# A Study of Variations in the Relation of Recurrent Laryngeal Nerve to the Thyroid Gland and Its Vascular Pedicles

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***Abstract***

**Introduction:** One of the important nerves in the neck area is the recurrent laryngeal nerve. Due to the anatomical variation in the course and the branching pattern the nerve is more prone to get injured during neck surgeries. This is due to lack of understanding about the anatomical variation of the recurrent laryngeal nerve, the course and branching pattern.

**Aim:** To study the variation in the course of recurrent laryngeal nerve to the thyroid gland and its vascular pedicle.

**Methods:** This prospective hospital-based study was undertaken in the Department of ENT at Sri Manakula Vinayagar Medical College and Hospital in Madagadipet, Puducherry. A total of 69 patients were included in the study. The study was conducted for 18 months, from November 2022 to May 2024. Throughout the investigation, each side of the neck was handled as an independent unit. This study looked at the entry into the larynx, the inferior thyroid artery, the course of recurrent laryngeal nerve, the branching pattern, and the relation to the thyroid gland.

**Results:** A total of 69 study participants participated in the study. And among them, 64 were patients, and 5 were cadavers from the anatomy lab. The mean age of the patients was found to be 46.68 $\pm$ 12.46 years. The recurrent laryngeal nerve's location in the neck (p-0.335), its branching pattern between the two sides (p-0.427), and its position with respect to the Berry ligament (p-0.962) were all shown to be insignificantly different by the study. Concurrently, the study found a statistically significant variation in the recurrent laryngeal nerve's correlation with the tubercle of Zuckerkandl (p-0.009) and the inferior thyroid artery (p-0.002). Approximately 11.5% of the patients experienced hypocalcemia during the post-operative phase, for which conservative measures were taken.
**Conclusion:** The operating surgeon should have a thorough knowledge of the anatomical variation in the recurrent laryngeal nerves to avoid any adverse events during the surgical procedures. This helps prevent unnecessary complications and improves the patient's quality of life.

***Keywords***: Thyroidectomy, Recurrent laryngeal nerve, Inferior thyroid arte.

## Introduction

The RLN (recurrent laryngeal nerve) is one of the critical nerves present in the neck region [1]. RLN is the primary motor nerve for all intrinsic laryngeal muscles except cricothyroid[2]. Numerous studies have shown that the right RLN has anatomical variation more than the left due to differences in the embryologic origin[3,4]. The anatomical route of the left RLN is longer than that of the right, hence it is more prone to injury from trauma and malignancy [5]. Research has shown that the right takes a more anterior and lateral path than the left RLN which raises the possibility of injury during surgery[6]. Damage to the nerve can have a detrimental effect on the patient's quality of life[7]. Precise identification and preservation of the nerve are crucial for surgeries. Iatrogenic injury is the most common cause of injury to the RLN [8]. Tumors are also a common source of RLN injury. The unilateral injury is difficult to diagnose as it is usually silent. Patients will notice a change in pitch and hoarseness in voice. While it has been demonstrated that bilateral vocal cord paralysis is less common it can manifest with more severe symptoms including breathing difficulty and aspiration[9]. Though latest technologies have come to monitor nerve injury during surgical procedures, data about the branching pattern and course of the recurrent laryngeal nerve are still needed in India. This study aims to evaluate the variation in the recurrent laryngeal nerve to the thyroid gland and its vascular pedicle.

## Materials and Methods

### Study area and Setting:

The Department of ENT conducted the hospital-based crossectional study at Sri Manakula Vinayagar Medical College and Hospital, Madagadipet, Puducherry. The study was done for a period of approximately 18 months (November 2022 to May 2024). SMVMCH is an ultramodern tertiary hospital maimed by skilled medical service providers. The hospital is equipped with 1180 beds and 250 ICU beds. The department of ENT caters to about 100 outpatients and an average of 4 surgeries on day to day basis.

### Study Participants:

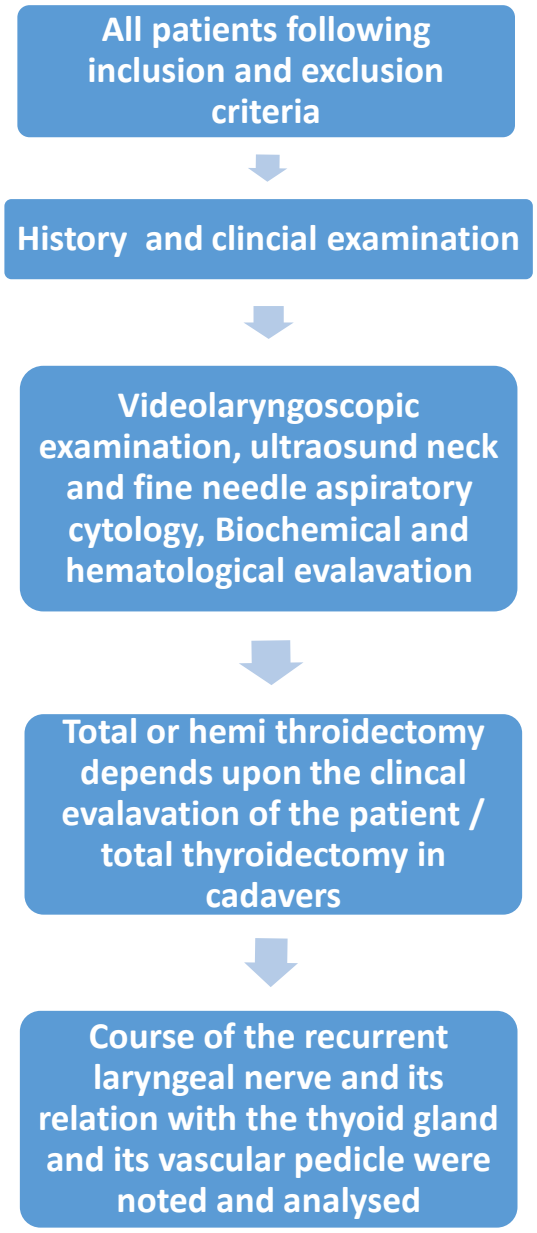
All patients who attend the ENT Outpatient Department who meet the following eligible criteria were included in the study. Patients who are more than 18 years of age admitted with thyroid swelling and who were willing for surgery were included and Cadavers from the anatomy lab were also included in the study.

### Sample Size and Sampling:

As per hospital records, on average 20 to 25 patients get operated for thyroidectomy per year. Based on the previous study conducted by Shindo ML et al., the hypothesized percentage frequency of outcome factor in the population (p=77% +/- 10%) confidence limit as a percentage of 100 (absolute +/- percentage) (d)=10%. With a confidence level of 95%, the sample size was calculated to be 69 (calculated using Open Epi software version 3.01). consecutive sampling was adopted.

### Data collection procedure:

After informed consent was obtained, the participants were subjected to proper history-taking and clinical examination. The case proforma consists of six parts. The first part of the questionnaire captured basic demographic details of the patients, such as name, age, sex, education, socio-economic status (modified BG Prasad Scale) of the family, and addresses with contact numbers. The second part consists of the history of the presenting illness, duration and progression of swelling, associated with pain or swallowing difficulty. History of voice change and breathlessness were evaluated followed by the history of smoking and alcohol intake. Then, the past and personal history of the patients were explored. The third part of the case proforma consisted of the general physical examination followed by the ENT examination and the neck examination was done in detail. The findings of the video laryngoscopic examination were then noted. The fourth part of the case proforma consisted of the findings of the hematological and biochemical examination. The fifth part of the clinical proforma consisted of the findings of the ultrasound neck and the fine needle aspiration cytology report. The sixth part contained information about the surgical technique and the intraoperative findings, including the RLN course, its relationship to the thyroid gland and inferior thyroid artery. And the complications developed during the postoperative period. And the details of the follow-up visits were recorded.



**Data analysis**:

The data was entered into the Epi Info program and analyzed using the statistical package for the Social Sciences software, version 25.0. Descriptive statistics were obtained for quantitative factors such as gender and age. Qualitative variables such as laryngeal findings, branching patterns, and their relationship with the various anatomical structures were evaluated based on frequency and percentage. Pearson's chi-square was used to evaluate the association between the demographic variables and the variation of the recurrent laryngeal nerve. A p-value <0.05 will be considered as statistically significant.

**Ethical consideration:**

This study was carried out after obtaining approval from the ethical committee of the Institute Ethics Committee (EC/88/2022).

**Reporting of the study:**

The study was reported by following STROBE guidelines.

**Result:**

**Table 1: Patient distribution according to the location of inferior thyroid artery in relation to the recurrent laryngeal nerve.**

| Position based on ITA | Right side | | Left Side | | p-value |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Anterior | 14 | 24.6 | 6 | 9.7 | 0.002 |
| Intermediate | 23 | 40.3 | 15 | 24.2 | |
| Posterior | 20 | 35.1 | 41 | 66.1 | |

When the inferior thyroid artery and the position of the right recurrent laryngeal nerve were examined, it was found that approximately 40.3% of the patients had the nerve between the inferior thyroid artery's branches, followed by 35.1% of patients who had the nerve posterior to the artery and 24.6% of patients who had the nerve anterior to the artery. On the left side of the neck, however, the nerve posterior to the inferior thyroid artery was present in more than half of the patients (66.1%), followed by the nerve between the artery's branches in 24.2% of the patients, and the nerve prior to the artery in 9.7% of the patients. With a p-value of 0.002, there is a significant variation in the location of the nerve near the artery on both sides, as in **Table 1**.

**Table 2: The patients were distributed according to the RLN's stance on Zuckerkandl tubercle.**

| Position based on Tubercule of Zuckerkandl | Right side | | Left Side | | p-value |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Medial | 50 | 87.7 | 42 | 67.7 | 0.009 |
| Lateral | 7 | 12.3 | 20 | 32.3 | |

On evaluating the position of the recurrent laryngeal nerve concerning the tubercle of Zuckerkandl and on exploring the right side of the neck, about 87.7% of the patients had the nerve medial to the tubercle of Zuckerkandl, and 12.3% of the patients had nerve lateral to the tubercle. Similarly, on the right side, about 67.7% of the patients had the nerve medial to the tubercle of Zuckerkandl, and 32.3% had the nerve lateral to the tubercle of Zuckerkandl. There is a significant difference between the sides of the neck concerning the relation of the recurrent laryngeal nerve and the tubercle of Zuckerkandl, with a p-value of 0.009, as in **Table 2**.

**Table 3: Patient distribution according to RLN type**

| Type of RLN | Frequency (n) | Percentage (%) |
|---|---|---|
| RLN | 68 | 98.5 |
| Non RLN | 1 | 1.5 |

Approximately 98.5% of the patients had recurrent laryngeal nerves, according to the distribution of patients based on this kind of nerve. On the other hand, one patient, or around 1.5% of the patients, had non-recurrent laryngeal nerves, as in **Table 3**

**Table 4: Patient allocation based on branching pattern**

| Branching | Right side | | Left Side | | p-value |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Single | 32 | 56.1 | 42 | 67.7 | 0.427 |
| Double | 20 | 35.1 | 16 | 25.8 | |
| Triple/Multiple | 5 | 8.8 | 4 | 6.5 | |

Regarding the distribution of the patients based on the branching pattern of the recurrent laryngeal nerve between the two sides. On the right side, it was noted that more than half of the patients, 56.1%, had a single branch, followed by 35.1% of the patients who had two branches of the recurrent laryngeal nerve, and 8.8% of the patients had a triple or multiple branches of the nerve. In contrast, on the left side, about 67.7% had a single trunk, 25.8% of the patients had double branching, and only 6.5% had triple or multiple branching. The branching pattern of the recurrent laryngeal nerve did not significantly change between the two sides, as shown in Table 4.

**Discussion:**

The recurrent laryngeal nerve is one of the most common nerves that get injured during neck surgery and this is because of the presence of anatomical variation and its location in the neck. Thus this study assessed the recurrent laryngeal nerve's anatomical diversity and its relationship to the thyroid gland and its vascular pedicle. So, a total of 69 patients participated in the study. Among the total patients, 64 were patients, and the remaining 5 were cadavers from the anatomy laboratory.

Regarding the distribution of the age of the patients with thyroid disorder the mean age of the patients who participated in the study was 46.68 ± 12.46 years. In the study by Chaudhary M et al. [10] the mean age of the patients with thyroid disorders was 36.64 years, which was a little lower than the results of our study.

Regarding the distribution of the patients based on gender, the majority of the patients who participated in the study (66.7%) were found to be females, and males contributed to about 33.3% of the total study participants. Like our study, Chaudhary M et al.[10] showed that females were more commonly affected by thyroid disorders than males. In his study, about 88% of the patients with thyroid disorders were found to be females.

Most of the patients with thyroid disorders were from the rural areas in our study, constituting about 62.3%, whereas only 37.7% were from urban areas. Similar to our study, Yan Y et al. [11] also showed that the prevalence of thyroid disorders was higher in rural areas compared to urban areas.

On evaluating the distribution of the patients based on the symptoms of presentation to the hospital, the majority of the patients, 65.2%, presented with swelling in the neck, followed by 30.4% of the patients who had breathing difficulty. About 14.5% of the patients had dysphagia as the presenting complaint, and only 8.7% of the patients had hoarseness of voice. The study by Ross DS et al. [12] also showed that the most common presentation of the patients with thyroid disorder was swelling in front of the neck.

In our study, about 42.2% of the patients had symptoms for less than one year, followed by 39.1% for 1 to 2 years, and only 18.7% for more than two years. Similar to our study, the study by Chaudhary M et al. [10], where about 60% of the patients had neck swelling for less than a year, followed by 26% of the patients who had a history of neck swelling between 5 years and about 14% of the patient had neck swelling between 5 and 10 years.

In our study, about 68.7% of the patients had a positive history of smoking, whereas 31.3% of the patients didn't have any smoking history. There are studies which showed that smoking will enhance the diffuse enlargement of the thyroid gland [13]. The diffuse enlargement of the thyroid gland may be due to the persistent inflammation induced by smoking, which can result in the enlargement of the thyroid gland. Smoking also induces changes in the thyroid function test, like a decrease in TSH and an increase in the thyroid hormones.

On exploring the history of alcohol consumption among the patients, it was noted that 43.7% of the patients had a positive history of alcohol consumption, only 56.3% of the patients didn't have any alcohol consumption history. However, the study by Baldhara YPS et al. [14] showed that alcohol use causes direct cellular toxicity of the thyroid cells, which in turn leads to the development of the nonduality of the thyroid and also thyroid cancers. However, studies from the American Thyroid Association showed that a moderate amount of consumption of alcohol leads to a decreased risk of the development of hypothyroidism.

On exploring the distribution of the patients based on the clinical diagnosis, nearly half of the patients had multi-nodular goitre, followed by 29% of the patients having a solitary nodular goitre, and about 14.5% had malignancy. And 7.2% of the cadaver cases were taken as usual. The study by Chaudhary M et al. [10] showed that about 64% of the patients

in their study had solitary nodular thyroid, and 36% of the patients had multinodular goitre.

On evaluating the patients based on the ultrasound grading, about 33.3% had TIRADS grade 3, and 31.9% had TIRADS grade 2. About 11.6% of the patients had TIRADS grade 4, and 8.7% and 14.4% had TIRADS 5 and 1 respectively. The study by Chaudhary M et al. [10] showed that about 68% of the patients who participated in the study had TIRADS II GRADE, followed by about 16% of the patients found to have TIRADS-III. About 6% and 10% of the patients were found to have TIRADS IV and V, respectively.

In our study 37.7% had Bethesda 2. According to the FNAC findings, around 46% of the 50 patients with thyroid enlargement in the research by Basharatetal et al. [15] were determined to be benign, followed by 44% of patients who were intermediate, and only 10% of the patients were labeled as malignant.

In our study, about 1.5% of the patients had non-recurrent laryngeal nerves, and almost all were found to have 98,5% recurrent laryngeal nerves. The study by Morais M et al. [7] showed that the incidence of the non-recurrent laryngeal nerve was around 0.3 to 0.8% on the right side among the general population. The non-recurrent laryngeal nerve was very rare on the left side.

Regarding the distribution of the patients based on the branching pattern of the recurrent laryngeal nerve between the two sides. On the right side, it was noted that more than half of the patients, 56.1%, had a single branch, followed by 35.1% of the patients who had two branches of the recurrent laryngeal nerve, and 8.8% of the patients had a triple or multiple branches of the nerve. In contrast, on the left side, about 67.7% had a single trunk, 25.8% of the patients had double branching, and only 6.5% had triple or multiple branching. The two sides had no significant difference in the recurrent laryngeal nerve branching pattern. Similar to the study by Chaudhary M et al. [10]

In our study, 52.6% of the patients had the recurrent laryngeal nerve in the tracheoesophageal groove, followed by 28.1% of the patients who had the nerve posterior to the trachea, 14% of the patients had the presence of the nerve anterior to the trachea, and only the 5.3% had lateral to trachea on the right side. Whereas on the left side, about half of the patients 53.2% had the nerve in the tracheoesophageal groove, followed by 33.9% had the nerve posterior to the trachea followed by 8.1% had the nerve lateral to the trachea, and at least 4.8% had anterior to the trachea. The study didn't show any significant difference in the position of the nerve between the sides of the neck. Consistent with the research conducted by Chaudhary M et al. [10].

On exploring the position of the recurrent laryngeal nerve concerning the inferior thyroid artery and on exploring the right side of the neck, about 40.3% of the patient had the nerve between the branches of the inferior thyroid artery, followed by 35.1% of the patient had the nerve posterior to the inferior thyroid artery and 24.6% of the patient had the nerve anterior to the artery. Whereas on the left side of the neck, more than half of the patients 66.1% had the nerve posterior to the inferior thyroid artery, followed by 24.2% of the patients had the nerve between the branches of the artery and 9.7% of the patients had the nerve anterior to the artery. A significant difference was noted in the position of the nerve about the artery on both sides, with a p-value of 0.002. and the study by Saldanha M et al. [16] showed that on the right side of the neck, about 95% of the patients had the inferior thyroid artery found superficial to the nerve, and about 5% had the artery deep to the nerve. On the left side, about 82% of the patients had the artery superficial to the nerve, and 18% had the inferior thyroid artery deep to the nerve.

In our study, about 87.7% of the patients had nerve medial to the tubercle of Zuckerkandl, and 12.3% had nerve lateral to the tubercle. Similarly, on the right side, about 67.7% of the patients had the nerve medial to the tubercle of Zuckerkandl, and 32.3% had the nerve lateral to the tubercle of Zuckerkandl. There is a significant difference between the sides of the neck concerning the relation between the recurrent laryngeal nerve and the tubercle of Zuckerkandl, with a p-value of 0.009 similar to the study by Chaudhary M et al. [10].

The function of the berry ligament and the recurrent laryngeal nerve were compared in our study. In our study, on the right side, all the recurrent laryngeal nerves were found on the lateral side of the ligament of the berry. In contrast, on the left side, about 1.6% of the patients had the recurrent laryngeal nerve within the ligament of the berry, and the remaining 98.4% had the nerve lateral to the structure similar to studies by Saldanha M et al. [16]

Approximately 66.7% of the patients had nodular colloid goitre, followed by 11.6% of patients with papillary carcinoma, according to the final histological diagnosis used to evaluate the patients. Only 5.8% of the patients were identified with Hashimoto's thyroiditis, but 8.7% of the patients had follicular adenoma and 7.2% had follicular cancer. Similar to our study, the study by Saldanha M et al. [16] also showed that the most common histopathological diagnosis was found to be nodular colloid goitre, which constitutes about 65% of the patients, followed by follicular adenoma, which constitutes about 10% of total cases. Hashimoto's thyroiditis was present in 8% of the cases, and papillary carcinoma was also noted in 8% of the total cases. Follicular carcinoma was noted in only 2% of the cases in the study, which was similar to our study result .

Strength:

1. We evaluated the diversity in the branching pattern of recurrent laryngeal nerve.
2. The connection between the thyroid gland and the recurrent laryngeal nerve.
3. We assessed the connection between the inferior thyroid artery and the recurrent laryngeal nerve.
4. We assessed the association of the variation of the recurrent laryngeal nerve and various demographic factors of the patient.
5. We identified and protected the non-recurrent laryngeal nerve during surgery.
6. The present study supports the concept of correlation between smoking and thyroid swelling.
7. The study helps in the identification of area of danger for safe thyroidectomy.
8. Adequate and detailed follow-up was done in the study.
9. All patients in the study were educated about the study and consent taken.
10. Identifying and preserving the nerve has a significant impact in the patient's quality of life.

Limitations:

1. The sample size of the cadavers and patients studied may not be large or diverse enough to generalize the findings to the broader population.
2. Anatomical variation can differ significantly among different ethnicities and demographics which may not be fully represented in the study.
3. Observer bias maybe seen as the dissection technique vary among different surgeons.
4. Nerve monitoring devices could used intraoperatively.

**Conclusion:**

Injuring the nerve will have a severe impact on the life of the patient. Our analysis revealed several anatomical variations in the recurrent laryngeal nerve course. Our investigation found that there were considerable differences between the two sides of the neck in the interaction between the inferior thyroid artery, the tubercle of zuckerkandl and the recurrent laryngeal nerve. The operating surgeon should have a thorough knowledge of the anatomical variation in the recurrent laryngeal nerves to avoid any adverse events during the surgical procedures. This helps prevent unnecessary complications and improves the patient's quality of life.

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