesophageal groove

INTRODUCTION

Approximately 500 years ago, Vesalius published *De Humani Corporis Fabrica Libri Septem*, which translates into 'On the Fabric of the Human Body in Seven Books'.^[1] His illustrations depicted the recurrent laryngeal nerve (RLN)

ascending along the trachea bilaterally [Figure 1]. Centuries after Vesalius, surgical anatomy texts have propagated this information, which has become the current standard of teaching.

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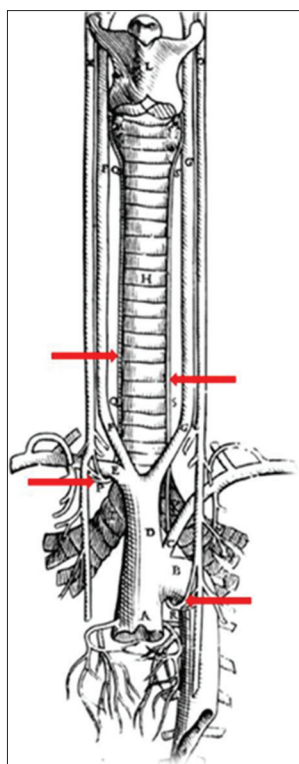


Figure 1: Illustration by Vesalius in 1543 of the courses of recurrent laryngeal nerves bilaterally, depicted by red arrows^[1]

The contemporary literature suggests that it often does not lie within the tracheo-oesophageal groove (TEG). This finding was highlighted by Naraynsingh *et al.* in 2022, who observed the course of the RLN during operations for thyroid and parathyroid indications alike.^[2] In this study, 41 nerves were observed, and their angles to the TEG were objectively measured. In only, one case was the RLN found to lie within the groove.

However, it can be argued that these findings could have been influenced by cervical pathology, which may have altered the native regional anatomy surrounding the nerves. Our prospective case series examined 26 neck dissections performed in patients without neck pathology to determine the normal course of 52 RLNs. Thus, the confounding factor of possibly altered anatomy does not apply to our cases.

METHODOLOGY

This prospective study was conducted at the Port of Spain General Hospital in Trinidad. Permission from the North West Regional Health Authority and ethical approval from The University of the West Indies were obtained (CREC-SA2564/03/2024). Consent from the deceased's next of kin was obtained for each case. All dissections were performed soon after death before formalin fixation.

The inclusion criteria for this study consisted of the body of a deceased patient who qualified for post-mortem investigation, along with verbal and signed consent from the next of kin of the deceased.

Exclusion criteria included patients who had known thyroid and parathyroid pathology, those found to have these pathologies or any native anatomical distortion incidentally at the time of autopsy. Cases in which a distorted neck anatomy was anticipated were also excluded from the study. Examples of these included patients with confirmed or suspected neck sepsis at the time of death.

After the first few post-mortem dissections, we adopted a 'Y-incision' for every case in lieu of the standard longitudinal incision conventionally performed during routine post-mortem at the institution. This approach allows for better exposure. In addition, compared with the longitudinal incision, it resulted in retaining the natural anatomical position of the structures within the neck without excessive retraction. Thus, the actual course and angle of the RLNs can be determined. Both dissection methods are shown in Figure 2a and b.

Following the skin incision, subcutaneous tissue and platysma within the superficial cervical fascia were incised and reflected along the neck strap muscles. The thyroid was then exposed and dissected out of the pretracheal fascia. The RLN was skeletonised on each side, and its course was revealed bilaterally. Images were taken parallel to the dissection plane, providing an accurate anteroposterior neck view with all structures visible. The same researcher performed all dissections.

Using computer software, a line drawn along the TEG and another along the RLN allowed objective measurement of the angle formed between the nerve and TEG. Two researchers performed the measurements individually to ensure accuracy.

RESULTS

Twenty-six neck dissections performed on fresh cadavers revealed 51 RLNs and one non-RLN (NRLN). This single case of NRLN was found on the right side of the neck [Figures 3 and 4]. The dashed line represents the TEG, whereas the RLN is a solid line [Figure 5]. Most RLNs were found outside the TEG, as shown in Figure 6. In most dissections, the RLN originated lateral to the TEG and then deviated medially as it ascended cranially towards its entrance into the larynx, forming the Recurrent Laryngeal Nerve: Traecho-oesophageal Groove Angle (RTA). The nerve coursed parallel to the TEG in a few specimens and then changed abruptly towards the laryngeal entrance [Figure 7]. One nerve coursed parallel and anterior to the TEG throughout its course and entered the larynx

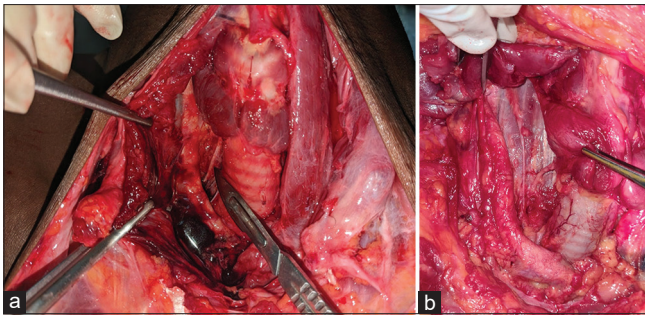


Figure 2: (a) A longitudinal incision was used to obtain the angle between the recurrent laryngeal nerve (RLN) and tracheo-oesophageal groove (TEG) bilaterally. (b) A Y-incision was made to obtain the course angle between the RLN and the TEG bilaterally, allowing for better exposure

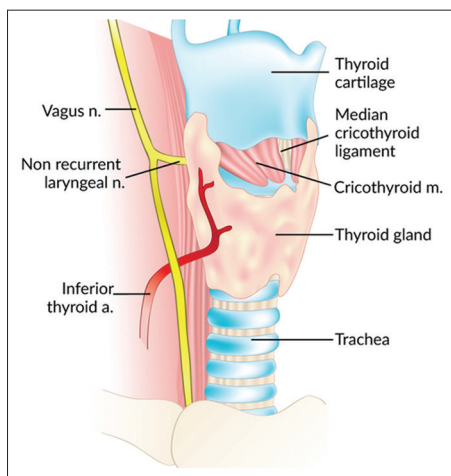


Figure 4: Non-recurrent laryngeal nerve^[3]

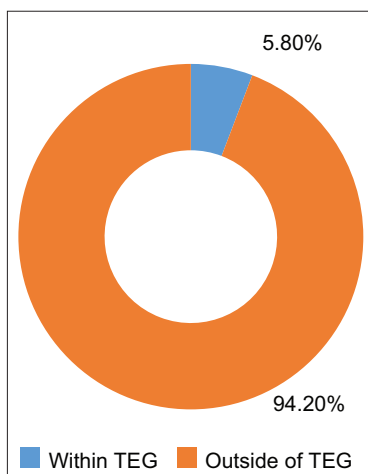


Figure 6: Percentage of recurrent laryngeal nerves found within and outside of tracheo-oesophageal groove. RLN: Recurrent laryngeal nerve, TEG: Tracheo-oesophageal groove

without a change in its angle [Figure 8]. On the right side, 25 nerves were found to have an RTA ranging between 9° and 65° with a mean of 27.9°. On the left side, three nerves were found within the TEG [Figures 9 and 10], and 23 were found



Figure 3: Non-recurrent laryngeal nerve dissection

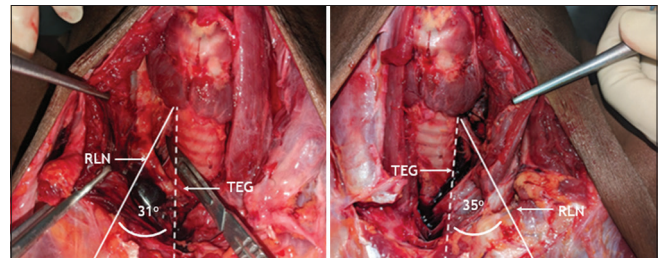


Figure 5: The tracheo oesophageal groove is outlined using a dashed line, and the recurrent laryngeal nerve is outlined using a solid line, allowing for RTA measurement between both straight lines. RTA is represented by a curved line. RTA: Recurrent laryngeal nerve to Tracheo-oesophageal groove Angle

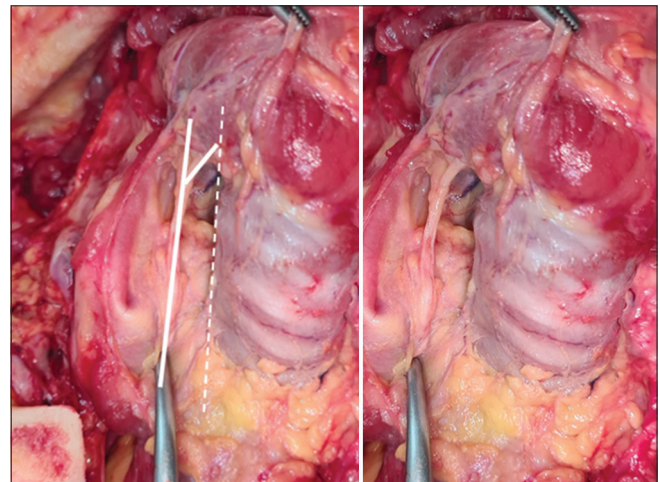


Figure 7: The parallel course of recurrent laryngeal nerve, highlighted by the solid line, with an abrupt change in direction of 34°, to meet the TEG highlighted by dashed line

at RTAs between 5° and 65° with a mean of 21.5°. Bifurcations of the RLN were noted in 32.7% of the dissections [Figure 11]. The percentage comparison between bifurcated nerves on the right and left is depicted graphically in Figure 12. Six branches were found in one specimen [Figure 13].

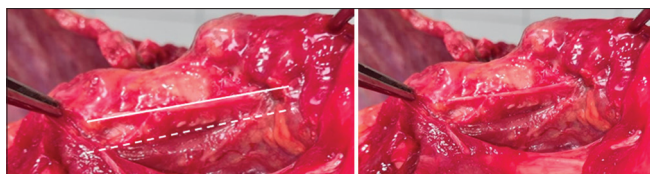


Figure 8: Left lateral view of the recurrent laryngeal nerve running parallel but anterior to the tracheo-oesophageal groove, entering the larynx without change in angle. Solid line represents Recurrent laryngeal nerve; Dashed line represents Tracheo-oesophageal groove

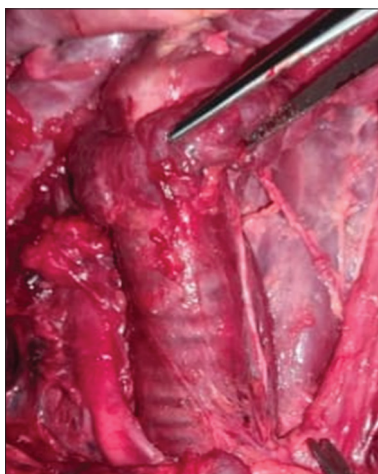


Figure 10: Recurrent laryngeal nerve with the tracheo-oesophageal groove

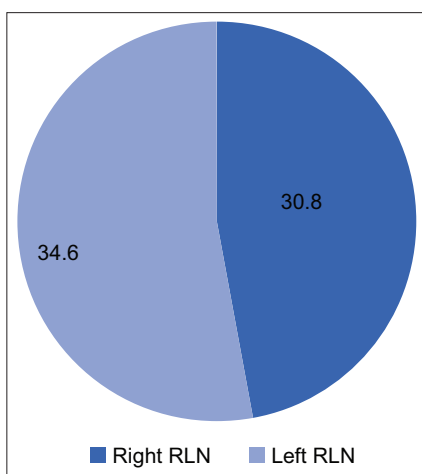


Figure 12: Percentage of bifurcated recurrent laryngeal nerves per side. RLN: Recurrent laryngeal nerve

DISCUSSION

The RLN is a branch of the vagus nerve. The nerve has comparatively variable courses on the left and right sides of the body, particularly within the chest. The left vagus nerve loops around the aortic arch and continues superiorly to the left RLN. The nerve loops around the subclavian artery on the right side before ascending upward towards the larynx. RLNs ascend bilaterally and course posterior to their respective thyroid lobes, entering the larynx at the cricothyroid joint.^[4]

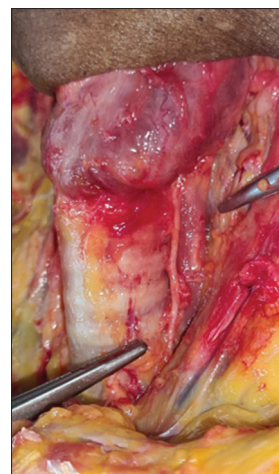


Figure 9: Left recurrent laryngeal nerve with the tracheo-oesophageal groove

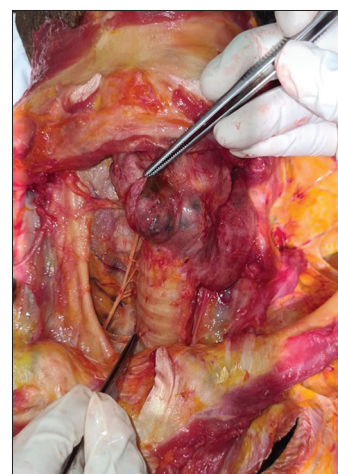


Figure 11: Right side recurrent laryngeal nerve with extralaryngeal branches

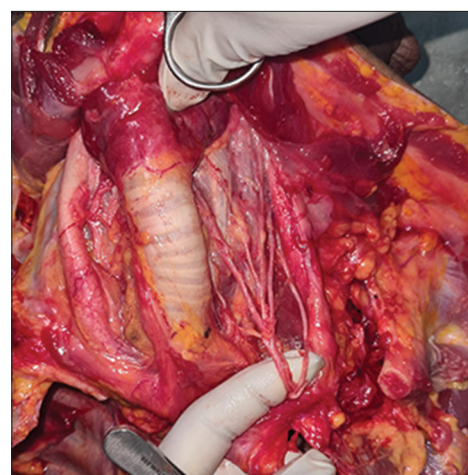


Figure 13: Specimen with multiple branches of the left recurrent laryngeal nerve

The RLNs innervate all intrinsic muscles of the larynx except the cricothyroid.

An anatomical anomaly may occur in 0.5%–1% of cases, resulting in a NRLN^[5] when the laryngeal nerve branches directly off the descending vagus nerve. This NRLN is often found on the right side and is associated with a subclavian artery anatomical variant known as *arteria lusoria*.^[3] In these rare cases, the right subclavian artery arises independently from the aortic arch as a fourth aortic branch, distal to the left subclavian artery. It then hooks back towards the right side, with variable relations to the oesophagus.^[6]

Henry *et al.* performed a meta-analysis on NRLN and estimated the overall prevalence to be 0.7% (95% confidence interval [0.6–0.9]). They found that the right NRLN was associated with an aberrant right subclavian artery in 86.7% of cases.^[3] Another study conducted by Donatini *et al.* reported the prevalence of this rare anatomical variant as 0.6%–1.3%.^[7] In our study, one case of NRLN was observed out of the 52 nerve dissections, equating to a prevalence of 1.9%. This value is marginally higher than that reported in the literature. This anomaly is usually an incidental finding associated with the risk of intraoperative nerve injury.^[8]

For centuries, the location of the RLN was taught as residing within the TEG, which was first described by Vesalius in 1543.^[1] Vesalius' teaching has traversed centuries of anatomical and surgical literature and can be described comparably in various textbooks. In 1858, over 300 years after Vesalius, the first edition of Gray's Anatomy propagated this teaching regarding the location of the RLN, stating, '*The recurrent laryngeal nerve... on both sides ascend in the groove between the trachea and oesophagus*'.^[9] Other texts, such as Clinically Oriented Anatomy, and Last's Anatomy^[10] and others, also used TEG as a landmark to describe the location of the RLN.

In 2017, a study was performed in Poland by dissecting the RLN in formalin-fixed cadavers by Henry *et al.*, in contrast to our study, in which all bodies were recently deceased and unfixed. They found that 68.1% of RLNs were within the TEG.^[11] A meta-analysis performed by the same group, which included 23 studies, including cadaveric and intraoperative dissections, reported similar results of 63.7% RLNs within TEG.^[11] These conclusions differ significantly from the findings of our study. In addition, Henry *et al.* vaguely described the RLNs' position compared to the TEG as anterior, anterolateral, lateral or posterior, and this is a nonspecific description provided.

In 2022, Naraynsingh *et al.* conducted a prospective study on the position of the RLN concerning the TEG and provided an accurate measurement of this relationship. They found that in 97% of the cases, the RLN lay lateral to the TEG. These findings

were consistent with ours, which showed that 96.2% of RLNs lay lateral to the TEG. Naraynsingh *et al.* based their study on *in vivo* surgical findings within a Caribbean population undergoing thyroidectomies and parathyroidectomies.^[2] They precisely defined the relationship between the RLN and TEG by measuring the angle at which the nerve entered the larynx, which objectively assessed the RLN-TEG anatomical relationship and RTA. They found that the mean RTA was 27.5° on the right and 25.5° on the left, whereas only one RLN was within the TEG. However, one can argue that the presence of parathyroid and thyroid pathology can cause alterations in neck anatomy and thus confound the results. Our study adopted the same methodology for measuring RTA but excluded all cases of neck pathology.

Our findings closely mirrored the results of Naraynsingh *et al.*,^[2] revealing a mean course angle of 27.9° and 21.5° on the right and left sides, respectively. Of the 52 RLNs, only 3 (5.8%) were found within the TEG. After reviewing the literature, we found our study of 52 RLN to be one of the most extensive cadaveric studies on this topic. In addition, this is the only cadaveric study performed on the RLN within the Caribbean.

We highlight that the RLN was found outside the TEG in most cases, in contrast to traditional teaching. Thus, surgeons should expect that the RLN is not in the TEG and is usually lateral to it. The most constant point at which the RLN was found was the cricothyroid joint posterior to the thyroid lobe. This entry is posterior to Berry's ligament and can be used as a visual landmark to find the nerve. Al-Salihi and Dabbagh noted similarly that the inferior cornu of the thyroid cartilage was the best guide to the site of entry of the nerve into the larynx.^[12]

It should be noted that the RLN may have extralaryngeal branches, which occur in various patterns. Bifurcation and trifurcation of the RLN are not well described in anatomical texts; however, these branches supply general visceral sensory fibres inferior to the glottis, cricopharyngeus, and other structures before entry into the larynx.^[4] We found that 32.7% of the nerves studied had extra-laryngeal branches, all outside the TEG; this figure is consistent with the literature.

Beneragama and Serpell documented that of 213 RLNs found intraoperatively, 36% were bifurcated or trifurcated before laryngeal entry.^[13] Extra-laryngeal nerve branches are often overlooked but are reported to be fairly frequent, with rates ranging between 24% and 70%.^[3] Most are divided into two branches, sometimes even more.^[14] Kostek *et al.* noted in their study on branching of the RLN that the majority were branched on the right side. They found the bifurcation rate on the right side to be 35.8%, compared with 29.4% on the

left side.^[14] However, contrary to their findings, the majority of the RLNs in our study occurred on the left compared to the right, branching at 34.6% and 30.7%, respectively. We highlight that all extralaryngeal branches of the RLN found in our study existed outside the TEG, reinforcing the importance of focused observation not only for the RLN as a single structure but also for its branches outside the TEG.

Knowledge of the RLN anatomy described above is essential when planning and performing surgical interventions within the neck. The most common of these surgeries are thyroid and parathyroid resections for varying indications. Damage to the RLN can result in vocal cord paralysis, resulting in morbidity and even mortality when occurring unilaterally and bilaterally, respectively.

CONCLUSION

Although historically described as lying within the TEG, we have established that within our Caribbean population, the RLN is not usually found within the groove but instead creates an RTA as it traverses its centripetal course lateral to the TEG. The data presented here challenge the teachings that have been accepted for over 500 years, offering significant implications for clinical, surgical and academic fields.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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