A Novel Surgical Landmark to Identify the Recurrent Laryngeal Nerve (Identifying Recurrent Laryngeal Nerve)

Yusuf Dundar (✉ Yusuf.Dundar@ttuhsc.edu)
Texas Tech University Health Sciences Center

Cynthia M Schwartz
Texas Tech University Health Sciences Center

Micah Lierly
Texas Tech University Health Sciences Center

Tam Q Nguyen
Texas Tech University Health Sciences Center

Kerry K. Gilbert
Texas Tech University Health Sciences Center

Drew Smith
Texas Tech University Health Sciences Center

Nadia Tello
Texas Tech University Health Sciences Center

Joehassin Cordero
Texas Tech University Health Sciences Center

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Abstract

Objective

There are many surgical landmarks have been proposed to localize the recurrent laryngeal nerve (RLN). However, there is still no reliable landmark to find the RLN precisely. The objective was to use the inferior border of the cricopharyngeal muscle and the ICTC to define a reliable landmark for the RLN.

Methods

Cadaver dissection study in an Academic Otolaryngology-Head and Neck Surgery Residency Training Program. A cadaveric study of 64 RLNs was carried out, including measurements of different surgical landmarks in conjunct to proposed surgical landmark (Dundar's point).

Results

The average distance from the reference point to the RLN is 2.3mm and the RLN is localized just posterior to the reference point in 95.3% of dissection specimens. The RLN passes under the inferior constrictor muscle in 90.6% of the cases. There was no statistically significant difference between right and left RLNs in term of relation with the reference point.

Conclusions

The proposed surgical point can be used as a reliable landmark to identify the RLN. This reference point can help surgeons during difficult cases by providing additional anatomical landmark.

Level of Evidence: IV

1. Introduction

Thyroidectomy is one of the most common procedures in head and neck practice. The recurrent laryngeal nerve (RLN) should be accurately identified to ensure safe thyroid surgery\(^1,2\). However, the RLN has many anatomic variations, and there is no single reliable landmark to localize it during thyroidectomy procedures\(^3\). This can be especially problematic during revision thyroidectomies when the primary surgery and post operative scar may distort the anatomy.

There are many surgical landmarks that have been used to localize the RLN, including the inferior thyroid artery, Berry's ligament, the tracheoesophageal groove, the inferior horn (cornu) of the thyroid cartilage (ICTC), the inferior pharyngeal constrictor muscle, Zuckerkandl’s tubercle, the carotid artery, and others\(^4\)\(^-\)\(^10\). However, none of those landmarks can be used to precisely localize the RLN because of its variable anatomic course. Yet, the ability to precisely locate the RLN is the gold standard in the prevention of nerve damage and voice preservation.
The most identifiable landmark of the RLN is the point of entry to the larynx, which is typically posterior to the ICTC\(^3\). This entry point is reliable and constant, regardless of anatomic variations or thyroid gland pathologies, likely because it is based on cartilage, which is usually less variable than soft tissue. However, the point of entry is almost always covered by several layers of soft tissue, blood vessels, and the inferior constrictor muscle. In addition, the RLN may have anatomic variations such as extra-laryngeal branches close to the point of entry, which makes exposing it challenging and prone to unexpected complications.

Locating the ICTC can be helpful in predicting the location of the point of entry. This feature was first introduced as a surgical landmark by Wang in 1975\(^4\). Uen et al. reported an average distance of 8 +/- 4 mm from the ICTC to the point of entry of the larynx\(^5\). However, this landmark, like many, only defines the nerve at one point, predicting the superoinferior location (y axis).

The inferior pharyngeal constrictor and cricopharyngeal muscles are other reliable landmarks to help localize the RLN. Wafae et al. reported that the RLN passes under the cricopharyngeal muscle or may pierce the muscular fibers\(^6\). This landmark also helps surgeons to predict the depth of the RLN. However, it is not easy to localize the nerve using this landmark alone because there is a risk of violating the RLN and its branches. Blind dissection of inferior pharyngeal constructor and cricopharyngeal muscles can lead to unwanted nerve complications. Surgeon needs to know where to look for the nerve precisely. Ideally, a surgical landmark needs to be i) safe, ii) easy to identify, iii) reliable, iv) provide three-dimensional coordinates, and v) possess a stable relationship with the targeted anatomic structures, in this case, the RLN.

2. Materials and Methods

The goal of this study was to identify an ideal surgical landmark or combination of landmarks to localize the RLN. This cadaveric study is designed to evaluate the possibilities of using a novel combination of two different reliable landmarks to localize the RLN with three-dimensional coordinates.

i. The first landmark is the inferior rim of the cricopharyngeal muscle, which provides the x-axis to predict the vertical/cranio-caudal location as well as the z-axis to predict the depth of the nerve (Figure 1)

ii. The second landmark is a vertical line from the most prominent portion of the ICTC. This second landmark provides the y-axis and helps to predict anterior-posterior location of the nerve (Figure 1).

The proposed reference point (Dundar's point) in this study is the crossing point of the x and y axes described above (Fig. 1 - ). This reference point is also shown marked on the cadaveric specimens, in Fig. 2. The depth of the RLN from the reference point is defined by the cricopharyngeal muscle, which provides the z-axis. Our hypothesis is RLN can be found precisely by using the proposed reference point regardless from thyroid pathologies, previous surgeries, or anatomic variations.
Specimens

Thirty-two embalmed human cadavers were appropriately acquired through the Institute of Anatomical Sciences, Willed-Body Program at Texas Tech University Health Sciences Center, Lubbock TX, USA and approved for use by the TTUHSC Institutional Anatomical Review Committee. Cadaver specimens were handled in accordance with university policy and State of Texas regulations as determined by the Texas State Anatomical Board. At our institution, the Institutional Review Board does not consider research on cadavers to constitute human research. This project was approved by the Texas Tech University- Health Sciences Center, Institutional Anatomical Review Committee (IARC) on 12/21/21, and the IARC approval number was #21-1221-R. All State of Texas and University (TTUHSC OP 73.20) regulations were followed during the collection of data for this project. All cadavers were evaluated and were excluded from the study if any of these conditions were noted: i) congenital defects of the thyroid and/or RLN, ii) previous neck surgery in planes that could have disrupted the thyroid and/or RLN, and/or iii) existing neck wounds or obvious neck penetrating trauma.

The study was performed during the summer cadaver dissection course for the School of Health Professions within the TTUHSC Institute of Anatomical Sciences. The dissections were performed by the authorial team, under the supervision of the lead author, to ensure consistency. The necks of 32 white human adult embalmed cadavers were examined. They included 18 male and 14 female cadavers, with an age at death ranging between 56 and 92 years (mean age, 78.7 years). No gross pathology of the thyroid gland was observed. All cadavers were inside the size and weight range established by the Institute of Anatomical Sciences' Willed Body Program for the acceptance of body donation (weight from 40.8 to 89.8 kg, mean of 64.3 kg; and height from 149.9 to 193.0 cm, mean of 171.9 cm). They had been partially dissected by TTUHSC School of Health Professions students during the academic year and subsequently dissected by the authors.

If the cadaver met inclusion criteria, the study personnel proceeded with identifying the thyroid and recurrent laryngeal nerves. During the cadaver dissection, the positioning of the cadavers involved placing them in a supine position without the use of shoulder roll placement. The heads of cadavers were maintained in a neutral position to ensure consistency and eliminate potential variations that could arise from different head or neck positions. Then the strap muscles were separated, and the middle thyroid vein and the superior thyroid artery pedicles were identified and sacrificed. Next, the inferior constrictor and cricopharyngeal muscles and the ICTC were identified and marked. The proposed surgical reference point was marked, and the RLN was identified. The RLN was dissected proximally and distally to determine quantitatively its relationship with the other surgical landmarks. The following measurements were documented with the head in a centered supine position, without manipulating or retracting the surrounding structures:

- Distance from the proposed reference point
- Distance from the ICTC
- Relationship with the inferior constrictor muscle
- Extralaryngeal branching of the RLN
- Distance to Berry’s ligament
- Relationship with the inferior thyroid artery
- Angle with the tracheoesophageal groove
- Distance to the point of entry to the larynx and the proposed landmark
- Size of the thyroid gland

3. Results

Thirty-two cadavers were dissected, and 64 thyroid measurements were taken. A one-way ANOVA was performed to analyze the data using GraphPad Prism 9.4.1 (Dotmatics, Boston, Massachusetts, USA). Table 1 summarizes the measurement data from the collection of cadaveric dissections. The location of the RLN averaged about 2.3 mm from the reference point, 9.6 mm from the ICTC, and 2.3 mm from Berry’s ligament. The distance from the reference point to the point of entry to the RLN into the larynx averaged 9.4 mm. Proximal extralaryngeal branching (before the inferior rim of crycopharngeous muscle) averaged 1.4 branches per RLN. Distal branching (after the inferior rim of crycopharngeous muscle) averaged 2.1 branches. Notice that the reference point always lies within a few millimeters of the RLN in neutral position without any soft tissue retraction. In 95.3% of the specimens, the RLN was just posterior to the reference point. The RLN passed under the inferior constrictor muscle in 90.6% of the cases.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Measurements.</th>
<th>Right</th>
<th>Left</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean thyroid size</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Length</td>
<td>44.75 (mm)</td>
<td>42.87 (mm)</td>
<td>0.427</td>
</tr>
<tr>
<td></td>
<td>Width</td>
<td>29.31 (mm)</td>
<td>28.21 (mm)</td>
<td>0.540</td>
</tr>
<tr>
<td><strong>Mean distance of landmarks from the RLN</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reference point</td>
<td>2.25 (mm)</td>
<td>2.34 (mm)</td>
<td>0.662</td>
</tr>
<tr>
<td></td>
<td>IHTC</td>
<td>9.62 (mm)</td>
<td>9.65 (mm)</td>
<td>0.960</td>
</tr>
<tr>
<td></td>
<td>Berry’s ligament</td>
<td>2.34 (mm)</td>
<td>2.21 (mm)</td>
<td>0.575</td>
</tr>
<tr>
<td></td>
<td>Reference to point of entry of larynx</td>
<td>9.62 (mm)</td>
<td>9.25 (mm)</td>
<td>0.483</td>
</tr>
<tr>
<td><strong>Mean number of RLN branches</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RLN branches before the reference point</td>
<td>1.25</td>
<td>1.34</td>
<td>0.573</td>
</tr>
<tr>
<td></td>
<td>Distal RLN branches</td>
<td>3.37</td>
<td>3.37</td>
<td>1</td>
</tr>
<tr>
<td><strong>Mean angle from the tracheoesophageal groove (degrees)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>23.94</td>
<td>21.60</td>
<td>0.285</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6–45 )</td>
<td>(7–41 )</td>
<td></td>
</tr>
</tbody>
</table>
A Chi square was performed to compare the relationships between other various anatomical points on the right and left sides, as shown in Table 2. The mean angle between the tracheoesophageal groove and the right RLN averaged 23.9° and the left averaged 21.6°. However, differences were not significant. With respect to the relationship of the RLN and the inferior thyroid artery, the right side and left side exhibited significantly ($p = 0.003$) different patterns, with the right RLN passing over or between branches of the inferior thyroid artery more often than the left.

### Table 2

Relationships between the specified anatomical points.

<table>
<thead>
<tr>
<th>Relationship with the reference point</th>
<th>Right (n)</th>
<th>Left (n)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>1</td>
<td>2</td>
<td>0.5</td>
</tr>
<tr>
<td>Posterior</td>
<td>31</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relationship with the inferior constrictor muscle</th>
<th>Right (n)</th>
<th>Left (n)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under</td>
<td>29</td>
<td>29</td>
<td>0.223</td>
</tr>
<tr>
<td>Penetrates</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Over then penetrates</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Extralaryngeal branching</th>
<th>Right (n)</th>
<th>Left (n)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>29</td>
<td>29</td>
<td>0.664</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relationship with the inferior thyroid artery</th>
<th>Right (n)</th>
<th>Left (n)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under</td>
<td>20</td>
<td>31</td>
<td>$0.003^*$</td>
</tr>
<tr>
<td>Between</td>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Over</td>
<td>4</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

4. Discussion

The RLN serves to innervate most of the muscles of the larynx, such as those responsible for opening (e.g., posterior cricoarytenoid muscles), closing, and tensioning the vocal cords. Thus, vocal paresis or paralysis, associated with intra-operative damage to the RLN, can cause problems with speaking, such as dysphonia and aphonia, and problems with respiration. Not surprisingly, these issues can be the source of patient dissatisfaction and malpractice litigation, with otolaryngology and endocrine surgery among those specialties at legal risk. Safely locating the RLN during surgery, particularly revision surgery or other cases with distorted anatomy, is crucial, and this study provides a reliable method for locating the RLN that does not rely upon easily destroyed or distorted landmarks such as Berry’s ligament.

Vocal cord paresis or paralysis are common complications associated with thyroid surgery. The incidence of temporary paresis tends to be more prevalent than permanent paralysis. A large study by Chiang et al. reported temporary paresis in 2–4% of patients undergoing surgery for thyroid cancer and
primary benign thyroid disease, respectively. Permanent paralysis for these groups were 0.7% and 0.2%, respectively. Numbers in this range are reported in several other studies\textsuperscript{13}. The recent literature\textsuperscript{13} suggests that incidences of RLN palsy or paresis are more prevalent than previously reported in published large studies, possibly because centers with unfavorable outcomes may not report their data. Also, there is a lack of a routine laryngeal examination postoperatively; often, postoperatively, the vocal cords are not evaluated at all, so many cases of well-compensated, unilateral paresis or paralysis may go unnoticed. Incidences of temporary vocal palsy, associated with Graves’ disease and reoperations, were noticeably higher. Chiang et al\textsuperscript{12} pointed out that identification of the RLN is “the only way” to avoid injury. In their surgical approach, the RLN was not identified early in operation but as the operation proceeded towards Berry’s ligament\textsuperscript{12}. Similarly, Mohil et al\textsuperscript{13} indicated that damage to the RLN can be avoided by understanding the anatomy and routinely identifying the RLNs during surgery.

In this study we conducted a cadaver study to evaluate the reliability of Dr. Dundar’s reference point which he uses routinely for both revision thyroid surgeries and selected primary cases. This approach contributes to the identification of the RLN easier regardless from the distorted anatomy by previous surgeries and thyroid pathologies. Surgical steps include; i) skin incision and flap elevation, ii) separating strap muscles, iii) subcapsular dissection and delineating thyroid, iv) superior pole dissection and identifying/preserving superior laryngeal nerve, v) ligating superior thyroid vessels, vi) retracting thyroid antero-medially and delivering through the neck incision, vii) identifying RLN and superior parathyroid gland, viii) ligating inferior thyroid vessels right by the thyroid capsule, ix) dissecting thyroid from Berry’s ligament and trachea, x) bleeding control and closure. RLN can be found in many ways as previously described including lateral approach, finding inferiorly at Lore’s triangle, finding at point of entry or medial to lateral approach etc. All conventional techniques rely on soft tissue landmarks and previous surgeries may destroy the anatomy which makes revision surgeries very challenging because of missing most of surgical landmarks. We have been utilizing the proposed surgical landmark for a considerable period and have found it to be highly reliable in both fresh and revision thyroidectomy surgeries. The Dundar’s reference point can be found by palpating the ICTC and then drawing a line from the ICTC down to the inferior border of the cricopharyngeal muscle. The ICTC can easily be palpated and the identifying inferior border of the cricopharyngeal muscle laterally is also relatively straightforward even in revision cases. Previous thyroid surgery may remove Berry’s ligament, thyroid vessels but the ICTC and inferior border of the cricopharyngeal muscle should still be present and not distorted in almost all patients. This approach to identifying the RLN may also be useful during endoscopic thyroidectomies that proceed from superior to inferior, as the ICTC will be encountered relatively early during the operation. The crossing point of these two previously described lines is our main reference point, and the nerve can be found easily by using the proposed reference point. The nerve is usually located right posterior from the reference point and passes under the cricopharyngeal muscle and dives into cricoarytenoid joint. However, surgeon should be aware of extralaryngeal branching and there is almost always one nerve branch before the main nerve dives under cricopharyngeal muscle.
Our results indicate the proposed reference point is a reliable landmark and the RLN is within 2.3mm from the reference point, in 95.3% of the cadavers the RLN just posterior to the reference point and passes under the cricopharyngeal muscle in 90.6% of the cadavers. There is no statistically significant variations between right and left RLN in relation to proposed reference point. The right RLN did have a statistically significant more ($p = 0.003$) variable relationship with the inferior thyroid vessels, which was expected, given that the right RLN has an embryologically more complicated course than the left RLN.

The main limitation of this study is being an anatomic cadaver dissection which exclusively included white cadavers and omitted Hispanics, Blacks and Asians etc. Another limitation is the absence of clinical or intraoperative correlation. These limitations should be addressed in future studies to assess the reliability of the proposed surgical landmark in actual thyroidectomy surgeries. However, the cadaver dissection study provided valuable opportunities to explore additional structures and analyze relationships beyond the scope of standard thyroidectomy surgeries. These included dissecting RLN branches, exploring ICTC, tracing RLN up to the cricoarytenoid unit etc.

5. Conclusion

In this study, we are proposing a novel landmark to identify RLN. The proposed point, defined by palpating the ICTC and then following a line from the ICTC down to the inferior border of the cricopharyngeal muscle, can be easily and safely found. The RLN will likely be at just posterior and within 2.3mm from the reference point. The RLN usually passes under the inferior rim of the cricopharyngeal muscle. Knowledge of the relationship of the RLN to the proposed point (Dundar’s point) may help guide surgeons in safe surgeries, particularly during tricky revision cases, where the anatomy may be distorted, and landmarks may be missing.

Declarations

Acknowledgments

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Ethical Approval: Obtained; 32 embalmed human cadavers were appropriately acquired through the Institute of Anatomical Sciences, Willed-Body Program at Texas Tech University Health Sciences Center, Lubbock TX, USA and approved for use by the TTUHSC Institutional Anatomical Review Committee.

Competing Interest: None
Authors’ Contributions: Yusuf Dundar MD: Study design, data gathering, data analysis, writing, editing. 25% total contribution. Cynthia M Schwartz MD: Data gathering, data analysis, writing, editing. 15% total contribution. Micah Lierly PT, DPT: Data gathering, editing. 10% total contribution. Tam Q Nguyen MD: Data gathering, editing. 10% total contribution. Kerry K. Gilbert PT, ScD: Data gathering, editing. 10% total contribution. Drew Smith MD: Data gathering, editing. 10% total contribution. Nadia Tello MD: Data gathering, editing. 10% total contribution. Joehassin Cordero MD: Data gathering, editing. 10% total contribution.

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Availability of data and materials: Yes (Dissection pictures and documents)

Conflict of interest: The authors declare that there is no conflict of interest regarding publication of this paper.

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Author Contribution statement for each listed author:

Yusuf Dundar MD: Hypothesis of the Study, Study design, data gathering, data analysis, writing, editing. 25% total contribution.

Cynthia M Schwartz MD: Data gathering, data analysis, writing, editing. 15% total contribution.

Micah Lierly PT, DPT: Data gathering, editing. 10% total contribution.

Tam Q Nguyen MD: Data gathering, editing. 10% total contribution.

Kerry K. Gilbert PT, ScD: Data gathering, editing. 10% total contribution.

Drew Smith MD: Data gathering, editing. 10% total contribution.

Nadia Tello MD: Data gathering, editing. 10% total contribution.

Joehassin Cordero MD: Data gathering, editing. 10% total contribution.

References


Figure 1

Dundar’s point ( ) is the intersection of (1) the inferior border of cricopharyngeal muscle and (2) a line from the most prominent portion of the inferior cornu of the thyroid cartilage (ICTC).
Figure 2

The reference point is the intersection of the inferior border of cricopharyngeal muscle and a line from the most prominent portion of the inferior cornu (horn) of the thyroid cartilage (ICTC).