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RESEARCH ARTICLE

The Recurrent Laryngeal Nerve does not lie in the Tracheo-esophageal Groove

Vijay Naraynsingh¹, Aryaa Ramnarine¹, Sandeep Maharajh¹, Samara Hassranah¹, Yardesh Singh¹, Shariful Islam¹, Shamir O. Cawich*¹

¹ Medical Associates Hospital, Corner Albert and Abercromby Street, St Joseph, Trinidad and Tobago, West Indies

* socawich@hotmail.com

ABSTRACT

Traditional anatomic textbooks suggest that the recurrent laryngeal nerve (RLN) ascends in the tracheoesophageal groove (TEG). However, during thyroid and parathyroid surgery, we have noted that the RLN is often not in the groove. In this study, we objectively measured the course of 41 RLNs in relation to the TEG. We found that the RLN was in the groove in only one case. On the right, the angle ranged from 0 – 50° (mean 27.5°) and on the left the range was 15 – 45°, (mean 25.5°) away from the TEG. In conclusion, it was unusual for the RLN to lie in the tracheo-esophageal groove. Thus, in mobilizing the thyroid lobe medially during thyroidectomy, one must exercise care as it is likely that one will encounter the RLN well lateral to the groove. We propose a new technique of objectively measuring the deviation of the RLN from the TEG.

Key Words: Recurrent laryngeal nerve; tracheoesophageal groove.

INTRODUCTION:

The ascent of the recurrent laryngeal nerve (RLN) in the tracheoesophageal groove (TEG) can be traced back to the book, *De Humani Corporis Fabrica Libri Septem* (1543) where Vesalius illustrated the recurrent nerve coursing along the trachea (Figure1)¹. Additionally, the RLN was described in the first edition of *Gray's Anatomy* (1858)². Gray stated, "The recurrent laryngeal nerve... on both sides ascend in the groove between the trachea and oesophagus." Centuries later, this remains the standard teaching in numerous anatomy and surgical textbooks. Snell

(2012)³, Ellis et al (2013)⁴, Moore et al (2014)⁵, and Garden et al (2018)⁶ all describe the RLN as coursing within the TEG.

However, we have noticed during thyroid and parathyroid surgery, the RLN is often not in the TEG, prompting us to find an objective way of defining its anatomy in relation to the TEG. Measurement of the angle of intersection of the nerve with the TEG is a useful objective record to compare the RLN location in studies. Our study highlights 41 cases in which the anatomical course of the RLN was observed intra-operatively during total thyroidectomy.

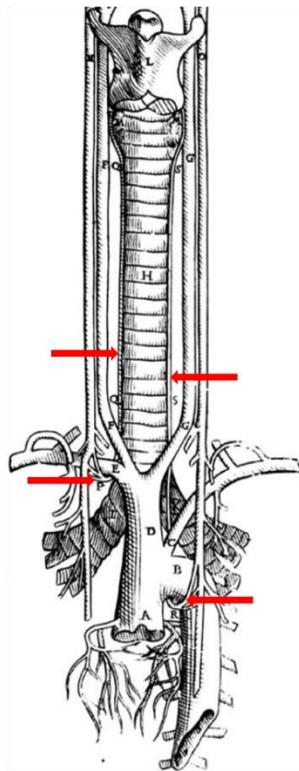


Figure 1: Vesalius's illustration highlighting the origin of RLN's around Subclavian on right and Aorta on left and course in the TEG (red arrows)

METHOD:

After securing permission from the local institutional review board, an independent researcher prospectively observed all consecutive thyroidectomies and para-thyroidectomies performed by a single surgeon at a tertiary referral hospital from January 1, 2018 to December 30, 2021. This was an observational study and the research protocols did not demand any changes in treatment. We excluded patients who did not consent to participate in the study, were under 18 years of age, who underwent previous neck surgery or irradiation, and those with clinical tracheal deviation for whatever reason.

In all cases, a standard neck collar incision was used and retractors were gently placed in order to avoid undue tissue tension during the operations. The operating surgeon deliberately identified the RLN as a part of standard operating protocols in order to avoid iatrogenic injury. The trachea was also exposed as a routine part of the thyroidectomy procedure. After the surgeon confirmed that both structures had been definitively identified, the independent observer was allowed to take photographs to capture the relationships of these two structures. The photographer ensured that the camera was positioned to capture a true antero-posterior view while retractors were so

placed as to only facilitate photography without traction on the RLN or trachea.

In all cases, the digital photographs were stored in a dedicated study computer. Three independent investigators then used Microsoft Office Powerpoint (Redmond, Washington, USA) to superimpose a line along the long axis of the

trachea and one along the course of the RLN. Each investigator then measured the angle where both lines intersected near the crico-thyroid joint using a standard protractor (Figure 2). In cases where the RLN ascended in the tracheoesophageal groove, the angle was zero and it rose incrementally as the RLN deviated from the groove.

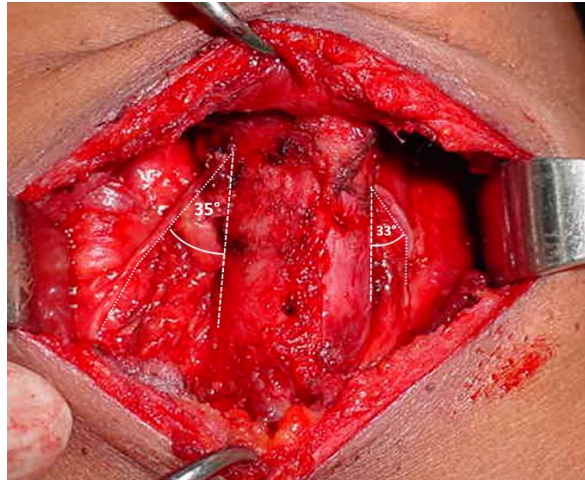


Figure 2: Angle measured where lines of TEG and RLN intersect near crico-thyroid joint at 35° on the right and 33° on the left

RESULTS:

The RLN was identified during 39 anatomical lobectomies and 2 parathyroid explorations. Forty-one nerves were included in this study, 19 on the right and 22 on the left. On the right, the angle ranged from 0 – 50° (mean 27.5°) (Fig.3); on the left the range was 15 – 45°, (mean 25.5°) (Fig.4). As the RLN courses caudally from the laryngeal entrance,

it almost always deviates further from the TEG, thus being quite lateral at the lower pole of the thyroid gland (Fig.5). In only 1 case did the nerve truly run its course in the TEG (Fig.6) In 4 cases, 3 on the left, a precise angle could not be defined as the nerve either meandered or changed course sharply (Figs 7,8,9).

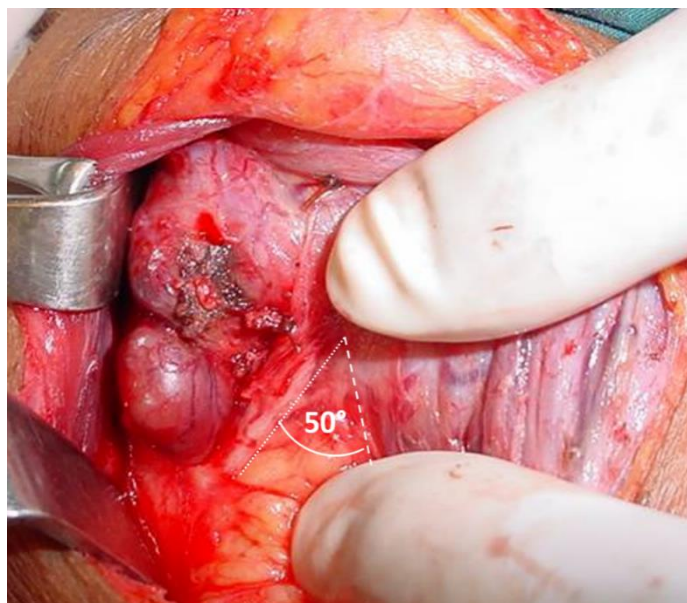


Fig 3: Right RLN coursing lateral to TEG and entering near crico-thyroid joint at 50°

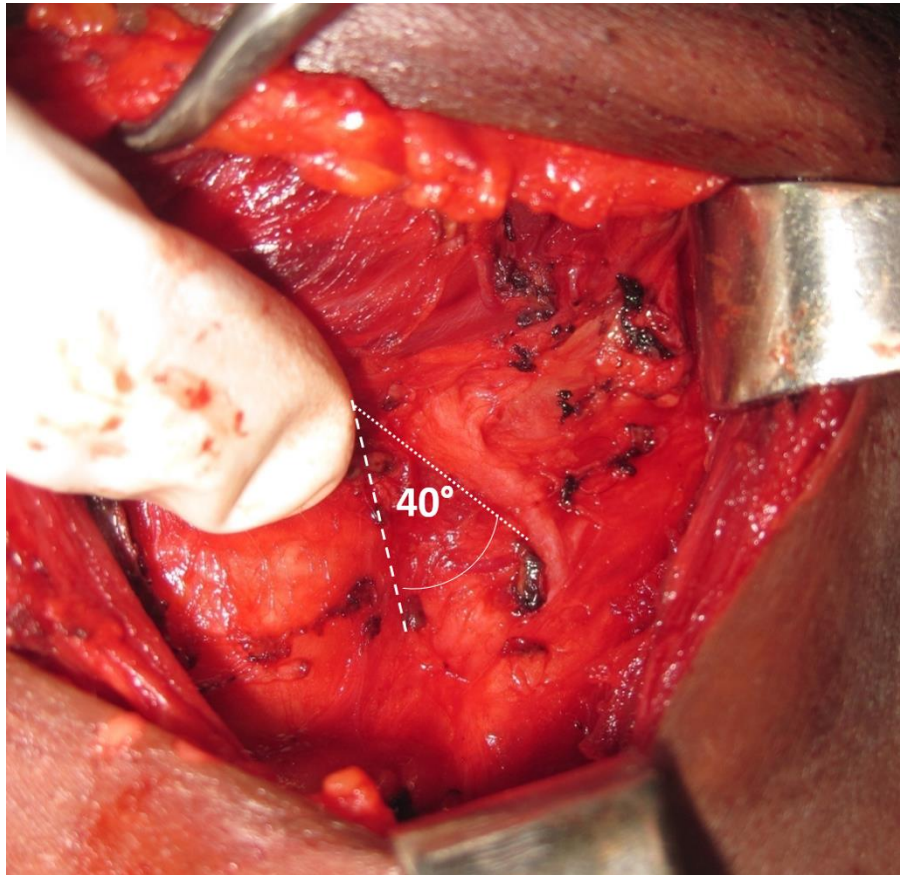


Fig 4: Left RLN coursing lateral to TEG and entering near crico-thyroid joint at 40°

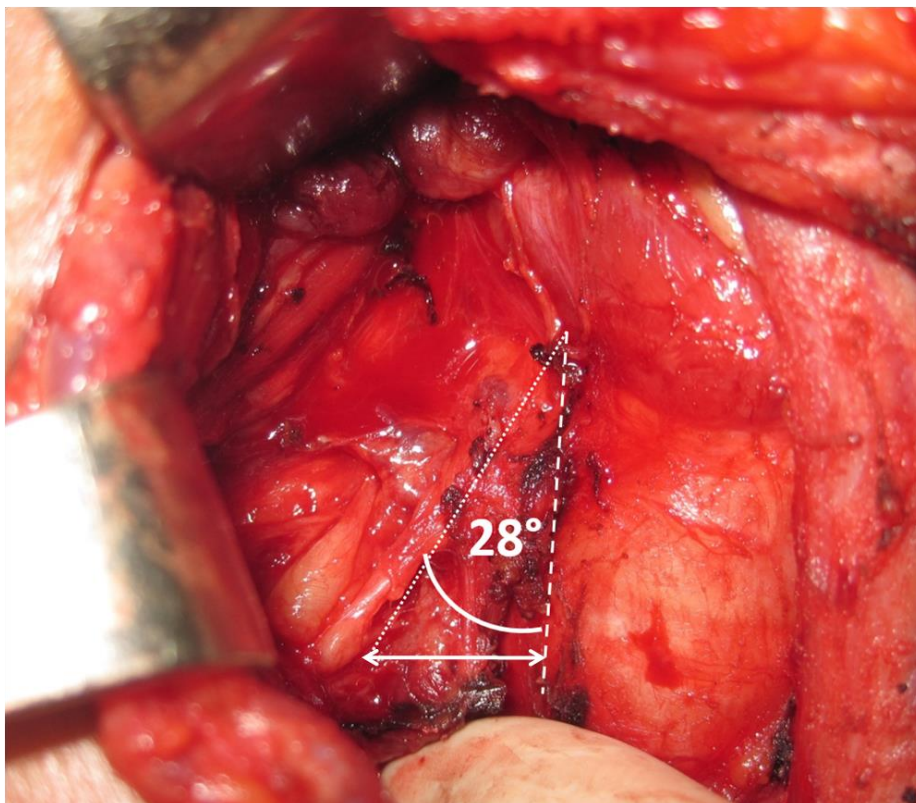


Fig 5: The course of RLN results in a significant lateral position to TEG caudally (double headed arrow)

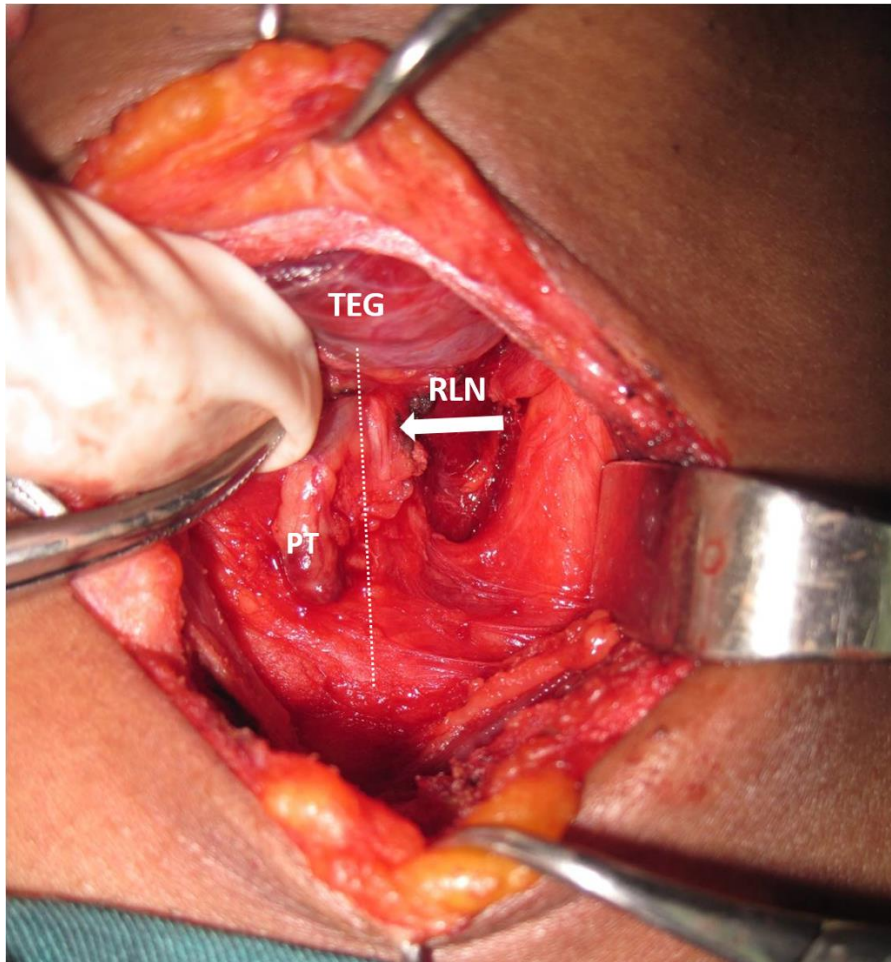


Fig 6: RLN (arrowed) coursing in the TEG. PT – right lower parathyroid adenoma

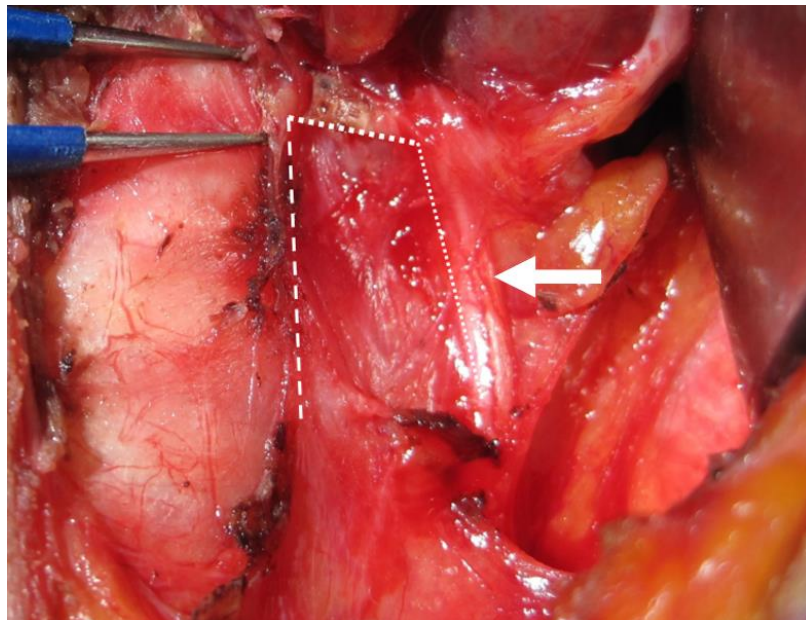


FIG 7: RLN (arrowed) coursing parallel to the TEG and then turning medially, very sharply at almost 90°, to enter the larynx

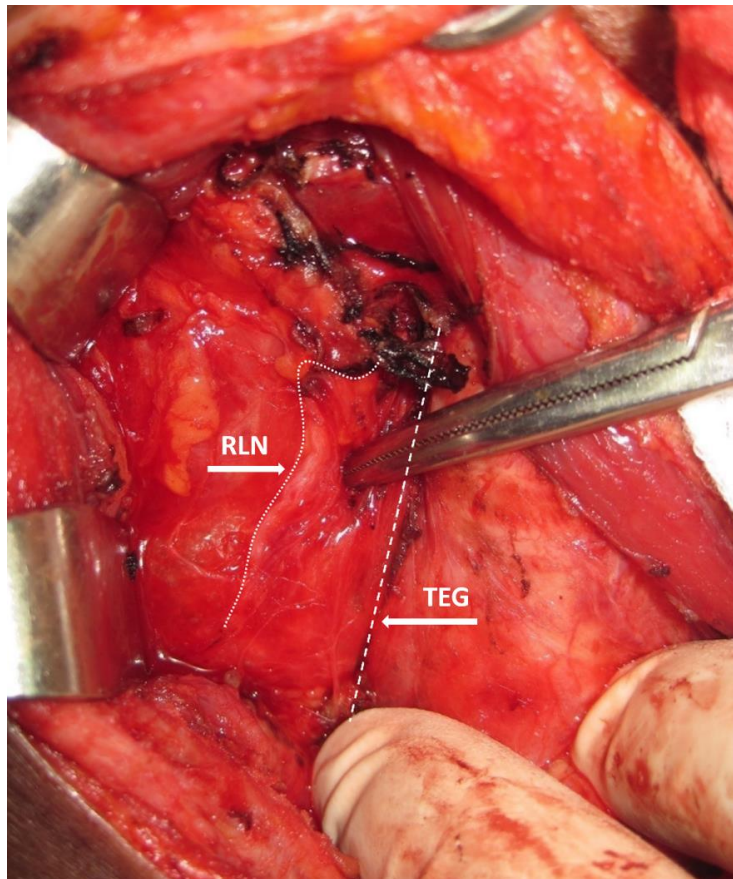


Fig 8: Meandering course of RLN lateral to TEG

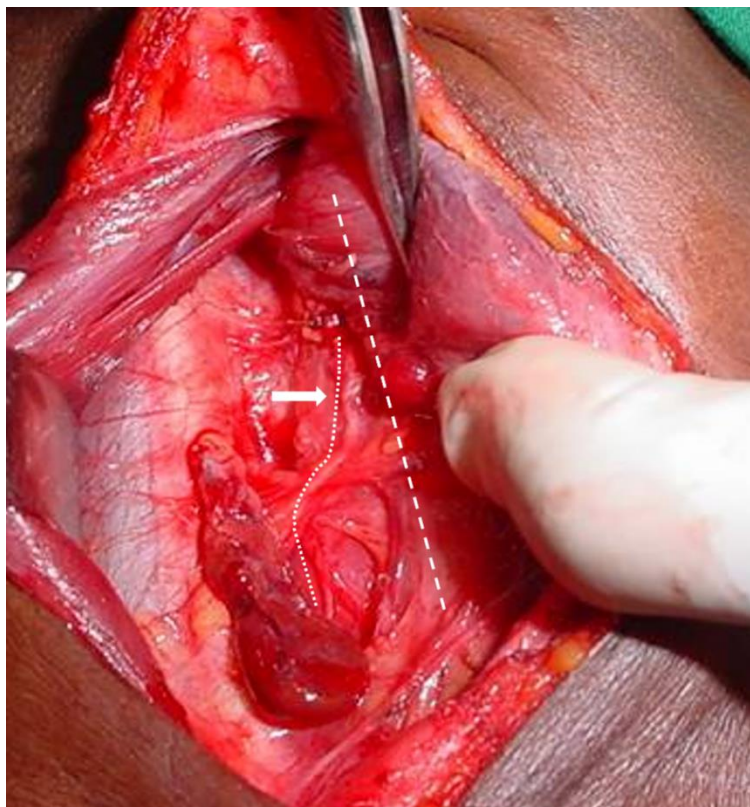


Fig 9: RLN (arrowed) curving lateral to TEG

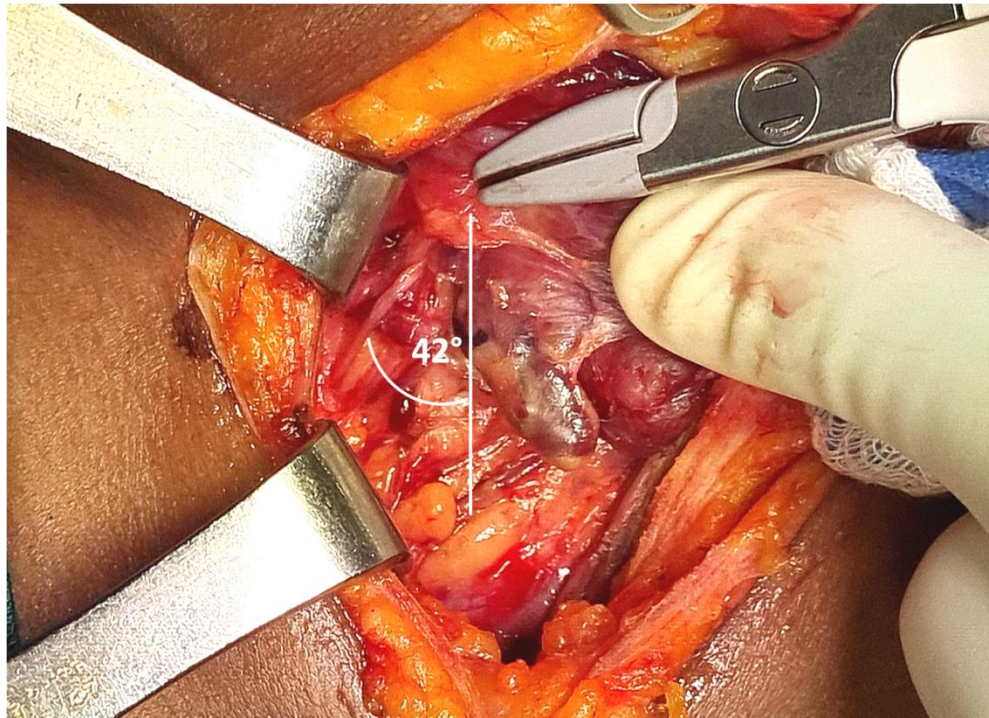


Fig 10: Without thyroid enlargement, the RLN lies well away (42°) from the TEG

DISCUSSION:

The TEG is an anatomical landmark used by surgeons as the RLN is the structure at most risk for iatrogenic injury during thyroidectomy⁷. The RLN, a branch of the vagus nerve provides sensory and motor innervation to the larynx. Its injury causes vocal cord paralysis which can be life changing; bilateral injury can be life-threatening.

Galen (second century AD) has been credited for identifying and naming the RLN⁸. He observed that sectioning of the nerve in a pig caused aphonia and, with the evolution of medicine, this nerve has still retained great importance. Billroth was able to reduce his mortality associated with thyroidectomy from 36.1% to 8.3%, through advancements of anaesthesia, asepsis and haemostasis but his morbidity rate remained high. In his series of thyroidectomies between 1877 and 1881, 25% of patients had unilateral RLN injuries and 4.5% suffered bilateral injuries⁹. Kocher's capsular dissection technique reduced his mortality from 17% to 0.5%¹⁰; in 1909, he became the first surgeon to receive the Nobel Prize in Medicine and Physiology for his work on thyroid disease.

In 1927, Higgins noted that 'The prevention of injuries of the recurrent laryngeal nerve demands an accurate understanding of the anatomical relations of the nerve on the part of everyone who deals with surgery of the larynx or of the thyroid gland'¹¹. However, it was Lahey (1938) who insisted on careful, delicate, dissection of the RLN and determined that exposure of the nerve reduced

injury during thyroidectomy to 0.3%^{7,9}. Many standard anatomy texts still describe the RLN as running within the TEG. This can be seen in the first edition of Gray's Anatomy (1858) and in anatomy textbooks commonly used today. Moore et al (2014) described "The right RLN... ascends between the trachea and esophagus. The left RLN... ascends to the larynx in the groove between the trachea and esophagus."⁵ Snell (2012) mentioned "The right RLN.... ascends between the trachea and esophagus. The left RLN... ascends in the groove between the trachea and esophagus"³ and Ellis et al (2013) stated "The RLN lies in the groove between the oesophagus and trachea."⁴

Surgical texts also reinforce this description of the anatomy of the RLN. Garden et al (2018) detailed "The RLN, a branch of the vagus, passes upward in the groove between the oesophagus and trachea."⁶ Furthermore, Townsend et al (2017) outlined "The right RLN can usually be found within 1 cm lateral to or within the TEG. The left RLN enters the TEG as it ascends to the level of the lower pole of the thyroid."¹²

Previous studies indicate a range from 24.9% to 100% in which the RLN lies in the TEG^{13,14}. A cadaveric study conducted by Henry et al (2017) found the RLN within the groove in 68.1% of cases and when the RLN was located outside the groove, it was most commonly found lateral to the TEG¹⁵. Similarly, Gupta et al (2019) found the RLN within the TEG in 69.8% of patients undergoing thyroidectomy¹⁶. Both studies suggested "an

attempt should first be made to identify the RLN in the TEG and then the course of the nerve should be traced upwards to the ligament of Berry to confirm the position and structure."^{15,16} By implication they both suggest that the nerve is found in the TEG.

However, our data is vastly different in that the RLN almost never lies in the TEG. In fact, in 96.6% of the cases the RLN lay lateral to the groove at a mean angle of 27.5° on the right or 25.5° on the left. In thyroid surgery, the lobe is pulled medially during initial mobilization¹⁷; the nerve could be injured if surgeons wait until they encounter the TEG to look for it since the RLN is almost always lateral to the TEG. This is particularly true at lower pole of the gland since the nerve at an angle of 25°-30° would often be 1-3cm away from the TEG at this level. It is theoretically possible one can argue that with enlargement, the goitre displaces the RLN, thus producing an aberration of normal anatomy in our surgical patients. However, there is clear evidence that if the trachea is pushed by the thyroid, so is the esophagus. Brinch et al measured and documented the degree of esophageal displacement and its effects on esophageal function¹⁸. Thus, if both the trachea and esophagus are displaced medially by an enlarged thyroid lobe, then the TEG is also pushed along with the RLN, if the nerve lies in the groove. The fact that we can measure the angle between the RLN and the TEG means that the nerve did not lie in the groove even prior to lobe enlargement. However, without thyroid enlargement, as in parathyroid surgery, the RLN can be seen well lateral to the TEG. In Fig.10, the normal thyroid lobe is medialized to expose the parathyroid, but it is easy to see that the undisplaced RLN comes to the cricothyroid joint and TEG from a very lateral position at 42°.

In previous literature, the RLN's relation to the TEG is defined in such terms as 'posterior half of trachea', 'anterior half of trachea', 'outside', 'lateral', 'anterolateral' to the groove^{16,18}. These terms, though descriptive, are non-specific; no measurements are recorded.

No matter what anatomical variations are encountered, the RLN meets the TEG just behind the cricothyroid joint. Thus, a line along the TEG and another along the RLN will afford us the opportunity to record objectively the angle of deviation of the

RLN from the TEG. In some cases (4 of our 41 -about 10%) the nerve is meandering or sharply angulated (Fig 7,8,9) and this measurement may not be possible. However, documentation of the nerve-groove angle (NGA), possible in 90% of our cases, will allow us to compare nerve deviation across studies, populations and goiter sizes. Using this technique, it should also be possible to measure how far away the RLN is from the TEG at the lower pole of the gland, although it was not done in this study. The wide deviation of the nerve from the TEG at the lower pole does not allow us to endorse the recommendation 'that an attempt should first be made to identify the RLN in the TEG and then the course of the nerve should be traced upward....'¹⁶. This popular teaching may well result in RLN injury well lateral to the TEG. In view of the lateral position of the RLN relative to the TEG, it appears safest to be fastidious about true capsular dissection during medial mobilisation of the lobe, dissecting carefully in this plane to the posterolateral edge of Berrys' ligament and the cricothyroid joint where the nerve holds a constant position. This care in capsular dissection emphasized by Kocher was made even more extreme by George Crile who in 1932 recommended 'leaving the posterior capsule of the thyroid in each thyroid resection'¹⁹.

CONCLUSION:

It is quite unusual for the RLN to lie in the TEG as it courses posterior to the thyroid gland. Thus, in mobilizing the thyroid lobe medially during thyroidectomy, one must exercise care as it is likely that one will encounter the RLN well lateral to the TEG. Measurement of the angle between the TEG and the RLN provides an objective, reproducible method of defining their anatomic relationship.

Conflict of Interest:

The authors have no declarations
There are no conflicts of interest to report for this work

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