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Clinical Factors Associated with Difficulty in Identifying the Recurrent Laryngeal Nerve in Thyroid Surgery

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ABSTRACT

Background: An objective assessment of the difficulty in identifying the recurrent laryngeal nerve (RLN) in thyroid surgery is hard because it can be affected by the surgeon's experience and skills. Although several factors such as body habitus, size of the tumor, and operated side have been believed to be associated with the difficulty in finding the RLN, no reports have objectively validated the idea. Visual inspection over the visceral layer of pretracheal fascia is one of the safe approaches for identifying the RLN in thyroid surgery. Because this "visual inspection method" does not need dissection within the paratracheal adipolymphatic tissue, the success of the RLN identification is not affected by the surgeon's skill. This study aimed to disclose the factors associated with the difficulty finding RLN in thyroid surgery by assessment of the "visual inspection method."

Methods: A retrospective study was conducted on patients who underwent thyroid surgery. We evaluated the association between the failure of the "visual inspection method" and clinical variables, including gender, age, body mass index (BMI), operated side, nodule size, mediastinal extension of goiter, and cricoid position.

Results: In total, 147 RLNs in 115 patients were included in this study. Overall, 35 RLNs could not identified by the "visual inspection method" and required additional manipulation within the paratracheal adipose tissue. Multivariate analysis showed that high BMI and low cricoid position were independently associated with failure of the "visual inspection method."

Conclusion: High BMI and low cricoid position were independently associated with difficulty in identifying the RLN during thyroid surgery.

Keywords: Recurrent laryngeal nerve, visual inspection, thyroid surgery, pretracheal fascia, body mass index, cricoid position

Introduction

Thyroid surgery has undergone refinement throughout its long history. Today, most thyroid surgeries are safely completed without major complications. Nevertheless, recurrent laryngeal nerve (RLN) injury remains a real risk. The reported rates of iatrogenic RLN injury range from 0.39% to 9.3% in the literature.[1–6] Vocal cord fixation due to RLN injury can result in permanent dysfunctions such as breathy voice, weakness of cough, and liquid aspiration. Bilateral palsy often requires tracheostomy to maintain respiration. The most frequent reason for intraoperative RLN injury is overstretching of the nerve at the region around Berry's ligament. Other causes include inadvertent clamping by forceps or transection of the nerve and constriction by a band of connective tissue.[5]

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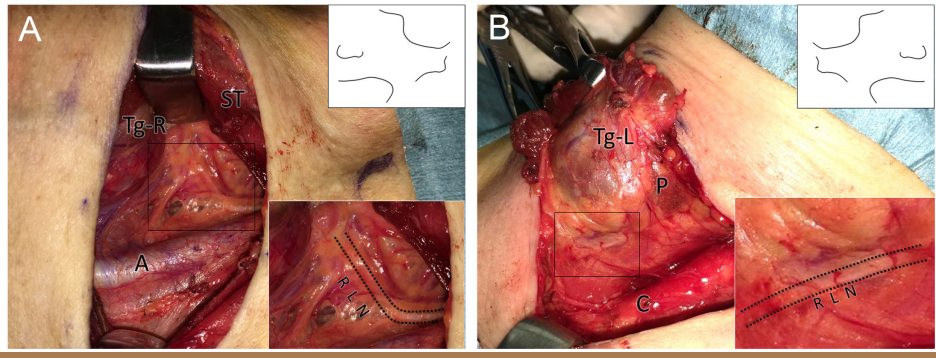

Figure 1. (A) Visual inspection over the visceral layer of the pretracheal fascia (v-PTF) on the left side of the neck. The right bottom shows the enlarged view of the boxed area. The right lobe of the thyroid gland is retracted medially. Both the v-PTF and the carotid sheath are kept intact. The right RLN (dotted line) is seen through the v-PTF. The RLN tends to course more laterally than the left RLN. (B) Visual inspection over the v-PTF on the left side of the neck. The right bottom shows the enlarged view of the boxed area. The left lobe of the thyroid gland is retracted anteriorly without disrupting the v-PTF. The left RLN (dotted line) is identified as running under the v-PTF. C, common carotid artery; P, parathyroid gland; RLN, recurrent laryngeal nerve; ST, sternothyroid muscle; Tg-L, left lobe of thyroid gland; Tg-R, right lobe of thyroid gland.

Generally, the RLN is identified by blunt dissection within the adipolymphatic tissue in the paratracheal space.[7,8] The detection of the RLN depends on the surgeon's skill and experience. Nuances of RLN course within the adipolymphatic tissue differ in each patient and are hard to predict. In addition, the dependence on the surgeon's experience prevents the objective analysis of the difficulty of RLN identification. Despite a common belief among surgeons that several clinical factors such as obesity, short neck, and large tumors are associated with difficulty in identifying the RLN during thyroid surgery, there has been no study that objectively validated this belief.

The pretracheal fascia (PTF) is an important anatomical layer covering the central compartment of the neck. The PTF is composed of 2 continuous layers. The muscular layer of PTF (m-PTF) spreads to cover the infrahyoid muscles. In contrast, the visceral layer of PTF (v-PTF) envelopes the larynx, trachea, thyroid gland, pharynx, esophagus, and RLN surrounded by the paratracheal adipolymphatic tissue.

When viewed from outside the v-PTF, the RLN is occasionally identified as a whitish string running just beneath the v-PTF (Figure 1). The visibility of the RLN through the v-PTF depends on anatomic factors but not surgical skills. Therefore, it can be used as an endpoint to objectively assess the difficulty of finding the RLN in thyroid surgery. Based on this concept, the present retrospective study aimed to identify the factors associated with the visibility of the RLN in thyroid surgery.

MAIN POINTS

- *The identification of the recurrent laryngeal nerve (RLN) is one of the key steps in thyroid surgery.*
- *Visual inspection over the visceral layer of the pretracheal fascia is a safe method to identify the RLN without dissecting within the paratracheal adipose tissue.*
- *The high body mass index and the low cricoid position are independent factors associated with the failure of the "visual inspection method."*
- *These two factors can be assessed preoperatively to predict the difficulty of finding the RLN in each case.*

Material and Methods

This study was conducted with the approval of the Institutional Review Board (IRB) of Japanese Red Cross Wakayama Medical Center (JRCWMC) (approval number 503, date: December 25, 2017). The requirement for written informed consent was waived by the IRB due to the retrospective, noninvasive, personally unidentifiable nature of the study. Instead, the study details were announced on the web-based announcement board of JRCWMC.

A retrospective cohort study was performed on patients who underwent thyroidectomy combined with central node dissection for a malignant or possibly malignant tumor between January 2016 and September 2018 at JRCWMC. The RLN at risk on every operated side was counted separately. The exclusion criteria included the sides where central node dissection had not been performed and sides where the standardized surgical method could not be performed due to advanced extrathyroidal tumor invasion. The database collected patient characteristics, size of thyroid nodule, range of thyroidectomy, pathology result, and several anatomical indexes. Mediastinal extension of the thyroid was defined as the caudal extension of the gland beyond the level of sternal notch. As a parameter for the position of the cricoid cartilage, the distance between the lower border of the cricoid cartilage and the sternal notch (cricosternal distance, CSd) was measured using computed tomographic (CT) images. To identify the factorsassociated with failure of the RLN identification by the "visual inspection method," several candidate factors were selected, including gender, body mass index (BMI) (cutoff value, 25), age (cutoff value, 75 years old), side of operation, nodule size (cutoff value, 4 cm), mediastinal extension of the thyroid gland, and cricoid position (cutoff value, 4 cm). The rate of iatrogenic RLN palsy was calculated based on the number of nerves at risk (Figure 2).

Operative procedures were standardized for reproducibility. Skin flaps were raised along the subplatysmal layer. After entering the sub-sternohyoid space, the muscular layer of the PTF was cut along the lateral border of the sternothyroid muscle. Then, the potential space between the v-PTF and the carotid sheath was bluntly dissected to expose the lateral aspect of the paratracheal space. The middle thyroid vein was transected when encountered. The v-PTF

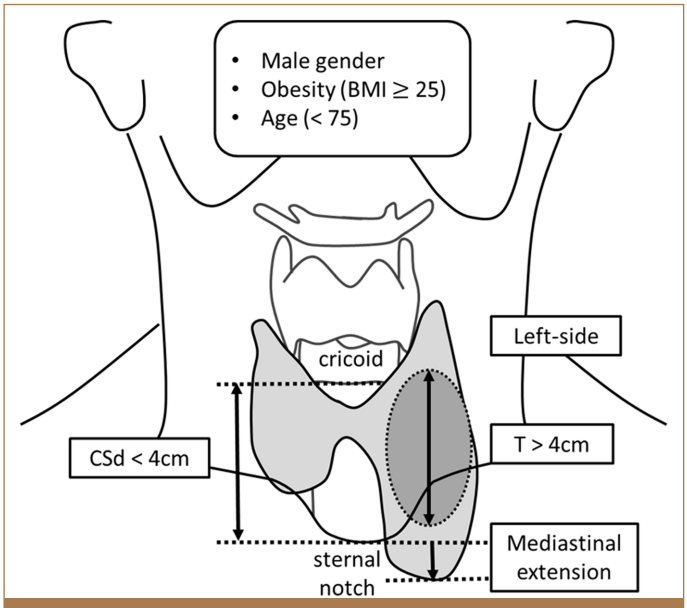

Figure 2. Candidate factors associated with the difficulty in identifying the recurrent laryngeal nerve identification by the "visual inspection method." BMI, body mass index; CSd, cricosternal distance.

and the carotid sheath were carefully kept intact during these steps (Figure 3). After that, the sternothyroid muscle overlying the thyroid lobe was transected at its upper and lower ends. After the superior vascular bundle of the thyroid lobe was cut while preserving the external branch of the superior laryngeal nerve, the thyroid upper pole was freed from the laryngeal framework. With the entire thyroid lobe being retracted anteriorly, the visibility of the RLN was evaluated by inspection from outside the v-PTF (Figure 4). Once the RLN was successfully identified by the inspection, the PTF covering the RLN was cut to expose the nerve. When the RLN was invisible from outside the v-PTF, the RLN was carefully searched for by conventional dissection within the paratracheal adipolymphatic tissue.

Vocal cord mobility was examined using a flexible laryngeal endoscope preoperatively and within a day after the operation. The rate of iatrogenic RLN palsy was calculated based on the number of nerves at risk.

Statistical analysis was performed with EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), which is a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria). In the analysis of the factors associated with the visibility of the RLN, Fisher's exact test was used for univariate analysis, and the logistic regression model was used for multivariate analysis. *P* values less than .05 were considered statistically significant.

Results

In total, 115 patients (25 male and 90 female) were included in this study. The mean age at surgery was 62 years (range: 14-90 years). The mean value of BMI was 23 kg/m^2 (range: 14-34 kg/m^2). The result of pathological examination was malignant in 70 and benign in 45 patients. The mean CSd was 50 mm (range: 15-75 mm). The mode of surgery was lobectomy in 76 patients and total thyroidectomy in 39.

Among 154 RLNs from all operated sides, 9 were excluded due to the exclusion criteria. As a result, a total of 145 RLNs at risk, consisting of 79 right RLNs and 66 left RLNs, were adopted for data analysis.

Mediastinal extension of the goiter was present in 11 operated sides. A nodule over 4 cm in size was present on 15 sides. The non-recurrent laryngeal nerve was not observed in this series. Of the 145 RLNs, 110 RLNs were visible from outside the v-PTF. The other 35 RLNs, which were invisible from the outside, were identified by standard dissection within the paratracheal adipolymphatic tissue inside the v-PTF. Postoperative iatrogenic vocal cord palsy was observed on 5 sides, 4 of which were temporary, and 1 was permanent.

In the univariate analysis using Fisher's exact test, high BMI (≥25) and low cricoid position (CSd <40 mm) were associated with the invisible RLN from outside the PTF (Table 1). A multivariate analysis using the logistic regression model showed that the two factors were statistically independent (Table 2).

Without the high BMI and the low cricoid position, the RLN has a high visibility rate of 85%. The rate dropped to 70% with high BMI, 60% with low cricoid position, and 33% in the coexistence of the two factors (Table 3).

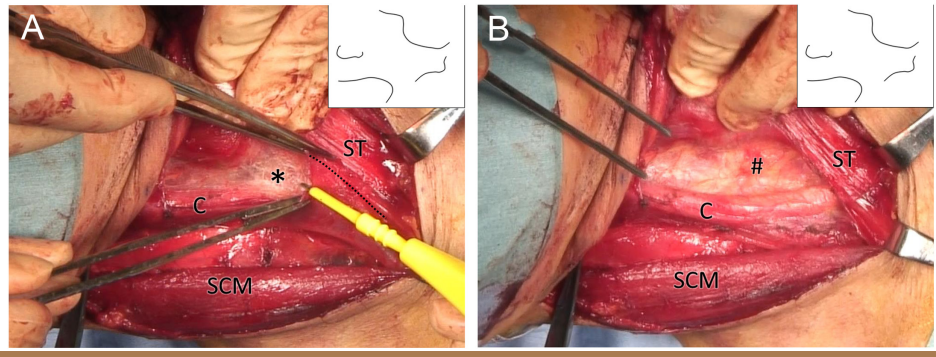

Figure 3. Operative view of thyroidectomy on the right neck. Lateral neck dissection has already been completed. (A) The muscular layer of pretracheal fascia (m-PTF) is being cut along the lateral border of the sternothyroid muscle (dotted line). The potential space (*) between the carotid sheath and the visceral layer of the pretracheal fascia (v-PTF) is being exposed. (B) The v-PTF (#) fully covers the lateral aspect of the paratracheal adipose tissue and the recurrent laryngeal nerve. C, common carotid artery; m-PTF, muscular layer of the pretracheal fascia; SCM, sternocleidomastoid muscle; ST, sternothyroid muscle; v-PTF, visceral layer of the pretracheal fascia.

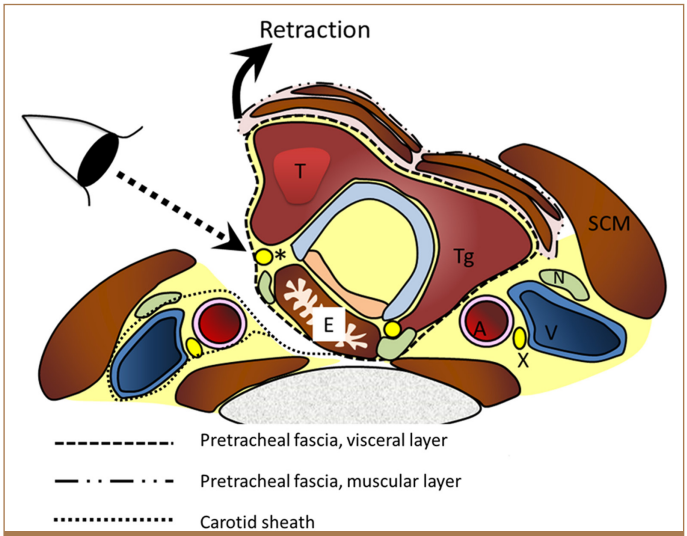

Figure 4. The "visual inspection method" for identifying the recurrent laryngeal nerve (RLN). Blunt dissection of the potential space between the pretracheal fascia (PTF) and the carotid sheath should precede the visual inspection to identify the RLN running under the enveloping PTF. A, common carotid artery; E, esophagus; N, lymph node; V, internal jugular vein; SCM, sternocleidomastoid muscle; X, vagus nerve; T, tumor; Tg, thyroid gland; *, RLN.

Discussion

Vocal cord palsy caused by iatrogenic RLN injury is one of the most critical complications of thyroid surgery and can result in severe dysphonia, dysphagia, or even dyspnea. The average incidence of RLN palsy after thyroid surgery is reportedly 9.8% for temporary palsy and 2.3% for permanent palsy.[9] Although intraoperative neuromonitoring of the RLN is commercially available, it has not significantly reduced RLN injury.[10] The RLN passes posterior to the carotid sheath after branching from the vagus nerve. Before innervating the larynx, the right RLN takes the route around the subclavian artery, while the left runs under the aortic arch. In the paratracheal space, the RLN runs within the adipolymphatic tissue, which is encapsulated by the v-PTF. It has been fully described that the left RLN tends to follow the tracheoesophageal groove, while the right RLN runs more laterally, near the surface of the v-PTF. After running close to the posterior surface of the thyroid gland, the RLN enters the larynx through the space between the posterolateral aspect of the thyroid cartilage and the cricoid cartilage. Routine RLN identification during thyroid surgery is supported by several studies reporting an increased incidence of permanent RLN palsy when the RLN was not identified.[11–14] However, manipulation during the search for the RLN has its own risk. Identifying the RLN around Berry's ligament is often complicated by the variable relationship among the RLN, ligament, and posterior thyroid tubercle.[15] In addition, extralaryngeal bifurcation or trifurcation of the RLN is often observed in this area.[16,17] Actually, it is reported that the RLN is at the most significant risk of getting injured around Berry's ligament.[5]

For this reason, identifying the RLN just above the superior thoracic inlet in the paratracheal space is recognized as a safer method to identify the RLN and its branches. However, blind dissection of paratracheal adipolymphatic tissue is often complicated by bleeding from branches of the inferior thyroid artery (ITA) and veins. In addition, the ITA does not significantly help identify the RLN because its anatomical relationship with the RLN is not constant.[18] Although the palpatory method has been reported as a way to avoid blind dissection, it relies heavily on the surgeon's experience, limiting its usage only to expert surgeons.[19]

On the other hand, finding the RLN from outside the v-PTF without digging the paratracheal adipolymphatic tissue does not require special skills. Because the RLN is always inside the v-PTF, there is virtually no risk of RLN injury as long as the v-PTF is kept intact. Once the RLN is visually identified, the rest of the procedures, such as RLN preservation and paratracheal lymph node dissection, can proceed swiftly and safely. Therefore, the visibility of the RLN from outside the

Table 1. Univariate Analysis of the Factors Associated with the Results of the "Visual Inspection Method" in RLN Identification

Variables		No. of RLN	Failure of Visual Inspection Method (%)		*P*
Gender	Male	29	11	(38)	.086
	Female	116	24	(21)	
Age	≥75	27	4	(15)	.32
	<75	118	31	(27)	
BMI	≥25	39	15	(38)	.027*
	<25	106	20	(19)	
Side	Right	79	15	(19)	.12
	Left	66	20	(30)	
Nodule size	>4 cm	15	5	(33)	.36
	≤4 cm	130	30	(23)	
Mediastinal extension	Yes	11	5	(45)	.14
	No	134	30	(22)	
CSd	<40 mm	24	12	(50)	.0030*
	≥40 mm	121	23	(19)	

P-values were calculated using Fisher's exact test.
RLN, recurrent laryngeal nerve; CSd, cricosternal distance.
*Statistically significant.

Table 2. Multivariate Analysis of Factors Associated with the Results of the "Visual Inspection Method" in RLN Identification

Variables	Odds Ratio	(95% CI)	*P*
Male gender	1.9	(0.68-5.3)	.22
Age <75 years	2.0	(0.55-7.0)	.30
High BMI (≥25)	2.8	(1.2-6.7)	.023*
Left side	2.1	(0.90-4.8)	.088
Tumor size >4 cm	1.7	(0.45-6.1)	.44
Mediastinal extension	0.94	(0.20-4.6)	.95
Low cricoid (CSd <4 cm)	3.4	(1.1-10.2)	.030*

P-values were calculated using logistic regression analysis.
RLN, recurrent laryngeal nerve; CSd, cricosternal distance; CI, confidence interval.
*Statistically significant.

Table 3. The Success Rate of the "Visual Inspection Method" by the Status of the Predictive Factors

High BMI (BMI ≥25)	Low Cricoid Position (CSd <40 mm)	Success of Visual Inspection Method (%)	
–	–	77/91	(85)
+	–	21/30	(70)
–	+	9/15	(60)
+	+	3/9	(33)

BMI, body mass index; CSd, cricosternal distance.

v-PTF can be used as an endpoint to objectively assess the difficulty of identifying the RLN purely from an anatomical standpoint without being affected by the surgeon's skill.

This study showed that the high BMI (≥ 25) and the low cricoid position (CSd <40 mm) were independently associated with the invisibility of the RLN from outside the v-PTF, which means that the identification of the RLN is more difficult when these factors are present than when absent. To the best of our knowledge, this is the first report to provide data supporting the general opinion among surgeons that RLNs are technically challenging to identify in patients with obesity or short necks.

A limitation of this analysis was the relatively small number of patients included, which limited the number of factors that could be analyzed in multivariate analyses. Comprehensive multivariate analyses based on data collected from a larger number of patients are needed to identify additional factors, including those not commonly believed to be associated with identifying the RLN.

The high BMI and the low cricoid position are independent factors associated with difficulty identifying the RLN in thyroid surgery. These factors provide valuable preoperative information regarding the difficulty in finding the RLN. When difficulty is expected, several measures can be taken to decrease the risk of RLN injury, such as the participation of fully experienced surgeons or the intraoperative neuromonitoring device, which may prevent unintentional injury to the RLN.

Ethics Committee Approval: *This study was approved by the Japanese Red Cross Wakayama Medical Center (approval number: 503; date: December 25, 2017).*

Informed Consent: *N/A*

Peer-review: *Externally peer-reviewed.*

Declaration of Interests: *The author has no conflict of interest to declare.*

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