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ORIGINAL ARTICLE

# Relative Topography of Laryngeal Nerves for Surgical Cruciality: An Observational Cadaveric Study

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**Abstract** To observe and evaluate the intricrate relationship of recurrent laryngeal nerve (RLN) and external branch of superior laryngeal nerve (EBSLN) to various anatomical structures in the neck like the inferior thyroid artery (ITA), Berry's ligament (LB), Zuckerkandl's tubercle (ZT) and with the superior thyroid artery (STA) for the knowledge of surgical cruciality during surgeries for thyroid gland diseases. This cadaveric observational study was conducted in the department of Otorhinolaryngology and Head and Neck Surgery with logistic support from Department of Anatomy. Total of 40 fresh frozen latex injected cadavers neck dissection was performed to study anatomical variations of thyroid gland and its related vessels and nerves. All measurements were recorded using digital caliper sensitive to 0.01 mm and photographs were documented. Topography of RLN was studied in relation to ITA, LB and ZT. The RLN was predominantly a posterior relation of the ITA in 86.25%, was deep to LB in 46.25% and was related posterior to ZT in 80% of cadaver dissected. The EBSLN has a variable relation with STA which was observed to lie at a distance of $< 1$ cm from STA in 66.25%. The difference between left and right side was not found to be statistically significant in all parameters ($p > 0.05$). The awareness and appreciation of the intricate topographical relations and its variations reinforce the surgeons to be careful when performing surgical procedures in the central compartment of the neck which avoid complications.

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## Introduction

Thyroid gland (THY-GL) is a butterfly shaped organ surrounding the anterolateral aspect of trachea in root of neck, has three parts, a right and left lobe joined by isthmus in midline. It is closely related to important structures in neck such as cervical esophagus, larynx, RLN, major vessels, superior laryngeal nerve (SLN), and parathyroid glands. Knowledge about precise anatomy of related structures play a vital role in thyroidectomies. Insult to the RLN can cause permanent or transient hoarseness, dysphasia, and total vocal cord paralysis. The RLN shows a great number of topographical relations to the adjacent cervical structures because of the multiple variations in its course. The complication resulting from injury to the RLN can be evaded by the identifying landmarks of the nerve [1–4].

Compared to the RLN, the SLN and its branches have not received comparable attention in surgical literature as the detection of injury to SLN branches requires a higher

degree of investigation. Damage to the EBSLN causes paralysis of the cricothyroid muscle, the tensor of vocal cords, which affects the patient's ability to achieve higher tones [5]. Upper pole of thyroid gland is the most susceptible site for injury to EBSLN during thyroid surgery, therefore, knowledge about the course of STA in relation to EBSLN is necessary to avoid post-operative complications.

There are different landmarks to expose and identify the RLN during the surgery. The important ones are ITA, LB (suspensory ligament of the thyroid gland), ZT and tracheaoesophageal groove. Other landmarks in the form of triangles like Beahr's, Joll's, Simon's, Lore's are also used to identify the RLN [6]. The most common site of injury to the RLN is near the LB, where the nerves penetrate into the larynx [7]. A reliable landmark and method for identifying the RLN is necessary to prevent postoperative complications.

The wide variability has been reported previously in regards to the location of RLN and its relationship to the surrounding structures. In the present study, by performing bilateral neck dissection of previously perfused forty fresh cadavers, we determine the relationship between the RLN and the ITA, LB, ZT and relationship of EBSLN with STA at upper pole of thyroid gland.

### Ethical Clearance

Institutional ethical clearance was obtained-MDC/DOME/62.

## Materials and Methods

This study involved bilateral neck dissection in 40 (27 males, 13 females) fresh frozen previously perfused with formalin and latex cadavers in Anatomy dissection laboratory at our institution. The cadavers who had history of trauma or surgical procedures around neck region and had evidence of neck deformities and neck tumors were excluded.

### Methodology

Prior to dissection latex was injected in all 40 cadavers into the CCA to enhance vasculature for observation of topographic relationship of major arteries around thyroid gland. A midline incision extending from mentum to manubrium was given. Infrahyoid muscles identified and cut. Fascia from the thyroid gland removed to expose arteries and veins and their branching pattern. After lifting the lower part of the gland, the RLN was identified in groove between trachea and oesophagus and its topography related to ITA, LB, ZT was studied. EBSLN and its relation to STA was observed. Data collection included morphometric details and anatomical distribution and variations of surrounding structures of both the sides of thyroid gland. Data were recorded and analysed with descriptive statistics i.e. frequency and percentages. The Pearson's chi-square test for independence was applied to find out the association or differences between sides with selected parameters in the study. The statistical significance was set at 5% level of significance ($P < 0.05$).

## Results

In the study, a total of 40 cadavers including 80 sides (i.e. right and left). RLN was found posterior to inferior thyroid artery in 69 sides (86.25%), in 9 sides (11.25%) RLN passed in between the branches of inferior thyroid artery and 2 sides (2.50%) RLN passed anterior to ITA (Table 1, Fig. 1). The difference between right and left sides was not found to be significant (Chi-square = 4.9080, $P > 0.05$).

In 37 sides (46.25%) RLN ran deep to LB, in 33 sides (41.25%) superficial to it and in 10 sides (12.50%) RLN ran through the LB (Table 2). No significant difference was observed between right and left sides (Chi-square = 0.5160, $P > 0.05$).

The size of ZT was observed as grade 1(< 5 mm) in 28 sides and in 52 sides as grade 2 (6–10 mm) (Table 3). RLN passed posterior to ZT (Type A) in 64 sides (80%) and in 16 sides (20%) RLN passed lateral to ZT (Type D) (Table 4, Fig. 2). No statistically significant difference was observed when left and right sides were compared (Chi-square = 0.3131, $P > 0.05$).

Distance between STA and the EBSLN was found to be > 1 cm (Type 1) in 27 sides (33.75) and < 1 cm (Type 2) in 53 sides (66.25%) (Table 5). No significant difference was observed between right and left sides (Chi-square = 0.0560, $P > 0.05$).

## Discussion

Major concern during thyroidectomy is to preserve RLN, EBSLN. Injury to these structures result in morbidity which includes hoarseness of voice, dysphagia, vocal cord paralysis. The RLN innervates intrinsic musculature of larynx and provides sensory supply to glottic area of larynx. On the left RLN arises from vagus when it crosses arch of aorta. It then loops around aorta to climb in tracheoesophageal groove behind THY- GL to enter the larynx [8, 9]. RLN on right side originates from vagus when it crosses right subclavian artery in front. It then circles around artery and climbs in tracheo-esophageal groove, to

**Table 1** Comparison of right and left sides with status of RLN location in relation to ITA

| Location in relation to ITA | Right side n (%) | Left side n (%) | Total n (%) |
|---|---|---|---|
| Anterior | 2 (5.00) | 0 (0.00) | 2 (2.50) |
| Posterior | 36 (90.00) | 33 (82.50) | 69 (86.25) |
| Between | 2 (5.00) | 7 (17.50) | 9 (11.25) |
| Total | 40 (100.00) | 40 (100.00) | 80 (100.00) |

Chi-square = 4.9080 $P$ = 0.0860

**Table 2** Comparison of right and left sides with status of RLN in relation to LB

| In relation to LB | Right side n (%) | Left side n (%) | Total n (%) |
|---|---|---|---|
| Deep | 17 (42.50) | 20 (50.00) | 37 (46.25) |
| Superficial | 18 (45.00) | 15 (37.50) | 33 (41.25) |
| Through | 5 (12.50) | 5 (12.50) | 10 (12.50) |
| Total | 40 (100.00) | 40 (100.00) | 80 (100.00) |

Chi-square = 0.5160 $P$ = 0.7730

**Table 3** Comparison of right and left sides with status of ZT

| ZT | Right side n (%) | Left side n (%) | Total n (%) |
|---|---|---|---|
| Grade 1 | 14 (35.00) | 14 (35.00) | 28 (35.00) |
| Grade 2 | 26 (65.00) | 26 (65.00) | 52 (65.00) |
| Total | 40 (100.00) | 40 (100.00) | 80 (100.00) |

Chi-square = 0.0000 $P$ = 1.0000

enter larynx behind cricothyroid articulation and inferior cornu of thyroid cartilage behind THY-GL [10–12].

The RLN in the neck is supplied by branches of ITA that supply parts of trachea and esophagus. The distal part of RLN is supplied by branch of inferior laryngeal artery which itself is branch of ITA [13]. Multiple variations have been explained in relationship of nerve to ITA and the branches. The 3 basic configurations include nerve anterior to the artery, nerve between branches of the artery, and nerve posterior to the artery [8]. We observed RLN had a variable relation with ITA. On both the sides the nerve was observed predominantly passing posterior to the ITA (90% on right and 82.50% on left). The RLN passing between the branches of ITA was more commonly observed on the left side (17.50%) compared to right side (5%). The nerve passing anterior to the ITA was least common noted on the right sides (5%) in our study. In a study led by Monfared et al. (2002) [13] the nerve passed anterior (21%) or posterior (28%) to its branches, on right. The nerve passed posterior to the branches of the artery (50%), between its branches (28%), and anterior to RLN (21%) on the left side. In the analysis of present study, higher frequency (86.25%) of posterior location of RLN to the ITA when both sides were considered as a set, followed by in between the branches of artery (11.25%) and least frequency of anterior location (2.50%) which was similar to study conducted by Kaisha et al. (2011) [14].

The relationship of the RLN to LB has been debated in the literature. LB anchors thyroid gland to laryngotracheal complex and forms a surgically important medial relation of the RLN as it loops to enter the larynx [15]. The relationship of RLN and LB has been observed as dorsolateral to ligament. Variations seen are the RLN is said to be medial to, lateral to, or embedded in lateral LB. In majority of the cases the RLN is embedded in suspensory LB and the nerves may be pulled forward and are therefore vulnerable to injury during glandular traction [11]. In present study we observed in majority of cadavers (46.25%) the

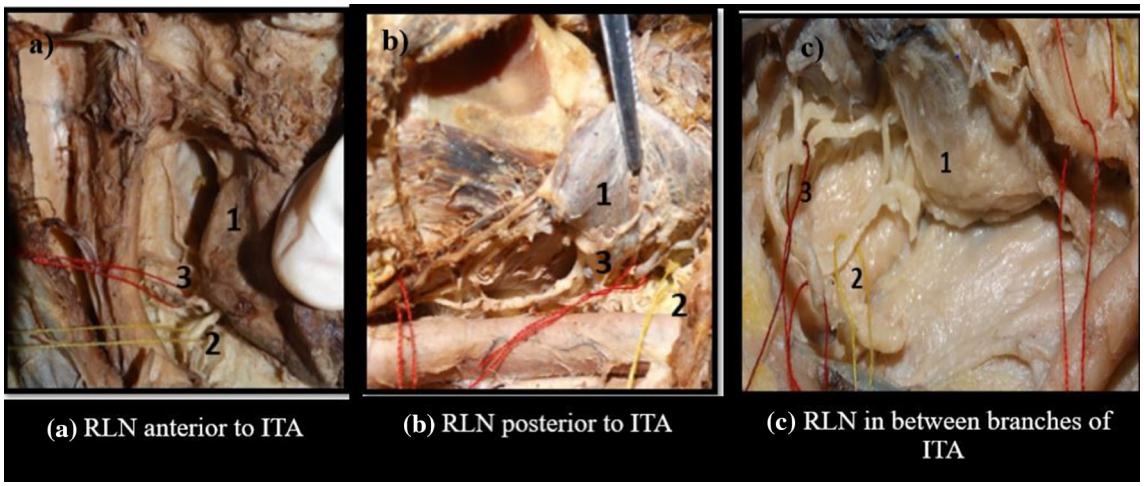


**Fig. 1** Topography of RLN in relation to ITA, 1-Thyroid gland, 2-recurrent laryngeal nerve, 3-inferior thyroid artery

**Table 4** Comparison of right and left sides with status of RLN in relation to ZT

| In relation to ZT | Right side n (%) | Left side n (%) | Total n (%) |
|---|---|---|---|
| Type A | 33 (82.50) | 31 (77.50) | 64 (80.00) |
| Type D | 7 (17.50) | 9 (22.50) | 16 (20.00) |
| Total | 40 (100.00) | 40 (100.00) | 80 (100.00) |

Chi-square = 0.3131 $P$ = 0.5760

**Table 5** Comparison of right and left sides with status of EBSLN in relation to STA

| In relation to STA | Right side n (%) | Left side n (%) | Total n (%) |
|---|---|---|---|
| Type 1 | 14 (35.00) | 13 (32.50) | 27 (33.75) |
| Type 2 | 26 (65.00) | 27 (67.50) | 53 (66.25) |
| Total | 40 (100.00) | 40 (100.00) | 80 (100.00) |

Chi-square = 0.0560 $P$ = 0.8130

nerve ran deep to ligament of Berry, when both the sides were considered as a set followed by superficial to ligament in (41.25%) and (12.5%) through the ligament. Sasou et al. (1998) [15] in their study found RLN was dorsolateral to LB in all the cases. Our study was similar to study conducted Kaisha et al. (2011) [14] where the RLN passed superficial to the ligament in 66.9% and it passed through the ligament in 7.4% of cases. Henry BM et al. (2017) [16] in their study noted RLN to be superficial to ITA in 90.3% of cadavers. Where as in there meta-analysis they noted that the pooled prevalence estimate of RLN being superficial to ITA was only 78.2%. They also noted that most Asian studies reported the relation of RLN being superficial to ITA was low (59.3%).

The ZT is the most protuberant area of the postero-lateral margin of the thyroid. Emil Zukerkandl named it in 1902. It is an embryologic fusion of ultimobranchial body and median thyroid process and forms a milestone for RLN in thyroid surgery. The ZT was found to be a reliable landmark to the nerve in our study. Pelizzo et al. (1998) [17] classified ZT based on size into 4 grades-Grade 0-unrecognizable, Grade 1- $<$ 5 mm, Grade 2–6–10 mm, Grade 3- $>$ 10 mm. He also gave relation in course of RLN with ZT as Type A- posterior to ZT surface, Type B – anterior to ZT, type C and type D- passing through ZT and lateral to ZT respectively. The present study found that location of RLN in relation to ZT in 64 sides (80%) was posterior (Type A) and in 16 sides (20%) nerve lied lateral to it (Type D). Our observation was similar to study by Yun et al. (2008) [18] where Type A was found in 92.1%.

External branch of superior laryngeal nerve (EBSLN) supplies cricothyroid muscle and mucous membrane of upper part of larynx. It has variable course along the branches of superior thyroid artery. It curves anteriorly and medially close to the lower edge of the thyroid cartilage before innervating of the cricothyroid muscle [19]. Kierner et al. (1998) [19] classified the topographical relationship of EBSLN to the STA into 4 categories. Type 1- EBSLN intersects STA $>$ 1 cm above upper pole of thyroid, Type 2- EBSLN intersects STA $<$ 1 cm of the upper pole, Type 3- EBSLN intersects STA immediately above thyroid gland upper pole, Type 4- EBSLN does not cross STA, but runs dorsal to the artery before it ramifies. In the present study we noted Type 2 to be the commonest being seen in

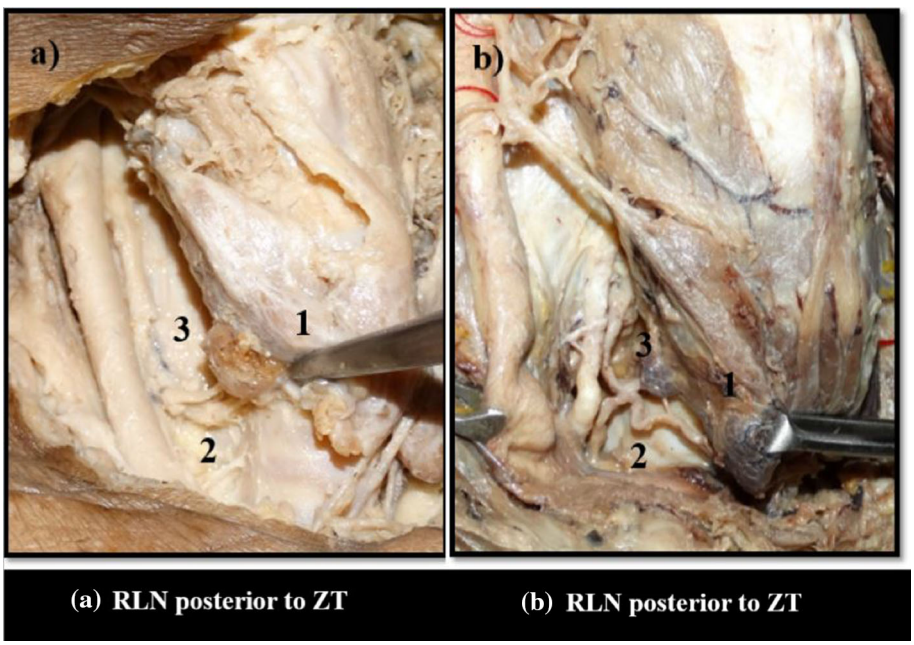


**Fig. 2** Topography of RLN in relation to ZT, 1-Thyroid gland, 2-recurrent laryngeal nerve, 3-Zuckerkandle's tubercle

66.25% followed by Type 1 in 33.75%. In the study by Kierner et al. (1998) [19] showed Type 1 to be the most common type observed in 21 specimens (42%), Type 2 in (30%), Type 3 and Type 4 in 14% specimens each.

## Conclusion

The present study noted that the RLN is mainly in posterior relation to the ITA, passed deep to LB and was seen posterior to ZT. The EBSLN has a variable relation with superior thyroid artery with type 2 being the commonest. Though individually ITA, LB and ZT showed to be reliable guide to locate the RLN, due to the presence of variability in literature we recommend to use all the known anatomical guides rather than using individual guide when locating the RLN along with the use of intra-operative nerve monitor which will enhance the chances of safe isolation of the nerve during the surgery.

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**Declarations**

**Conflict of interest** All authors declare that they have no conflict of interest.

**Ethical Approval** We agree that our study is ethical and compliant with ethical standards. Institutional ethical clearance obtained—MDC/DOME/62. All procedures performed in studies were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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