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MAIN ARTICLE

Characteristic travelling patterns of non-recurrent laryngeal nerves

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Abstract

Background: The non-recurrent laryngeal nerve is subject to potential injury during thyroid surgery. Intra-operative identification and preservation of this nerve can be challenging. Its presence is associated with an aberrant subclavian artery and the developmental absence of the brachiocephalic trunk. This study aimed to evaluate the incidence of non-recurrent laryngeal nerves and present a new classification system for the course of these nerves.

Methods: Non-recurrent laryngeal nerves were identified on the right side in 15 patients who underwent thyroidectomy. The incidence of non-recurrent laryngeal nerves (during thyroidectomy) and aberrant subclavian arteries (using neck computed tomography) was evaluated, and the course of the nerves was classified according to their travelling patterns.

Results: The overall incidence of non-recurrent laryngeal nerves was 0.68 per cent. The travelling patterns of the nerves could be classified as: descending (33 per cent), vertical (27 per cent), ascending (20 per cent) or V-shaped (20 per cent).

Conclusion: Clinicians need to be aware of these variations to avoid non-recurrent laryngeal nerve damage. A retroesophageal subclavian artery (on neck computed tomography) virtually assures a non-recurrent laryngeal nerve. This information is important for preventing vocal fold paralysis. Following a review of non-recurrent laryngeal nerve travelling patterns, a new classification was devised.

Key words: Recurrent Laryngeal Nerve; Thyroidectomy

Introduction

During thyroid surgery, injury to the recurrent laryngeal nerve (RLN) is the major iatrogenic cause of vocal fold paralysis. In order to decrease the incidence of this injury, the RLN should always be identified; an awareness of RLN anatomical variations and meticulous surgical technique are necessary.

The left RLN usually runs deeply in a straightforward course in the neck, and the right RLN runs superficially and may be more variable. There is always a possibility of anatomical variations in the course of the RLN, and the surgeon must carefully identify the RLN during surgery.[1–3] One of the major variants is the non-RLN, which originates from an aberrant origin of the subclavian artery.

The first discovery of non-RLNs was in cadavers. Stedman[4] reported a right-sided non-RLN in 1823. The incidence of non-RLNs is much greater on the right side than on the left side, and varies from 0.4 to 2.4 per cent.[5–7] Berlin[8] was the first to report finding a non-RLN on the left side in 1935. Left-sided non-RLNs are extremely rare, only occurring in cases of situs inversus combined with an aberrant left subclavian artery and a right-sided ligamentum arteriosum; an incidence of 0.04 per cent has been reported.[1]

The course of non-RLNs may vary. Two main types of course have been described by Cagnol *et al*.[9] The high type of non-RLNs (type I) arise perpendicularly from the vagal nerve trunk to join the laryngotracheal junction transversally via a short route. The low type of non-RLNs (type II) originate from the vagal nerve trunk and display a supero-external concavity before reaching the tracheoesophageal groove. In such an instance, the nerve may meet the inferior thyroid artery rather than passing underneath it, as it usually does.[10] Abboud and Aouad[11] reported only three cases of non-RLNs and classified the three types as horizontal, transverse and downward direction.

The course of non-RLNs from the vagus nerve to the larynx is very variable. To avoid injury to the non-RLNs, thyroid surgeons are warned about their existence; an intimate knowledge of their anatomical course is required. Here, we report 15 cases of non-RLNs, and discuss their incidence and travelling

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patterns, which may well represent variations of non-RLNs for thyroid surgeons.

Materials and methods

A retrospective review of the patients who underwent thyroidectomy over a 15-year period was performed.

From January 1997 to July 2012, 2658 patients (2179 females and 479 males) underwent thyroid surgery in our head and neck surgery department: 1674 total thyroidectomies and 984 unilateral lobectomies were performed (513 right lobectomies). A total of 2187 right laryngeal nerves were exposed.

The pathological findings were as follows: thyroid cancer (68 per cent), nodular goitre (21 per cent) and other benign disease (11 per cent).

Most of the patients ($n = 2366$, 89 per cent) had undergone pre-operative computed tomography (CT) of the neck. We evaluated abnormalities of the subclavian artery that led to an aberrant origin of the RLNs (Figure 1), particularly those of a retroesophageal origin.

During surgery, the course of the non-RLN from the vagus nerve trunk was evaluated. Cases were classified according to the following four non-RLN travelling pattern types: descending, vertical, ascending, and V-shaped with a descending–ascending pattern (Figures 2 and 3).

Results

Of the 2187 right laryngeal nerves exposed during thyroid surgery, we identified 15 (0.68 per cent) patients with non-RLNs on the right side (Table I). There were 13 females and 2 males, with a mean age of 52.7 years. Nine patients underwent total thyroidectomy with central neck dissection, and six patients underwent right hemithyroidectomy. Pathologically, 12 cases had papillary carcinoma and 3 cases had goitre or follicular adenoma (Table I). With regard to clinical symptoms (identified via a retrospective chart review), four patients (27 per cent) complained of mild dysphagia but denied other clinical symptoms such as dysphonia. There were pre-operative neck CT images for 14 of the 15 patients, all of which showed a retroesophageal aberrant subclavian artery that arose directly from the aortic arch (Figure 1).

When classifying the travelling patterns of the non-RLNs, we found five cases of the descending type, four of the vertical type, three of the ascending type and three of the V-shaped type (Table I, Figure 2). Non-RLNs arose from various levels of the vagus nerve, and the levels of the inferior thyroid artery were also very variable. However, we could not compare the relationship between non-RLNs and the inferior thyroid artery because of the variable location of the inferior thyroid artery. With regard to nerve injury among the 15 cases, 1 non-RLN was damaged during thyroid surgery; this non-RLN was classified as a V-shaped type with a descending–ascending pattern. The affected patient received end-to-end anastomosis of the injured nerve, but vocal fold paralysis was noted after surgery.

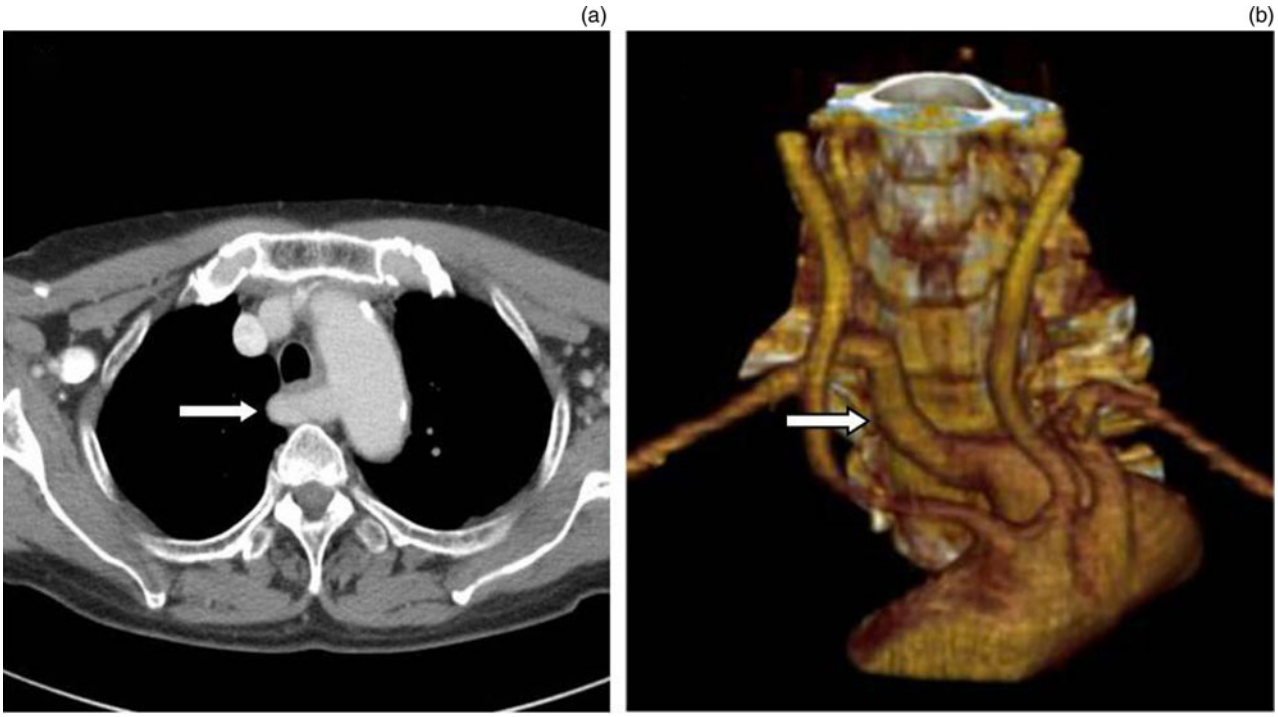

FIG. 1

(a) Axial computed tomography (CT) image through the upper mediastinum and lower neck showing the right subclavian artery (arrow) arising from the dorsal part of the aortic arch, and (b) volume-rendered, three-dimensional CT image of the aortic arch showing the right subclavian artery (arrow) arising from the aortic artery.

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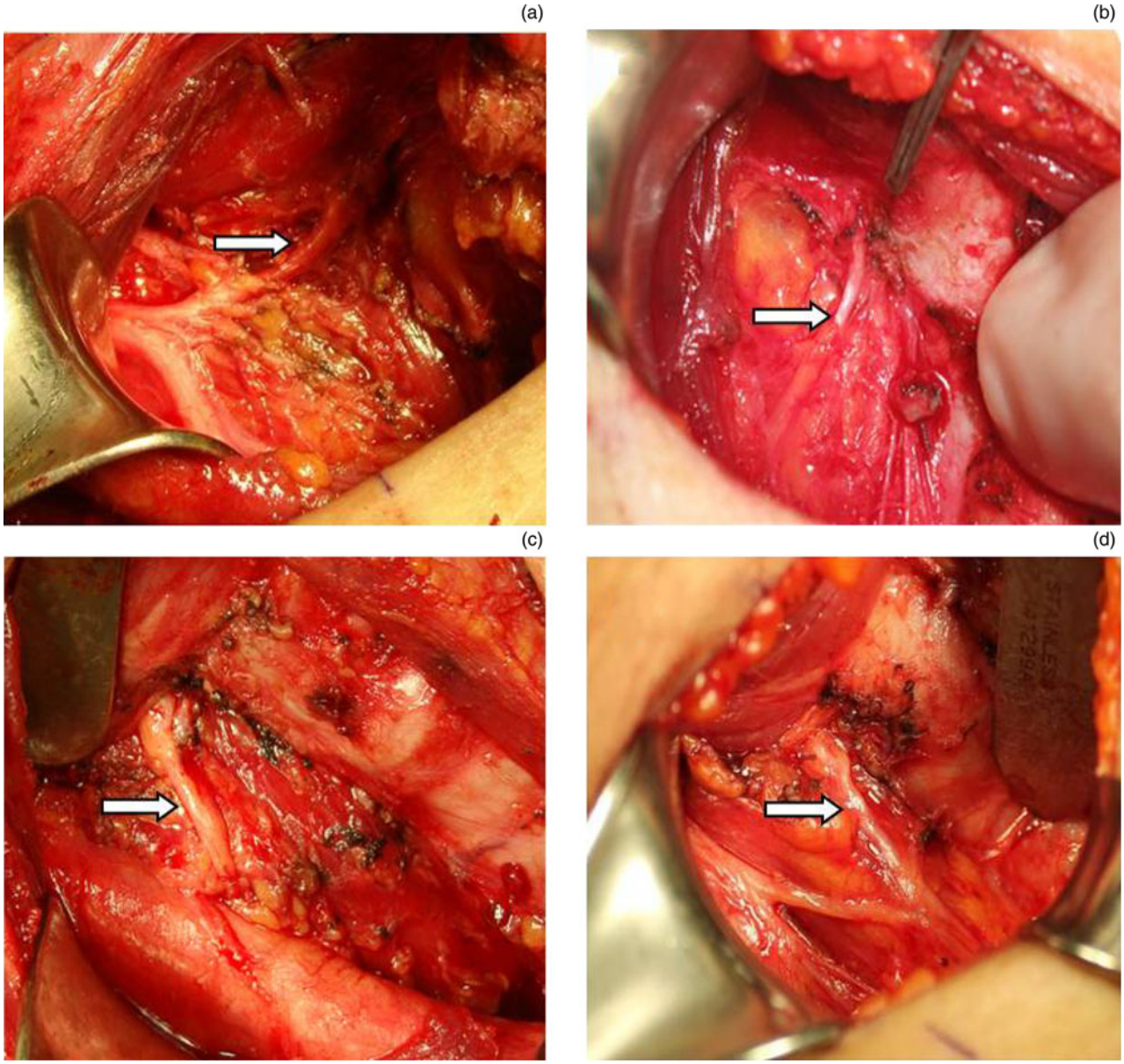

FIG. 2
Intra-operative views showing the four patterns of non-recurrent laryngeal nerves (arrows) arising directly from vagus nerve and entering the larynx in: (a) a descending, (b) a vertical, (c) an ascending and (d) a V-shaped manner.

Discussion

Careful dissection of the RLN is necessary to avoid nerve injury during thyroidectomy. The existence of anatomical variations in the RLN course is an additional factor contributing to its injury during thyroid surgery.[1,12] One of the potential variants is a non-RLN; this variant originates from an aberrant embryological origin of the subclavian artery.

Embryologically, both RLNs supply the sixth branchial arches.[13] These nerves pass beneath the sixth aortic arch and ascend to the larynx with the descent of the heart. On the right side, the distal portion of the sixth aortic arch, and the fifth aortic arch, disappear, and the RLN moves up to lie beneath the fourth arch. However, the right fourth aortic arch and proximal right dorsal aorta are occasionally obliterated, and the origin of the subclavian artery becomes anomalous. Its final origin is just below that of the left subclavian artery, and it reaches the right side by crossing the midline behind the oesophagus. This anomalous subclavian artery allows the inferior laryngeal nerve to be non-recurrent from the vagus nerve and to rise higher in the neck. This non-RLN then runs directly to the larynx, usually at the level of the thyroid gland upper lobe on the right side. Non-RLNs have very rarely been reported on the left side too.[14] This latter anomaly is invariably associated with situs inversus, a right-sided ligamentum arteriosum and a left retro-esophageal subclavian artery.[15]

The overall reported incidence of non-RLNs varies between 0.4 and 2.4 per cent on the right side.[2,12] Henry *et al.*[6] observed 31 cases of non-RLNs in 4921

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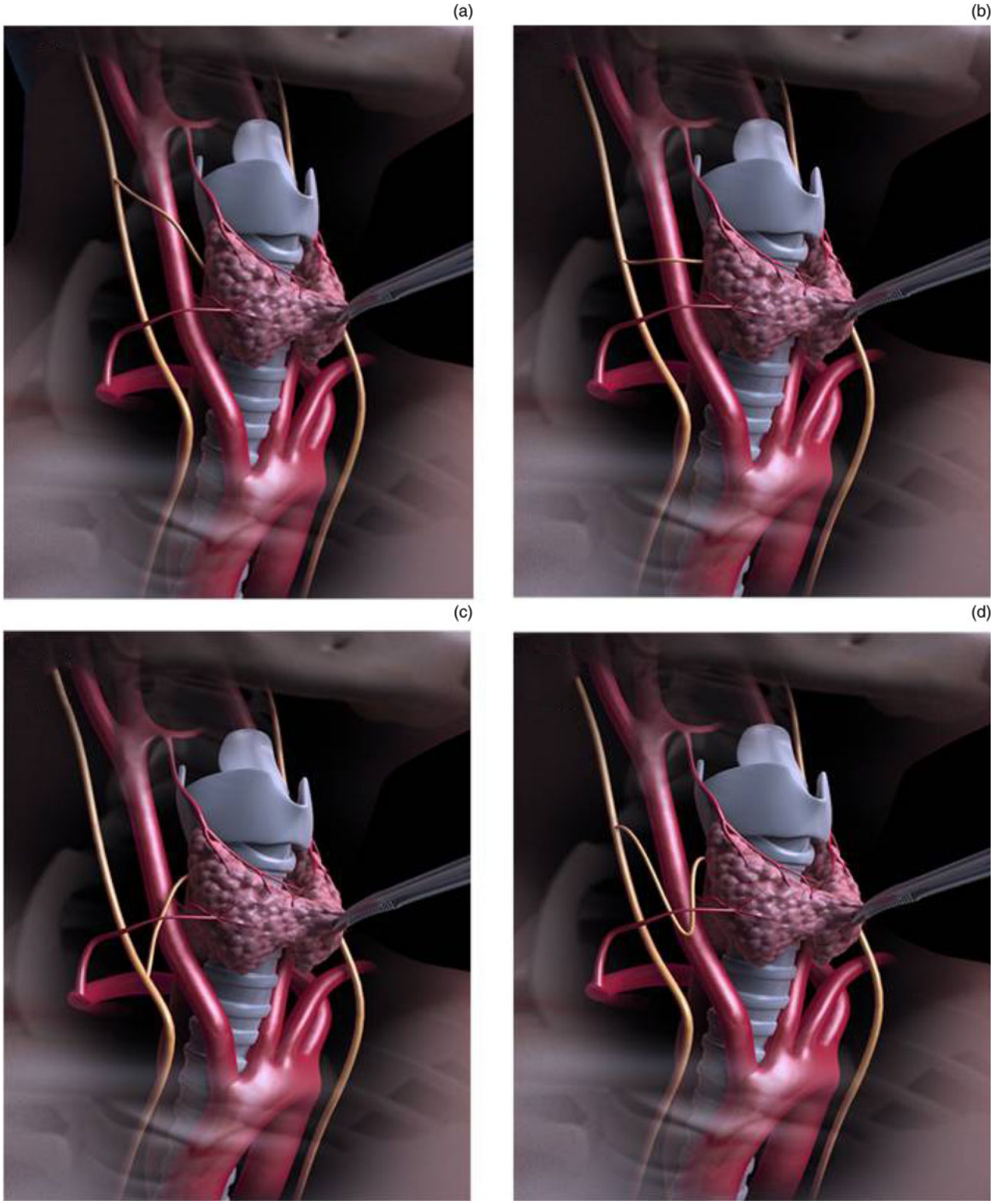

FIG. 3

Schematic presentations of the four types of non-recurrent laryngeal nerve course: (a) descending – the nerve descends from the vagus nerve trunk; (b) vertical – the nerve runs vertically to the cricothyroid joint; (c) ascending – the nerve runs upward to the cricothyroid joint; and (d) V-shaped – the nerve takes a downward course and runs upward to the cricothyroid joint.

neck dissections on the right side during thyroid and parathyroid excision within a 10-year period. Katz and Nemiroff [2] noted the RLN to arise directly from the vagus in the neck in 11 of 719 patients over 10 years. Sanders *et al*.[5] identified 7 cases of a non-RLN on the right side during 1000 thyroidectomies over a 20-year period. Humphrey[16] reported a 0.68 per cent incidence of this variation. The incidence of an aberrant subclavian artery identified on CT images in our study population is typical. The incidence of surgically

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TABLE I
PATIENT DATA SUMMARY

Pt age (y), sex	Procedure	Pathology	Non-RLN course type	Nerve injury
47, F	TT + CND	Papillary ca	Descending	–
51, F	R lobectomy	Goitre	Ascending	–
53, F	TT + CND	Papillary ca	Descending	–
34, F	R lobectomy	Goitre	Vertical	–
40, M	R lobectomy	Papillary ca	Vertical	–
57, F	TT + CND	Papillary ca	Descending	–
53, F	TT + CND	Papillary ca	Descending	–
70, F	TT + CND	Papillary ca	V-shaped	+
46, F	R lobectomy	Papillary ca	Descending	–
48, M	TT + CND	Papillary ca	V-shaped	–
53, F	TT + CND	Papillary ca	Vertical	–
64, F	R lobectomy	Follicular adenoma	Ascending	–
76, F	R lobectomy	Papillary ca	Ascending	–
52, F	TT + CND	Papillary ca	V-shaped	–
47, F	TT + CND	Papillary ca	Vertical	–

Pt = patient; y = years; non-RLN = non-recurrent laryngeal nerve; F = female; TT = total thyroidectomy; CND = central neck dissection; ca = carcinoma; R = right; M = male

identified non-RLNs in our study (0.68 per cent) is somewhat similar to that usually reported.

Generally, there are no reliable symptoms or signs that indicate the possibility of a non-RLN pre-operatively.[15] Some patients in this study complained of mild dysphagia and a foreign body sensation. Before surgery, the diagnosis of non-RLN may be made only if an aberrant subclavian artery is suspected. This aberrant artery is almost always associated with a non-RLN; however, the identification of an aberrant subclavian artery would be tantamount to identifying a non-RLN before surgery. Freed and Low[17] have suggested that barium oesophagography be included in pre-operative evaluation, especially for dysphagic patients. Relevant findings on oesophagography include an impression from the left to the upper right of the oesophagus, and on anterior plain chest X-ray include an anomalous origin of the right subclavian artery at the right peak of the aortic arch. A diagnosis of an aberrant subclavian artery with neck CT images is sound, as it is based on the direct identification of an aberrant artery passing behind the oesophagus.[10] Many patients undergo CT study of the neck before thyroid surgery to evaluate the anatomical relationships between the thyroid gland and the surrounding structures, especially the lateral neck lymph nodes. Thus, the identification of an aberrant subclavian artery can be reliably established using only CT images.[18,19] The existence of non-RLNs can also be evaluated using intra-operative nerve monitoring. Surgeons should be aware of the existence of non-RLNs when the inferior laryngeal nerve shows abnormal nerve monitoring during surgery.

Regarding the course of non-RLNs, Cagnol *et al.*[9] reported two anomaly types. The non-RLN enters the larynx at the cricothyroid joint through the fibres of the inferior constrictor muscle of the pharynx. In a type I anomaly, the non-RLN originates from the vagus nerve above the laryngotracheal junction and descends into the larynx, running together with the vessels of the superior thyroid lobe. In a type II anomaly, the non-RLN that originates from the vagus nerve runs on a level with the lower thyroid artery and then follows a transverse path parallel to the inferior thyroid artery.[14,20] Abboud and Aouad[11] reported three types of courses for non-RLNs: in type Ia, the nerve has a straight course at the level of the upper thyroid pole; in type Ib (the most common), the nerve runs transversely at the level of the thyroid isthmus; in type II, the nerve makes a downwards curve, eventually reaching the lower pole of the thyroid gland. In our study, we classified the courses in more detail, distinguishing four types. In the descending type, the non-RLN descends after originating from the vagus nerve trunk. In the vertical type, the non-RLN runs vertically to the cricothyroid joint. In the ascending type, the non-RLN runs upward to the cricothyroid joint. In the V-shaped type, the non-RLN takes a downward direction and runs upward to the cricothyroid joint.

- **This study evaluated the incidence of non-recurrent laryngeal nerves (non-RLNs) and presented a classification system based on their travelling course**
- **Fifteen right-sided non-RLNs were classified as descending, vertical, ascending or V-shaped**
- **A retroesophageal subclavian artery as seen on neck computed tomography scans indicates a non-RLN**

Because of these variations of non-RLNs, the surgeon should dissect the thyroid gland and surrounding tissues very carefully when there is pre-operative suspicion of a non-RLN. Surgeons should carefully identify the vagus nerve before thyroid dissection, and the

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vagus nerve should be gently dissected with elastic loops, enabling identification of the non-RLN and its course.[13] In particular, there may be a higher risk of nerve injury when the surgeon ties the superior thyroid vessels of the thyroid gland; this should therefore be performed with great caution.[13]

Conclusion

Although the non-RLN is a rare anomaly, its existence can have dramatic consequences with regard to laryngeal nerve injury during thyroid surgery. Surgeons are warned about the existence of non-RLNs and should have an intimate knowledge of their variable anatomical patterns. An aberrant retroesophageal subclavian artery can be easily observed using CT images before surgery, without additional studies. If the existence of a non-RLN is suspected based on pre-operative CT images, the thyroid gland should be meticulously dissected and the non-RLN identified, to prevent vocal fold paralysis.

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