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Research Article

Incidence and Variations in the Relationship Between the Recurrent Laryngeal Nerves to the Inferior Thyroid Arteries in Sudanese Subjects

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Abstract: Understanding the surgical anatomy of the relationship between recurrent laryngeal nerves (RLNs) and the inferior thyroid arteries (ITAs), and its possible variations is paramount to safe and effective thyroid surgery. *Objective:* The objective of the study was to investigate the relationship of the recurrent laryngeal nerve with the inferior thyroid artery in Sudanese subjects. A Multicentric Hospital based descriptive prospective study included all consecutive patients who fulfilled the criteria of the research and treated by thyroidectomy after acceptance of the informed consent during study period between December 2009 and May 2012. Using a pretested questionnaire each anatomical detail of the patients was documented by intraoperative photos. The collected data was managed statistically using SPSS version 21. The study included 82 patients (69 females and 13 males). The data analysis was based on 164 nerve dissections. The rate of identification of the RLN was 100%. Nine variations of the RLN were clarified. In the most observed variation the nerve was anterior to ITA in 63.4% on the right versus posterior to ITA in 50% on the left. When considering both sides, there was statistically significant difference in the relationship of the recurrent laryngeal nerve and the inferior thyroid artery between both sides (P = 0.04). In 26.9% cases the relationship between RLNs and ITAs were similarly occurred in opposite sides. In conclusion, racial variations could contribute to the explanation of the differences observed in the current study and in literature in the relationship between the RLN and the ITA.
Keywords: Thyroid; Recurrent laryngeal nerve (RLN); Inferior thyroid artery (ITA); Non- recurrent laryngeal nerve (NRLN); Gender

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 there are variations of the recurrent laryngeal nerve [1, 2]. The course of the RLN is determined by the pattern of development of the arteries with which it becomes related, and the variations of this pattern will determine variations in the anatomical disposition of this nerve [3]. Recognition of variations of the inferior laryngeal nerve is essential. The anatomical variations in the relation between the recurrent laryngeal nerves and the inferior thyroid arteries during thyroidectomy have been widely studied [4]. Recently surgeons advocate the routine identification and dissection of RLN to reduce its injury risk to minimum, and for endocrine surgeons it is unacceptable if RLN is not identified during thyroid surgery [5, 6]. It has been stated currently that during the past years more than 100 publications have described variations and techniques to identify RLN during surgery [7].

The literature concerning relationship between recurrent laryngeal nerve and inferior thyroid artery is highly variable and sometimes contradictory. So, our intention in this study was to learn more about our population regarding the surgical anatomical variations of the relationship between the RLN and ITA in Sudanese subjects and comparing the obtained results from Sudanese subjects with international data.

SUBJECTS AND METHODS

A convenience sample, non probability total coverage multicentre Hospital based descriptive prospective surgical anatomical study was carried out in Charity teaching hospital and Omdurman teaching hospital between December 2009 and May 2012. All adult patients from both genders with thyroid disorder that were managed surgically by subtotal thyroidectomy were enrolled into study after being accepted the pre given informed consent.

Patients with previous thyroid surgery or with malignant thyroid disease were excluded from the study. Preoperative diagnosis and status of thyroid disease was done clinically, thyroid function tests and histopatologically by fine needle aspiration or Tru cut needle biopsy when needed.

Our routine operative strategy to thyroid glands and the surgical technique that we have adopted has been described and standardized earlier [8].

Subtotal thyroidectomy is carried out through a transverse 'collar' incision, two fingers' breadth above the suprasternal notch. This lies in the line of the natural skin folds of the neck. Skin flaps are reflected, together with platysma, and the investing fascia opened longitudinally between the strap muscles and between the anterior jugular veins. If more room is required in the case of a large goitre, the strap muscles are divided; this is carried out at their upper extremity because their nerve supply (the ansa hypoglossi) enters the lower part of the muscles and is hence preserved.

The pretracheal fascia is then divided, exposing the thyroid gland. 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. The thyroid is then mobilized and its vessels ligated after identification of the RLN during the ligation of the inferior thyroid artery and superior laryngeal nerve during the ligation of the superior thyroid artery in each side separately.

The RLN was classified in accordance with its position, anterior, posterior, or between branches of the ITA.

All operations were undertaken in both hospitals by the same surgical team. Each anatomical detail of the patients was documented immediately during operation.

Data collected using a predesigned questionnaire. All thyroidectomies performed during the period of study were evaluated, and the various relations between the recurrent laryngeal nerves and the inferior thyroid arteries as well as the presence or absence of non-recurrent laryngeal variant were recorded. Each anatomical detail of the patients was documented by intraoperative photos.

Data analysis was performed using SPSS version 15.0 for Windows. All quantitative data were presented as mean values ± standard deviation (SD). We used the Chi-square test (χ^2) to compare the differences between the right and left RLNs with confidence level 95%. Student's t test was used to compare between three different relations of RLN to ITA (anterior to, posterior to and between branches of the ITA). A *p* value <0.05 considered to be significant.

RESULTS

The whole sample size was 112 patients. Of them, 30 patients did not fit the inclusion criteria, so were excluded from the study. Only 82 patients were included for the final assessment 69 (84.15%) were females and 13(15.85%) were males, with male to female ratio of 1:5.3. Their mean age was 42.8 ± 8.4 years. Depending on the extent of resection of thyroid tissue, surgery was subtotal thyroidectomy in all cases. The data analysis was based on 82 patients and 164 nerve dissections. The rate of identification of the RLN was 100% for all patients and for all nerves dissected. Nine variations of the RLN were clarified in this study. In the most observed variation the nerve was anterior to ITA in 63.4% on the right versus posterior to ITA in 50% on the left (Table 1).

Table 1: Combinations of the recurrent laryngeal nerve (RLN) positions considering both sides (n=82)

Relation of right RLN to ITA		**Relation of left RLN to ITA**			**Total**
		Anterior to the ITA	**Posterior to the ITA**	**Between branches of the ITA**	
Anterior to the ITA	Count	6	25	21	52
	% of Total	7.3%	30.5%	25.6%	63.4%
Posterior to the ITA	Count	1	13	8	22
	% of Total	1.2%	15.9%	9.8%	26.8%
Between branches of the ITA	Count	2	3	3	8
	% of Total	2.4%	3.7%	3.7%	9.8%
Total	Count	9	41	32	82
	% of Total	11.0%	50%	39%	100%

Variations such as a non-recurrent laryngeal nerve or the absence of the ITA were not found in this study. When comparing the relationship in both sides, there was statistically significant difference in the relationship of the recurrent laryngeal nerve and the inferior thyroid artery between both sides (P = 0.04). The relationship found on one side did not always occur on the opposite side. Only in 26.9% cases the relationship between recurrent laryngeal nerves (RLNs) and inferior thyroid arteries (ITAs) were similarly occurred in opposite sides. There was a statistically significant difference in the distributions of the three types of relationships between recurrent laryngeal nerve (RLN) and inferior thyroid artery (ITA) in right and left sides (P = 0.03). In both sexes, the left RLN lay more frequently posterior to the inferior thyroid artery (ITA), in 47.83% (33 female patients), and 61.54% (8 male patients) (Table 2).

There was no statistically significant difference in the relationship between the left recurrent laryngeal nerve and the left inferior thyroid artery (P = 0.18).

Table 2: Relation of RLN to ITA according to genders in the incidence and variation in the relationship between the recurrent laryngeal nerves and the inferior thyroid arteries considering both sides (n=82)

		Relation of RLN to ITA			Total
		Anterior to the ITA	Posterior to the ITA	Between branches of the ITA	
Females	Count	53	51	34	138
	% within group	38.4%	36.96%	24.64%	100%
	% of Total	32.35%	31.1%	20.7%	84.1%
Males	Count	8	12	6	26
	% within group	30.77%	46.16%	23.07%	100%
	% of Total	4.9%	7.35%	3.65%	15.9%
Total	Count	61	63	40	164
	% of total	37.2%	38.5%	24.3%	100%

Whereas, in the right side the right RLN lay more frequently anterior to the inferior thyroid artery (ITA), in 63.77% (44 female patients), and 61.54% (8 male patients). There was statistically significant difference in the relationship between the right recurrent laryngeal nerve and the right inferior thyroid artery (P = 0.009).

Overall considering the both sides the recurrent laryngeal nerve was found to lay mostly posterior in 38.4% (63/164), followed by decreasing order in the incidence anterior and between branches of inferior thyroid artery, 37.2% (61/164) and 24.4% (40/164) respectively. There was no statistically significant difference in the relationship between the recurrent laryngeal nerve and the inferior thyroid artery (P = 0.36). The influence of the considered side (right or left) on the position of the RLN was analyzed. The influence of the sex of patients on the position of the RLN was not analyzed fully due to the great difference in the available number of male and female specimens.

DISCUSSION

Numerous authors have studied the different ways the recurrent laryngeal nerve crosses the inferior thyroid artery. This crossing has been classified in different ways. During surgery in this study three possibilities were considered: the recurrent laryngeal nerve was either superficial to (anterior) or deep to (posterior) the inferior thyroid artery or between its branches. This is in agree with others [9-14]. When considering both sides together in our study we found that the recurrent laryngeal nerve in most of cases to assume the posterior position in relation to the inferior thyroid artery (38.4%). Analyzing 19 studies which reported this relationship, when considering the both sides as a set, 17 showed that the RLN is more frequently located posterior to the ITA, between 24.47% to 75.58% of the time [2,9-26] (Table 3).

Considering right and left sides separately, differences appear, as our study showed that there is a difference in the relationship between the right and the left sides, this is in contradiction with the study by Fowler and Hanson [9] in their dissection of 400 cadavers as they found no difference between the right and the left sides.

Our study showed that, on the left side, the recurrent laryngeal nerve (RLN) was found in most cases to assume a posterior position in relation to the inferior thyroid artery (ITA) in 50%.

In 15 analyzed works, 14 showed the predominance of the posterior position of the nerve in relation to the artery on the left [10-22, 24, 25].

Consequently, in our study it followed by, in decreasing order of frequency, positions between the branches and anterior to the artery, as we found the nerve in 39% of cases lying between the branches of the artery and in 11% superficial to the artery.

This in agrees with others who observed that the nerve lying between branches followed by being anterior to the inferior thyroid artery [2, 11, 13, 27], while the findings disagrees with others where the nerve was lying anterior followed by being between branches [10, 26].

On the right, the variation is larger. Our study showed that, on the right side, the recurrent laryngeal nerve (RLN) in most of cases assumes an anterior position in relation to the inferior thyroid artery (ITA) in 63.4%.

The estimation that the RLN is superficial in 67% on the right side in Page's study [28] is compatible with our finding, but incompatible with many reports.

Analyzing the same 15 works, 8 showed that the RLN passes more frequently between the branches

of the ITA. In 5, the RLN passed posterior to the ITA in most cases, and in only 2 studies was it placed anterior to the artery with higher frequency [10-22, 24, 25].

Consequently, in our study, this followed by, in decreasing order of frequency, posterior position and between the branches of the inferior thyroid artery, as we found the nerve in 26.8% of cases lying posterior to the artery and in 9.8% between the branches of the artery.

This is in agreement with Flament *et al.* [13], but these findings disagrees with others [1, 2, 10, 11] where they found that the nerve in the right side lying mostly in a posterior position or between the branches to the artery.

The finding of the right recurrent laryngeal nerve to be found between the branches of the inferior thyroid artery is the least incidence (9.8%) is in agreement with that reported by Berlin [10] and Uen *et al*. [2].

While others found that the nerve passed in between the branches of division of the artery in most of cases [11,26]. Flament *et al. [*13] in their meta-analysis study found no difference in the order as they found that the incidence of the nerve of being between the branches equal to the incidence of being posterior to the artery in the right side.

It would be interesting to analyze the influence of gender differences on the relationship between the recurrent laryngeal nerve (RLN) and the inferior thyroid artery (ITA). The available number of male patients for dissection was small in relation to the number of female ones. Thus, the analysis of the difference in the distribution of the 3 types of relationships between the RLN and the ITA between the two sexes was concisely performed. More over in our study we found some difference concerning the anatomic variations of the nerve between males and females:

On the right side the recurrent laryngeal nerve crossed the inferior thyroid artery superficially in 63.77% of females, and 61.54% of males, whereas on the left side the RLN crossed the inferior thyroid artery superficially in 13.04% of females and not recorded in males.

Table 3: Results of authors considering right and left sides together

Author	Year	Country	Number of visualized nerve	RLN Anterior to the ITA (%)	RLN posterior to the ITA (%)	RLN between branches of the ITA (%)
Fowler & Hanson [9]	1929	USA	400	26	65.5	8.5
Berlin [10]	1935	USA	140	32.14	53.57	14.29
Bachhuber [11]	1943	USA	200	14.5	44	40.5
Simon [12]	1943	USA	86	17.44	75.58*	6.98*
Reed [15]	1943	USA	506	18.6	39.1	36.5
Armstrong & Hinton[16]	1951	USA	100	34	43	23
Wad [17]	1955	UK	200	10.5*	47.5	34.5
Bowden [18]	1955	UK	58*	18.97	41.38	34.48
Hunt *et al.* [19]	1968	Australia	151	29	57	9
Skandalakis *et al.* [20]	1976	USA	204	20.6	41.6	37.3
Flament *et al.* [13]	1983	France	---	19.45	30.2	50.35*
Hirata [21]	1992	Japan	784*	18.65	46.25	35.1
Lekacos *et al.* [22]	1992	Greece	191	16	51	33
Chang-Chien [23]	1980	Taiwan	100	24	56	20
Al-Salihi & Dabbagh [14]	1989	Iraq	212	23.11	53.78	23.11
Costa *et al.* [24]	1997	Brazil	98	37.76*	39.08	22.44
Sturniolo *et al.* [25]	1999	Italy	280	31.1	43.2	25.7
Campos & Henriques [26]	2000	Brazil	143	27.97	24.47*	46.86
Uen *et al.* [2]	2006	China	120	14.15	65.8	20.05

*** Minimum and maximum percentage value for each position**

This agrees with the study by Page *et al.* [28] where the nerve was superficial in 70.24% and 51.35% of females and males respectively on the right side, where as on the left side the nerve was superficial in 12.74% and 4.88% of females and males respectively.

When considering both sides together, the position of the recurrent laryngeal nerve (RLN) found in male and female patients are presented previously. In females, the RLN lay more frequently anterior to the inferior thyroid artery (ITA) (38.4%), whereas, in males it lay more frequently posterior to the ITA (46.16%). Of

course there was an important difference between these populations (69 females and only 13 males) and caution is needed in drawing conclusions.

In 73.1 % of the cases, the relationship found on one side did not occur again on the opposing side. Reed [15] in the U.S.A. found different relationships on the two sides in 17% of the cases. Hirata [21] in Japan found the same relationship on the two sides in 40% of male corpses and in 28.6% of female ones. Sturniolo *et al*. [25] in Italy found the same relationship on both sides in 51.2% of the cases. The same author found a different relationship between the two sides 48.8% of the time. Campos & Henriques [26] found a different relationship 37.32% of the time. In the sample presented here, only in 26.9% of the cases the orientation found on one side occurred again in the opposing side. No non-recurrent inferior laryngeal nerve was found in the current study. This is similar to the result obtained by others [25, 29], but differ from others [1, 30, 31] (Table 4).

Table 4: Reports of frequency of non recurrent laryngeal nerve (NRLN)

Author	Year	Surgical cases (n)	Frequency of NRLN (%)
Sturniolo *et al.* [25]	1999	192	0.0
Defechereux *et al.* [30]	2000	2517	0.79
Vallicioni *et al.* [31]	2003	2128	0.4
Ardito *et al.* [1]	2004	1342	0.2
Souza *et al*. [29]	2009	73	0.0

CONCLUSION

This study highlights three anatomic variations of the recurrent laryngeal nerve, and confirms the literature findings concerning the nerve and the inferior thyroid artery.

On the right side in most cases, the recurrent laryngeal nerve (RLN) was found anterior to the inferior thyroid artery (ITA), followed by, in decreasing order of frequency, positions posterior and between the branches of the artery.

On the left, the RLN was placed more frequently posterior to the artery, followed by, in decreasing order of frequency, positions between the branches and anterior to the ITA.

In 73.1% of the cases, the relationship found on one side did not occur again on the opposing side. Study also stated that anatomic variations might be different for males and females.

Racial variations could contribute to the explanation of the differences observed in the current study and in literature in the relationship between the RLN and the ITA.

Moreover, the thyroid surgeon must be aware of the existence of anatomical variations, which are not as rare as one may think. Thus, all 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.

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