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ORIGINAL ARTICLE

The recurrent laryngeal nerve and the inferior thyroid artery—anatomical variations during surgery

Ozer Makay · Gokhan Icoz · Mustafa Yilmaz · Mahir Akyildiz · Enis Yetkin

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Abstract
Background and aims Recognition of variations of the inferior laryngeal nerve is essential. We aimed to investigate the relationship of the inferior laryngeal nerve with the inferior thyroid artery.
Materials and methods A study was undertaken between August 2005 and August 2006. A total of 253 adult patients undergoing thyroid surgery were included in this prospective, non-randomized study. Both sides of the thyroid gland were considered separately.
Results Sixteen variations of the nerve were clarified. In the most observed variation, the nerve was deep to the artery. Two and three nervous branches were seen in 22.5% and 1.6% of the patients, respectively. Bifurcation of the nerve was mostly observed on the left side. No non-recurrent laryngeal nerve was found.
Conclusion To avoid the risk of nerve damage during thyroid surgery, a good knowledge of the variations of the inferior laryngeal nerve is essential. This is important to achieve an undisturbed quality of life for the thyroid patient.

Preliminary results of this current study were presented at the 2nd Thyroid Cancer Conference held in Milano, Italy on 2nd–4th July 2006.

O. Makay (✉) · G. Icoz · M. Yilmaz · M. Akyildiz · E. Yetkin
Department of General Surgery,
School of Medicine, Ege University,
Bornova,
Izmir 35100, Turkey
e-mail: ozer.makay@ege.edu.tr

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Introduction

Thyroid surgery requires a thorough knowledge of the neck anatomy and its anatomical variations. This is of utmost importance, since it is well known that variations of the recurrent laryngeal nerve (RLN) are prone to iatrogenic injuries. Consideration and recognition of these variations is essential to prevent the hazard to the nerve [1]. The estimated risk of injury during thyroid surgery varies widely. Several factors, like underlying disease, extent of resection, and experience of surgeon are believed to be involved in the increased risk of recurrent nerve injury [2]. Meanwhile, it has been a consensus that this risk should be kept less than 2% in all types of thyroid surgery [3]. Although traction and diathermy injury have been implicated as possible causes of nerve injury, resulting in neuropraxia and axonotmesis, which fails to resolve, damage to an unseen branch of the recurrent nerve may also be a possible explanation [4]. It is obvious that the incidence of permanent or transient nerve injury will decrease due to improved knowledge of the anatomical details of the recurrent laryngeal nerve. Usage of the inferior thyroid artery (ITA) as one of the anatomic landmarks for identification of the RLN and routine exposure of the nerve will help to minimize the chance of injury [1]. Meanwhile, this landmark is not wholly reliable because of the anatomic variability of both the RLN and the ITA.

The aim of the present study was to assess the anatomical relationship of the RLN with the inferior thyroid artery in 253 adult Turkish thyroid patients.

Materials and methods

Consecutive admissions presented with surgical thyroid diseases were recruited prospectively in a tertiary referral hospital. The study was conducted in 253 patients between August 2005 and August 2006. Patients who had previous thyroid surgery were excluded. Indications for the thyroid surgery at our institution were clinical suspicion of malignancy, compressive symptoms, or obvious cosmetic problems, even if fine-needle aspiration biopsy results were negative. Our routine operative strategy to thyroid nodules and the surgical technique that we have adopted has been previously described and standardized [5]. The thyroid gland was meticulously dissected using a capsular dissection technique. A full dissection of the RLN just below and above the inferior thyroid artery to the level of entry into the larynx, under the cricothyroid muscle, was routinely undertaken. During the course of the dissection, ramifications of the nerve become apparent.

In the present study, both sides of the thyroid gland were considered separately, and each RLN was kindly dissected to show the following:

–Varieties of the topographic relations to the ITA
–Ramifications of the RLN before entering the larynx

All operations were undertaken by the same endocrine surgical team. Each anatomical detail of the patients was documented. The documentation instrument is available upon request. Besides, every variation was recorded photographically. Postoperative course and complications of each patient were also noted. Data analysis was performed using SPSS version 10.0 for Windows. All quantitative data were presented as mean values±standard error of the mean. Comparisons of anatomical findings between groups were performed by using the χ^2 test. A p value <0.05 was considered significant.

Results

The data analysis was based on 253 patients and 501 nerve dissections: 250 on the right side and 251 on the left side. The rate of identification of the RLN was 100% for all patients and for all nerves dissected. See Table 1 and Fig. 1 for patient and disease characteristics.

Sixteen variations of the RLN were clarified in this series. In the most observed variation (43.5% on the left versus 41% on the right), the nerve was deep to the unbranched (single trunk) ITA (Fig. 2). The right RLN lay posterior to the ITA and its branches in 64.1% (n=163) of dissected nerves, while 24.1% (n=61) lay anterior to the artery. Nearly 8% (n=19) were found in between the branches of the artery on the right side. The left RLN lay posterior to the artery and its branches in 71.5% (n=181), 19.7% (n=50) of which lay anterior. In 5.4% (n=13), RLN was found in between the branches of the artery on this side (Table 2). The distributions of the three types of relationships between RLN and the ITA differed significantly (p<0.05). Meanwhile, there was no significant difference between left and right sides concerning the relation of the RLN to the inferior thyroid artery (p>0.05). The relationship found on one side did not occur on the opposite side in 36.5% cases.

Table 1 Patients' characteristics

	n=253
Age (mean±SD)	48±8
Gender (% ♂/♀)	81/19
Type of surgery (%)	
Thyroidectomy	66
Near-total thyroidectomy	32
Hemithyroidectomy	2
Permanent recurrent laryngeal nerve palsy	0

Overall, before entering the larynx, a bifurcation or trifurcation of the nerve was seen in 22.5% (n=57) and 1.6% (n=4) of the patients, respectively. Bifurcation of the RLN was insignificantly more observed on the left side (15% versus 14.2%; p>0.05), while a trifurcation was observed on the right side in three of the four cases. Bilateral bifurcated RLN were observed in 17.5% (n=10) of 57 cases. One nerve (0.4%) showed a fanwise fashion on the right side before entering the larynx (Fig. 3). In two (0.8%) cases, the inferior thyroid artery passed through the branches of the bifurcated RLN. Another interesting variation was seen in three (1.2%) cases where branches of the bifurcated artery passed through the branches of bifurcated RLN. No non-recurrent laryngeal nerve was identified. There were clinically no inferior laryngeal nerve palsies in this series.

Discussion

This article represents 16 anatomic configurations of the RLN and the ITA. It has been stated currently that during the past 5 years more than 100 publications have described variations and techniques to identify RLN during surgery

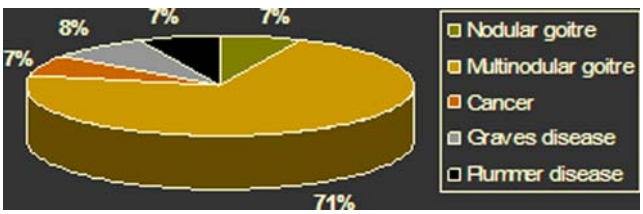

Fig. 1 Classification of thyroid disorders of the study group

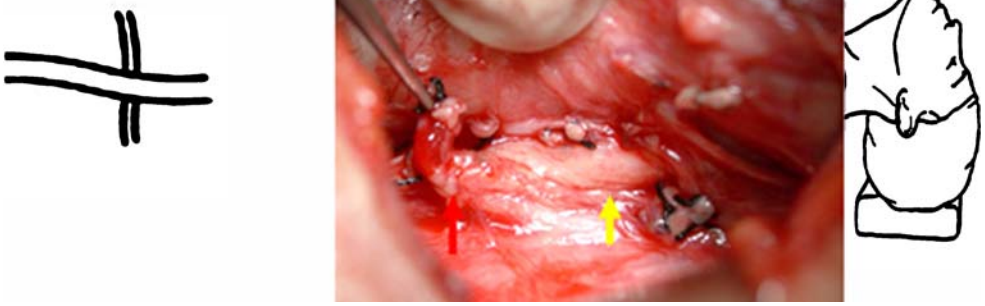

Fig. 2 Surgical exposure of the relation of the recurrent nerve passing behind the inferior thyroid artery (*yellow arrow* nerve, *red arrow* artery)

[3]. Although this prospective series of consecutive thyroidectomies provides little new information, it is worthwhile to emphasize once more the importance of the quantity of the variety of RLN. It is well known that the mechanism of this injury is not only transection and ligation of the nerve; traction, compression, and thermal trauma with electrocautery also lead to RLN injury. A major philosophical point is that during surgery, no structure should be divided unless the RLN is identified [6]. This should be a standard practice.

Exposure of the thyroid gland is the "sine qua non" for preventing injury to nerves and vessels [7]. The philosophy behind identifying RLN during surgery is to protect the patient from its hazardous complications. Sustaining voice function via preservation of the RLN integrity is important for the quality of life of the patient. Since unawareness of the variations of the RLN and ITA may be hazardous for the surgeon and patient, our intention in the present prospective study was to learn more about our patient population regarding the anatomical variations of the RLN and ITA.

Our knowledge of variations of the RLN comes from multiple studies [8–12], recently mentioned by Yalcin [13]. Based on these, mean incidences of the relationships of the RLN and ITA were as follows: on the left side, the nerve trunk lay posterior to ITA in 52.1% (27% to 63.7%), anterior to it in 13.7% (9.8% to 24%), and passing between its branches in 25.4% (9% to 33.1%); on the right side, the nerve trunk lay posterior to ITA in 23% (16% to 47.7%), anterior to it in 25.5% (17.4% to 40%), and between its branches in 36.5% (14% to 48%). It is interesting that, on the left, 64.1% and, on the right, 71.5% of patients' RLN lie under the artery, which are both higher rates than most other reports. Statistically, significant differences were found between groups on both sides. Publications from Page et al. [14] and Uen et al. [6] described the RLN to be deep to the artery in 89% and 92% on the left. These rates differ from the results of the current study where 71.5% of the left-sided RLNs were calculated to be inferior to the artery. The estimation that the RLN is superficial in 67% on the right side in Page's study is incompatible with many reports, including the current study; this anatomic relation was found to be 24.1%.

The current series has identified a nearly identical rate of bifurcation (14.2% versus 15%) and an obvious higher rate of trifurcation (1.2% versus 0.4%) of the right RLN

Table 2 Distribution of the relation of the recurrent laryngeal nerve with the inferior thyroid artery

Recurrent laryngeal nerve	Right	Left
superior to ITA	24.1%	19.7%
inferior to ITA	64.1%	71.5%
between ITA branches	7.6%	5.4%

There was no significant difference between left and right sides ($p>0.05$). There was significant difference between groups ($p<0.05$).
ITA Inferior thyroid artery

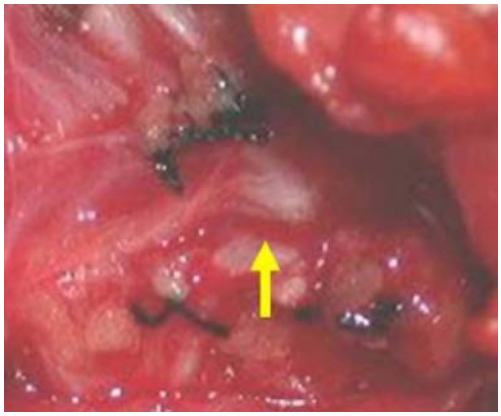

Fig. 3 Recurrent laryngeal nerve showing a fanwise fashion

compared with the left. A review of the available literature shows that the division rate of the RLN is highly variable and can differ between 30% and 100% [2, 4, 15–16]. The issue comes up that there is no consensus on the terminology for the division of the RLN [17–19]. In our own experience, we found the nerve divided in 24.1% of cases into two or three branches on both sides. A review of the available literature shows that this frequency is lower than most of that reported. It is conceivable that the thyroid surgeon should keep in mind that the branching pattern of the RLN is not rare in order to show every effort to protect these branches. Once the nerve is identified, it is best to follow it inferiorly and superiorly to make sure that the identified structure is not actually one of the branches of the RLN.

Conducting an attempt to recognize RLN during surgery of the thyroid is controversial. The debate over the necessity of RLN identification during thyroid surgery continues considerably. Even though there is an effort to standardize the concept of identification of the RLN during surgery in order not to harm the nerve [6, 14, 20–26], there are centers that do believe in thyroidectomy without identifying RLN in order to protect the nerve from injury [27]. Proponents of these cited some factors for their preference; any attempt to identify the nerve will increase the risk of injury. Kasemsuwan and Nubthuenetr [27] believed that there is no adequate evidence to support that the identification of RLN during surgery would be a significant factor in reducing the likelihood of RLN injury. Others reported that identifying the nerve–artery relation does not decrease the risk of complication [1, 28, 29]. However, some supporters of routine identification of the RLN reported a fivefold decreased risk of RLN injury [25, 26]. To clarify the role of the necessity of nerve dissection, we should focus on trials that reveal answers to the surgeon who is questioning whether identifying the nerve-artery relation really does decrease the risk of complication.

There are many landmark articles that reveal anatomic stations to identify the RLN [6, 30–33]. In one of these, ITA is believed to be the most important anatomic landmark for identification of RLN. In that paper, a vessel loop technique has been advocated where applying traction to the artery is believed to tense the nerve like a string [31]. However, we believe that this concept does not hold true. Our operative philosophy in defining the RLN is ‘define the structure without disturbing itself and any adjacent structure.’ Our lack of enthusiasm for the use of the ITA as the sole anatomic landmark is based on our observation that in nearly every one of the four dissections, the RLN was found anterior to the ITA.

Our experience with 501 nerve dissections indicated that absence of the ITA was not evident and an anomalous thyroid artery rising from the brachiocephalic trunk—the so-called ‘ima artery’—was not identified. Meanwhile, the incidence of absence of the ITA is reported to be 6% [34]. This knowledge is one of the reasons why we should not use ITA as ‘the only landmark’ to identify RLN. It must be kept in mind that the variability of the anatomic pattern of the ITA affects the constancy of the relation between nerve and artery [35].

This study has some weak points. Although we have noted different branching patterns of RLN, we did not document the level of the arborization. Meanwhile, it is obvious that, in cases where the RLN arborizes prior to its entrance into the larynx at the cricothyroid joint, injury to a small branch may result in voice changes. We did not describe particular emphasis on the correlation of anatomical variations with sexual differences. We also did not measure the diameter of either the nerve or its branches. Relationship of the RLN with the tracheo-esophageal groove was not identified. On the basis of embryology, the course of the RLN in the tracheo-esophageal groove may differ, comparing the left side to the right. Whether the anatomy of the nerve in the area of the Berry ligament has an impact on iatrogenic nerve will be evaluated in further studies.

Thyroid surgery is considered to be the safest surgical procedure [36]. Thus, all thyroid surgeons should take every effort not to dissatisfy this consideration and keep in mind all types of relationships between both RLN and ITA and their branches. Despite the above marked weak points, it is clear from this study that preventing nerve damage is not to stay away from it but to identify it. We believe that, although there are numerous reports in which each of them identified more than 15 RLN variations, the surgeon him/herself, who is still carrying out a blind dissection, is a major risk factor for RLN injury. Do we still have to learn more about the anatomical configurations of the RLN to avoid injury and achieve an undisturbed quality of life for the thyroid patient, which is of utmost importance?

References

1. Ardito G, Revelli R, d'Alatri L, Lerro V, Guidi ML, Ardito F (2004) Revised anatomy of the recurrent laryngeal nerves. Am J Surg 187:249–253
2. Sturniolo G, d'Alia C, Tonante A, Gagliano E, Taranto F, Lo Schiavo MG (1999) The recurrent laryngeal nerve related to thyroid surgery. Am J Surg 177:485–488
3. Mishra AK, Agarwal A, Selven CK, Nair A (2007) Response to "Anatomic configurations of the recurrent laryngeal nerve and inferior thyroid artery". Surgery 141:281–282
4. Beneragama T, Serpell JW (2006) Extralaryngeal bifurcation of the recurrent laryngeal nerve: a common variation. ANZ J Surg 76:928–931
5. Makay O, Unalp O, Icoz G, Akyildiz M, Yetkin E (2006) Completion thyroidectomy for thyroid cancer. Acta Chir Belg 106:528–531
6. Uen YH, Chen TH, Shyu JF, Shyr YM, Su CH, Chen JY (2006) Surgical anatomy of the recurrent laryngeal nerves and its clinical applications in chinese adults. Surg Today 36:312–315
7. Shaha AR (1993) Safe ligation of the superior thyroid vessels. J Surg Oncol 53:208
8. Lekacos NL, Tzardis PJ, Sfikakis PG, Patoulis SD, Restos SD (1992) Course of the recurrent laryngeal nerve relative to the inferior thyroid artery and the suspensory ligament of Berry. Int Surg 77:287–288
9. Moreau S, De Rugy MG, Babin E, Salame E, Delmas P, Valdazo A (1998) The recurrent laryngeal nerve: related vascular anatomy. Laryngoscope 108:1351–1353
10. Simon MM (1943) Recurrent laryngeal nerve in thyroid surgery—triangle for its recognition and protection. Am J Surg 60:212–220
11. Berlin DD (1935) The recurrent laryngeal nerves in total ablation of the normal thyroid gland; an anatomical and surgical study. Surg Gynecol Obstet 60:19–26
12. Armstrong WG, Hinton JW (1951) Multiple divisions of the recurrent laryngeal nerve; an anatomic study. Arch Surg 62:532–599
13. Yalcin B (2006) Anatomic configurations of the recurrent laryngeal nerve and inferior thyroid artery. Surgery 139:181–187
14. Page C, Foulon P, Strunski V (2003) The inferior laryngeal nerve: surgical and anatomic considerations. Report of 251 thyroidectomies. Surg Radiol Anat 25:188–191
15. Riddell VH (1956) Injury to recurrent laryngeal nerves during thyroidectomy; a comparison between the results of identification and non-identification in 1022 nerves exposed to risk. Lancet 271:638–641
16. Clader DN, Luter PW, Daniels BT (1957) A photographic study of the superior and inferior laryngeal nerves and the superior and inferior thyroid arteries. Am Surg 23:609–618
17. Nemiroff PM, Katz AD (1982) Extralaryngeal divisions of the recurrent laryngeal nerve. Surgical and clinical significance. Am J Surg 144:466–469
18. Schweizer V, Dorfl J (1997) The anatomy of the inferior laryngeal nerve. Clin Otolaryngol Allied Sci 22:362–369
19. Steinberg JL, Khane GJ, Fernandes CM, Nel JP (1986) Anatomy of the recurrent laryngeal nerve: a redescription. J Laryngol Otol 100:919–927
20. Harness JK, Fung L, Thompson NW, Burney RE, McLeod MK (1986) Total thyroidectomy: complications and technique. World J Surg 10:781–786
21. Jatzko GR, Lisborg PH, Muller MG, Wette VM (1994) Recurrent nerve palsy after thyroid operations—principal nerve identification and a literature review. Surgery 115:139–144
22. Lo CY, Kwok KF, Yuen PW (2000) A prospective evaluation of recurrent laryngeal nerve paralysis during thyroidectomy. Arch Surg 135:204–207
23. Steurer M, Passler C, Denk DM, Schneider B, Niederle B, Bigenzahn W (2002) Advantages of recurrent laryngeal nerve identification in thyroidectomy and parathyroidectomy and the importance of preoperative and postoperative laryngoscopic examination in more than 1000 nerves at risk. Laryngoscope 112:124–133
24. Chiang FY, Wang LF, Huang YF, Lee KW, Kuo WR (2005) Recurrent laryngeal nerve palsy after thyroidectomy with routine identification of the recurrent laryngeal nerve. Surgery 137:342–347
25. Al-fakhri N, Schwartz A, Runkel N, Buhr HJ (1998) Rate of complications with systematic exposure of the recurrent laryngeal nerve and parathyroid glands in operations for benign thyroid gland diseases. Zentralbl Chir 123:21–24
26. Mattig H, Bildat D, Metzger B (1998) Reducing the rate of recurrent nerve paralysis by routine exposure of the nerves in thyroid gland operations. Zentralbl Chir 123:17–20
27. Kasemsuwan L, Nubthuenetr S (1997) Recurrent laryngeal nerve paralysis: a complication of thyroidectomy. J Otolaryngol 26:365–367
28. Bergamaschi R, Becouarn G, Ronceray J, Arnaud JP (1998) Morbidity of thyroid surgery. Am J Surg 176:71–75
29. Wagner HE, Seiler C (1994) Recurrent laryngeal nerve palsy after thyroid gland surgery. Br J Surg 81:226–228
30. Pelizzo MR, Toniato A, Gemo G (1998) Zuckerkandl's tuberculum: an arrow pointing to the recurrent laryngeal nerve (constant anatomical landmark). J Am Coll Surg 187:333–336
31. Toniato A, Boschin IM (2006) Re: "anatomic configurations of the recurrent laryngeal nerve and inferior thyroid artery". Surgery 140:482–483 author reply 483
32. Cakir BO, Ercan I, Sam B, Turgut S (2006) Reliable surgical landmarks for the identification of the recurrent laryngeal nerve. Otolaryngol Head Neck Surg 135:299–302
33. Hisham AN, Lukman MR (2002) Recurrent laryngeal nerve in thyroid surgery: a critical appraisal. ANZ J Surg 72:887–889
34. Hollinshead WH (1982) Anatomy for surgeons: the head and neck. vol 1 3rd (ed) Philadelphia, Harper & Row, p 455–458
35. Moreau S, Goullet de Rugy M, Babin E, Salame E, Delmas P, Valdazo A (1998) The recurrent laryngeal nerve: related vascular anatomy. Laryngoscope 108:1351–1353
36. Shaha AR (2000) Thyroid cancer: extent of thyroidectomy. Cancer Control 7:240–245