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# RECURRENT LARYNGEAL NERVE VARIATIONS IN RELATION TO VARIOUS LANDMARKS DURING THYROID SURGERIES AND CADAVERIC DISSECTIONS AT A TERTIARY HOSPITAL

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**ABSTRACT** **Introduction:** The recurrent laryngeal nerve (RLN) is a vital anatomical and surgical element in thyroid surgery. Its anatomical knowledge is extremely important for any surgeon to prevent injury to the nerve which is one of the chief hazards of thyroid surgery. The RLN is more prone to injury when no attempt is made to identify it. **Aim:** To study the relationship of recurrent laryngeal nerve with various landmarks i.e, 1) Inferior thyroid artery 2) Berry's ligament 3) Zuckerkandl's tubercle (ZT) 4) Beahrs triangle. **Materials And Methods:** This was a prospective study which included 25 patients undergoing hemi thyroidectomy/total thyroidectomy [Group A] in Surgery department and 50 cadaveric dissections (25 cadavers) of normal or enlarged thyroid [Group B] in Anatomy department at Rajindra Hospital, Patiala. Data was reported in terms of mean, standard deviation, percentages and charts using SPSS 22 software and Microsoft Excel. Data was analysed using Chi square and Fischer exact tests. **Results:** This study showed that 78.4% of RLNs in live surgeries and 64% of the RLNs in cadaveric dissections were posterior to the artery. In live surgeries, all the nerves were superficial to the berry's ligament(100%) where as in cadaveric dissection, 92% of the nerves were superficial to berry's ligament. The nerve was found to be posterior to the Zukerkandl tubercle in 70.6% of cases in live surgeries and in cadaveric dissection, 90% were found posterior to the tubercle. Beahrs triangle was appreciated in 36.8% thyroidectomies whereas its appreciation was as high as 92% in cadaveric dissections. **Conclusion:** From our study it was also concluded that the LB was the most consistent and reliable landmark to identify the RLN followed by the ZT.

**KEYWORDS :** Recurrent Laryngeal Nerve, Inferior thyroid artery, Berry's Ligament, Zuckerkandl's tubercle, Beahrs Triangle

## INTRODUCTION

Thyroid surgery is one of the most commonly performed procedures in head and neck surgery[1]. The recurrent laryngeal nerve (RLN) is a vital anatomical and surgical element in thyroid surgery. Because of its close proximity to the thyroid gland, its anatomical knowledge is extremely important for any surgeon performing head and neck surgery[1].

RLN is prone to injury during thyroid surgery due to its variable course. The most common cause of RLN palsy is iatrogenic RLN injury. Unilateral RLN paralysis leads to voice fatigue, changes in vocal range and pitch whereas bilateral palsy leads to stridor, dyspnea and life-threatening glottal obstruction. Therefore, several landmarks have been proposed for proper identification of the nerve during thyroidectomies to decrease the incidence of injury[2-3].

A most classical landmark among them is the inferior thyroid artery (ITA). After arising from the thyrocervical trunk at the inner border of the anterior scalene muscle, it courses medially towards thyroid gland. The artery reaches the thyroid gland at the junction of the upper two thirds and lower third of the outer border[4]. RLN both on the right as well as on the left run either posterior, anterior or between the branches of ITA[5].

The Ligament of Berry (LB) is a dense consolidation of pretracheal fascia, that anchors the thyroid gland to the trachea and larynx[6]. The distal 2 cm of the extra laryngeal course of the RLN is intimately related to the LB hence constituting an important landmark in the course of the RLN and is the most common site of surgical injury to the RLN[7-8].

Zuckerkandl's tuberculum (ZT) is an enlargement of the lateral edge of the thyroid lobes, closely connected with the superior parathyroid gland. Pelizzo considered the tubercle of Zuckerkandl to be a constant landmark, and proposed a four-grade classification system according to the size of this anatomical feature[9].

Similarly, various triangles have been described along the course of RLN. Important among them is Beahrs triangle which is also known as Riddle's triangle. Beahrs triangle is bounded by common carotid artery at the base, superiorly by inferior thyroid artery and the lower arm of the triangle is formed by RLN[10-11].

Henry et al[12] and Armstrong et al[13] suggested that LB is the best landmark for identification of the nerve whereas there are studies done by Pelizzo et al[9], Asgharpour et al[14], Gauger et al[15], Irkorucu et al[16] and Kaisha etal[17] which suggest ZT as the best landmark. Thus, there is no conclusive evidence for a single best landmark for the identification of nerve. This study is also an attempt to determine the best landmark that aids in the identification of the recurrent laryngeal nerve and thus minimizing the chances of injury to the RLN.

## MATERIALAND METHODS

This was a prospective study which included 25 patients undergoing hemi thyroidectomy/total thyroidectomy [group A] in Surgery department and 50 cadaveric dissections (25 cadavers) of normal or enlarged thyroid [group B] in Anatomy department at Rajindra Hospital, Patiala between May 2019 to 2020. Data was analyzed using IBM SPSS software version 22 and MS Excel and was reported in terms of mean, percentages, tables and charts. Chi square and Fischer exact tests were applied to find association between the variables and p-value less than 0.05 was considered statistically significant.

**3 types of variations of RLN were noted in this study namely non branching, branching in two and non recurrent laryngeal nerve.** The relation of RLN with ITA was compared as the nerve passing anterior, posterior or in between the branches of ITA. The relation of RLN with LB was compared as the nerve passing superficial, deep or penetrating the LB. The relation of RLN with ZT was compared as the nerve passing anterior or posterior to ZT. Beahrs triangle was identified and the relation with the nerve was noted.

### Inclusion Criteria For Surgical Patients

1. Patients undergoing hemithyroidectomy/ total thyroidectomy for benign conditions.
2. Patients willing to participate in the study.

### Exclusion Criteria For Surgical Patients

1. Patients not fit or not willing for surgery.
2. Patients not willing to participate in the study.

3. Thyroid malignancies.

## RESULTS

### 1. Relation of RLN with ITA

In live surgery, a total of 37 RLNs were found to have relation with ITA. 7 (18.9%) nerves were passing anterior to ITA and a single nerve (2.7%) was found passing in between the branches of ITA. Majority of these nerves i.e. 29 (78.4%) RLNs were found posterior to ITA.

In 25 cadaveric dissections, 50 RLNs were identified. All the RLNs and the main trunk or branches of the ITA were found to intersect in our study (100%). 5 (10%) nerves were passing anterior to ITA and 13 (26%) nerves were found passing in between the branches of ITA. Majority of these nerves i.e. 32 (64%) RLNs were found posterior to ITA.

**Table/Figure 1: Relation of RLN with ITA in live surgeries**

| Side | Anterior to ITA | | Between the branches of ITA | | Posterior to ITA | |
|---|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | Number | Percentage |
| Left | 3 | 17.6 | 1 | 5.9 | 13 | 76.5 |
| Right | 4 | 20.0 | 0 | 0.0 | 16 | 80.0 |
| Total | 7 | 18.9 | 1 | 2.7 | 29 | 78.4 |
| Fisher Exact Test | 1.211 | | | | | |
| P value | 0.829 | | | | | |
| Significance | Non Significant (NS) | | | | | |

**Table/Figure 2: Relation of RLN with ITA in cadaveric dissections**

| Side | Anterior to ITA | | Between the branches of ITA | | Posterior to ITA | |
|---|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | Number | Percentage |
| Left | 2 | 8.0 | 8 | 32.0 | 15 | 60.0 |
| Right | 3 | 12.0 | 5 | 20.0 | 17 | 68.0 |
| Total | 5 | 10.0 | 13 | 26.0 | 32 | 64.0 |
| Fisher Exact Test | 1.077 | | | | | |
| P value | 0.683 | | | | | |
| Significance | Non Significant (NS) | | | | | |

### Relation of RLN with LB

In live surgeries, RLN was consistently found to be superficial to Berry's Ligament in all the cases (100%). The non recurrent laryngeal nerve was also superficial to the ligament (100%). No cases were seen where the nerve was piercing, or traversing deep to the ligament.

Out of 50 RLN cadaveric dissections, 46 (92%) nerves were found to be superficial to the ligament whereas 4 (8%) were found to be penetrating the ligament and no nerve was found to traverse deep to the ligament.

**Table/Figure 3: Relation of RLN with LB**

| Side | Superficial to LB | | Deep to LB | | Penetrating LB | |
|---|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | Number | Percentage |
| Left | 17 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| Right | 21 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| Total | 38 | 100.0 | 0 | 0.0 | 0 | 0.0 |
| Chi Square | - | | | | | |
| P value | - | | | | | |
| Significance | - | | | | | |

**Table/Figure 4: Relation of RLN with LB in cadaveric dissections**

| Side | Superficial to LB | | Deep to LB | | Penetrating LB | |
|---|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | Number | Percentage |
| Left | 23 | 92.0 | 0 | 0.0 | 2 | 8.0 |
| Right | 23 | 92.0 | 0 | 0.0 | 2 | 8.0 |
| Total | 46 | 92.0 | 0 | 0.0 | 4 | 8.0 |
| Fisher Exact Test | - | | | | | |
| P value | - | | | | | |
| Significance | - | | | | | |

### Relation of RLN with ZT

In live surgeries, Zuckerkandl tubercle was identified in 32 (84.2%) hemi thyroid specimen. ZT was indeterminate in 6 (15.8%) hemi thyroid specimen. 2 (5.3%) nerves were passing anterior to ZT and 30 (78.9%) RLNs were found posterior to ZT.

In our study, ZT was identified in 45 (90%) cadaveric dissections. Tubercle was indeterminate in 5 (10%) dissections. 45 (90%) nerves were found posterior to the tubercle. Not a single nerve was found anterior or piercing the parenchyma of the tubercle.

**Table/Figure 5: Relation of RLN with ZT in live surgeries**

| Side | Anterior to ZT | | Posterior to ZT | | Indeterminate | |
|---|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | Number | Percentage |
| Left | 1 | 5.9 | 12 | 70.6 | 4 | 23.5 |
| Right | 1 | 4.8 | 18 | 85.7 | 2 | 9.5 |
| Total | 2 | 5.3 | 30 | 78.9 | 6 | 15.8 |
| Fisher Exact Test | 1.683 | | | | | |
| P value | 0.581 | | | | | |
| Significance | Non Significant (NS) | | | | | |

**Table/Figure 6: Relation of RLN with ZT in cadaveric dissections**

| Side | Anterior to ZT | | Posterior to ZT | | Indeterminate | |
|---|---|---|---|---|---|---|
| | Number | Percentage | Number | Percentage | Number | Percentage |
| Left | 0 | 0.0 | 21 | 84.0 | 4 | 16.0 |
| Right | 0 | 0.0 | 24 | 96.0 | 1 | 4.0 |
| Total | 0 | 0.0 | 45 | 90.0 | 5 | 10.0 |
| Fisher Exact Test | 2.000 | | | | | |
| P value | 0.349 | | | | | |
| Significance | Non Significant (NS) | | | | | |

## DISCUSSION

Injury to the recurrent laryngeal nerve is one of the chief hazards of thyroid surgery. The RLN is more prone to injury when no attempt is made to identify it[18,19]. So it is important to identify and preserve the RLN routinely during thyroid surgery to minimize the incidence of RLN injury.

In the present study, 50 cadaveric dissections (25 cadavers) and 25 live surgeries (13 hemithyroidectomy and 12 total thyroidectomy) were done. The RLN and its relation to ITA, LB, ZT were observed to conclude the most consistent landmark that can be reliably used to identify RLN.

Knowledge of the relationship between the RLN and the ITA is very important for the surgeon performing thyroid surgery. A branch of ITA may be mistakenly identified as RLN resulting in a catastrophic transection injury[20,21].

This study has shown that 29 (78.4%) RLNs in live surgeries lies posterior to the ITA. Similarly cadaveric dissection also showed 32 (64%) of the RLNs were posterior to the artery. Our results are also consistent with the findings of a large prospective study conducted by Ardito G et al[22], where 61% on the right side and 77.4% on the left side, the nerve was passing posterior to the ITA. Many other studies Page C et al[23], Nyeki AR et al[1], Yalcxin B et al[24] etc, which have reported that the posterior relation of the nerve to the artery is most commonly seen. The idea of that the RLN is more frequently posterior to the ITA, and moreover, expecting this relation to repeat on both sides, gives a false sense of security to the surgeon[25].

If the nerve lies anterior to, or between the branches of the ITA, there is increased chance of injuring the nerve during the thyroid gland mobilization than when the nerve is posterior to the ITA. Therefore, the identification and visual control of the RLN and the ITA, as well as the determination of their anatomical relationships, are essential principles for diminishing morbidity related to thyroidectomies.

**Table 7: Comparison of variations of RLN in relation to ITA with different studies**

| Author | Live/Cadaveric Dissection | Year of study | Place of study | Sample Size | Total | Anterior | | Between | | Posterior | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Left | Right | Left | Right | Left | Right |
| Armstrong WG et al[13] | Cadaveric | 1951 | New York | 50 | 100 | 14 | 20 | 9 | 14 | 27 | 16 |
| Al-Salihi AR et al [21] | Cadaveric | 1989 | Iraq | 106 | 212 | 13 | 36 | 10 | 39 | 83 | 31 |
| Lekacos NL et al [26] | Live | 1992 | Greece | 172 | 191 | 12 | 38 | 25 | 19 | 45 | 52 |
| Campos BA et al [27] | Cadaveric | 2000 | Brazil | 76 | 142 | 13 | 27 | 32 | 35 | 27 | 8 |
| Page C et al [23] | Live | 2002 | France | 79 | 40 | 4 | 4 | 6 | 10 | 10 | 6 |
| Ardito G et al [22] | Live | 2004 | Italy | 1543 | 1856 | 18 | 113 | 187 | 256 | 706 | 576 |
| Matubis JS et al [28] | Cadaveric | 2011 | Philippines | 54 | 108 | 12 | 20 | 3 | 9 | 39 | 25 |
| Tang WJ et al [25] | Cadaveric | 2012 | China | 80 | 160 | 6 | 60 | 5 | 12 | 69 | 8 |
| Nyeki AR et al [1] | Live | 2015 | Cameroon and Gabon | 56 | 62 | 3 | 10 | 4 | 5 | 23 | 17 |
| Ling XY et al[29] | Live | 2016 | Australia | 4327 | 5876 | 334 | 822 | 634 | 826 | 1932 | 1328 |
| Present study | Live surgery | 2019-2020 | India | 25 | 37 | 3 | 4 | 1 | 0 | 13 | 16 |
| | Cadaveric Dissection | | India | 25 | 50 | 2 | 3 | 8 | 5 | 15 | 17 |

**Table 8: Comparison Of Variations Of RLN In Relation To Ligament Of Berry With Different Studies**

| Author | Live surgery/ Cadaveric dissection | Place of Study | Year of study | Sample Size | Number of RLNs | Superficial (%) | Penetrating (%) | Deep (%) |
|---|---|---|---|---|---|---|---|---|
| Hunt PS et al[31] | Cadaveric dissection | Australia | 1968 | 100 | 151 | 47 | 0 | 53 |
| Sasou S et al[32] | Live surgery | Japan | 1998 | 486 | 689 | 100 | 0 | 0 |
| Çakir BÖ et al[3] | Cadaveric dissection | Turkey | 2006 | 65 | 130 | 100 | 0 | 0 |
| Kaisha W et al[17] | Cadaveric dissection | Kenya | 2011 | 73 | 146 | 67 | 7.4 | 25.6 |
| Pradeep PV et al[30] | Live surgery | India | 2012 | 404 | 584 | 61 | 31.2 | 7 |
| Asgharpour E et al[14] | Cadaveric dissection | Spain | 2012 | 143 | 286 | 88.1 | 11.9 | 0 |
| Nyeki AR et al[1] | Live surgery | Cameroon and Gabon | 2015 | 56 | 62 | 93 | 6.5 | 0 |
| Present study | Live surgery | India | 2019-2020 | 25 | 38 | 100 | 0 | 0 |
| | Cadaveric dissection | | | 25 | 50 | 92 | 8 | 0 |

**Table 9 : Comparison of prevalence of ZT with different studies**

| Author | Cadaveric dissection / live surgery | Place of study | Year | Sample size | Prevelance |
|---|---|---|---|---|---|
| Won SY et al[33] | Cadaveric dissection | Korea | 2016 | 30 (60 sides) | 83% |
| Kaisha W et al[17] | Cadaveric dissection | Kenya | 2015 | 73 (146 sides) | 59% |
| Yalcxin B et al[24] | Cadaveric dissection | Turkey | 2007 | 50 (100 sides) | 100% |
| Irkorucu O et al[16] | Live surgery | Turkey | 2016 | 100 (176 sides) | 73.4% |
| Mehmood Z et al[34] | Live surgery | Pakistan | 2015 | 84 (52 sides) | 62% |
| Page C et al[23] | Live surgery | France | 2009 | 79 (40 sides) | 7% |
| Gauger PG et al[15] | Live surgery | Australia | 2001 | 100 | 63% |
| Pelizzo MR et al[9] | Live surgery | Italy | 1998 | 104 | 100% |
| Gurleyik E et al[35] | Live surgery | Turkey | 2012 | 100 (160 sides) | 51% |
| Present study | Live surgery | India | 2019-2020 | 25 (38 sides) | 84.2% |
| | Cadaveric dissection | | | 25 (50 sides) | 90% |

In our live surgeries all the nerves were consistently found to be superficial to berry's ligament in all the cases irrespective of sides.(100%). In cadaveric dissection, 46 nerves (92%) were found to be superficial to berry's ligament. Our results coincides with the prevalence rates noted in studies such as those by Çakir BÖ et al(100%)[3], Asgharpour E et al (88.1%)[14], Kaisha W etal (67%)[17], Nyeki AR et al(93%)[1] and Pradeep PV et al(61%)[30].

As per the literature and our study, the relation of the nerve with the LB is very consistent and the nerve is almost always superficial to the LB. So it is safe to use LB as the reliable landmark for the identification of nerve during surgery.

In our live surgeries, 30(78.9%) nerves were found posterior to the tubercle. Similarly in cadaveric dissection, 45 nerves (90%) were found posterior to the tubercle. Overall, majority of the studies reported that the RLN is related to the posterior or to the posteromedial to ZT. This study showed that most of the ZT in our patients were less than 10 mm and the surgeon should be careful for recognising it. The sizes of ZT may vary according to multiple factors such as the volume of thyroid gland, the severity of the thyroid disease, and the number of nodules. The difficulty in identification of ZT makes it unreliable to use as the consistant landmark for identification of RLN.

Beahrs triangle is bounded by common carotid artery as base, inferior thyroid artery superiorly and RLN as lower arm of triangle. In our live surgeries, in 36.8% of cases Beahrs triangle was appreciated where as in cadaveric dissection, 92% of cases Beahrs triangle was appreciated. Recognizing the boundaries of triangle posterior to thyroid after retracting the ipsilateral thyroid lobe medially, helps in avoiding injury to RLN[10].

Our study depicts the difficulty of visualization of Beahrs triangle in the live surgery as compared to cadaveric dissection.

In our study no patient had temporary or permanent RLN palsy post operatively. With the proper identification of landmarks and the course of RLN the injury can be prevented.

## CONCLUSION

From our study it was also concluded that the Ligament of Berry was the most consistent and reliable landmark to identify the Recurrent Laryngeal Nerve followed by the Zuckerkandl tubercle. As this study was conducted with limited sample size, further studies with larger sample size are needed to establish the best landmark for the identification of the nerve and to prevent the recurrent laryngeal nerve injury during surgery.

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