Assessment of nerve stimulation during thyroidectomy for identification of the external branch of superior laryngeal nerve

Ibtehal M. EL-Gaabary, Mahmoud M. EL-Sherief, Mohamed A. Hablus, Hamdy A. Mohamed

Department of General Surgery, Faculty of Medicine, Tanta University, Tanta, Egypt

Correspondence to Ibtehal M. EL-Gaabary, MBChB, MD, Department of General Surgery, Faculty of Medicine, Tanta University, Tanta, 31511, Egypt. Tel: 01091079088; E-mail: ibtehalmagdi.1992@yahoo.com

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Background

The external branch of the superior laryngeal nerve (EBSLN) injury is an important and not uncommon, though frequently overlooked, complication of thyroid surgery. The rate of EBSLN injury has been reported to vary from 0 to 58%, depending on different postoperative assessment methods. Injury to the EBSLN during thyroid operation can paralyze ipsilateral cricothyroid muscle, and the clinical symptoms mainly include vocal fatigue and diminished vocal frequency range, especially with respect to raising pitch, which may result in decreased quality of life, particularly for voice professionals.

Patients and methods

This prospective study included 22 patients with goiter. They were divided into two groups: group 1 (G1) included all cases in whom nerve stimulator was used and group 2 (G2) included all cases in whom trial of visual identification of the EBSLN was done.

Results

It was found that patients with short obese neck, large gland size, large gland weight, and retrosternal extension showed difficulty in EBSLN identification and had high risk of nerve injury ($P<0.042$, 0.04, 0.03, and 0.041, respectively). Nerve stimulator has improved identification of EBSLN ($P<0.036$) with less voice affection postoperatively ($P<0.04$), with no statistical difference between both groups regarding operative time.

Conclusion

It was concluded that routine use of nerve stimulator in surgical interventions on the thyroid gland will be beneficial for more secure identification and prevention of EBSLN injury and preservation of voice quality postoperatively.

Keywords:
cricothyroid muscle, external branch of superior laryngeal nerve, loss of high-pitched voice, nerve stimulator, thyroid gland surgery

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Introduction

Thyroid gland surgery is one of the most common endocrine surgeries worldwide. Although it is considered by many surgeons as a very common procedure, there are still some complications, with unacceptable and unfavorable consequences for the patient. One of these complications that have a great effect on patient's quality of life is external branch of the superior laryngeal nerve (EBSLN) injury [1].

EBSLN provides motor innervation to the cricothyroid muscle (CTM), which is the tensor muscle of the vocal cord. The close relation with the superior thyroid vessels makes the EBSLN vulnerable to iatrogenic injury every time the superior pole of the thyroid is dissected. When the EBSLN crosses the superior thyroid vessels lower in the neck, the risk of surgical damage to the nerve increases by transection, traction, entrapment, thermal damage, or disrupted blood supply [2].

EBSLN injury leads to paralysis of CTM, which results in fundamental voice changes such as decreased frequency of the voice, inability to produce high-frequency sounds, and reduced vocal projection. Given the difficulty in diagnosing abnormal conductivity of the EBSLN, the definite incidence of injury is deemed unknown. The EBSLN is very fine, ~0.8 mm in diameter, and it is often invisible because it may run under the fascia of the inferior pharyngeal constrictor muscle [3].

The actual prevalence of EBSLN injury is difficult to assess owing to limited data and heterogeneous methods used in different studies. At the very least, the surgeon should ensure that the EBSLN is not

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injured at the time of dividing tissues at the superior pole by identification of its course or excluding its presence in the divided tissue visually or by nerve monitoring [4].

Although there is no standardized method for the preservation of the EBSLN, three methods have been described to minimize the potential risk of EBSLN injury during superior thyroid vessels dissection and ligation [3]:

(1) Ligation of the individual branches of the superior thyroid vessels under direct vision on the thyroid capsule without attempts to visually identify the nerve [5].
(2) Visual identification of the nerve before ligation of the superior thyroid pole vessels [6].
(3) The use of either a nerve stimulator or intraoperative neuromonitoring for mapping and confirmation of the EBSLN identification [7].

Electrical nerve stimulation is commonly used during nerve localization for peripheral nerve blocks. It has gained lately widespread acceptance in thyroid surgery to aid in identification of EBSLN during upper pole dissection [8].

The use of a standardized approach to the functional preservation of the EBSLN can be facilitated by application of nerve stimulation resulting in improved preservation of voice following thyroidectomy or parathyroidectomy [9].

Contractility or twitching of CTM after stimulation of the structure in question was accepted as correct identification of EBSLN. However, despite this well-known belief, there has been no large and prospective study to demonstrate the diagnostic values of CTM twitch inspection with neurostimulation, especially based on the postoperative EMG result [10].

Patients and methods

This prospective study included 22 patients who presented with goiter and offered surgical thyroid excision. They were admitted to the general surgery department, Tanta University hospital, in the period from March 2018 to March 2019. An ethical approval was obtained from the ethics committee of Tanta University Hospitals, before the enrollment of patients started. All patients signed an informed consent about the procedure, possible complication and recording. The patients in this study were divided into two groups: group 1 (G1) included all cases in which nerve stimulator was used, and group 2 (G2) included all cases in which trial of visual identification of the EBSLN was done. Informed consent was taken from all patients. All patients were examined generally and locally. All patients were subjected to preoperative laboratory and radiological investigations including routine preoperative workup, thyroid function tests, neck ultrasound, neck computed tomography with contrast if needed, and FNAC. Patients who were younger than 20 years old or older than 60 years old, patients with previous thyroid surgery, or those who showed advanced malignancy were excluded from this study.

Methods

For their surgeries, the patients were under general anesthesia with a usual endotracheal tube without electrodes. After the intubation with use of muscle relaxant, the anesthesia was maintained with sevoflurane and narcotics without use of muscle relaxant anymore during surgery in eight cases.

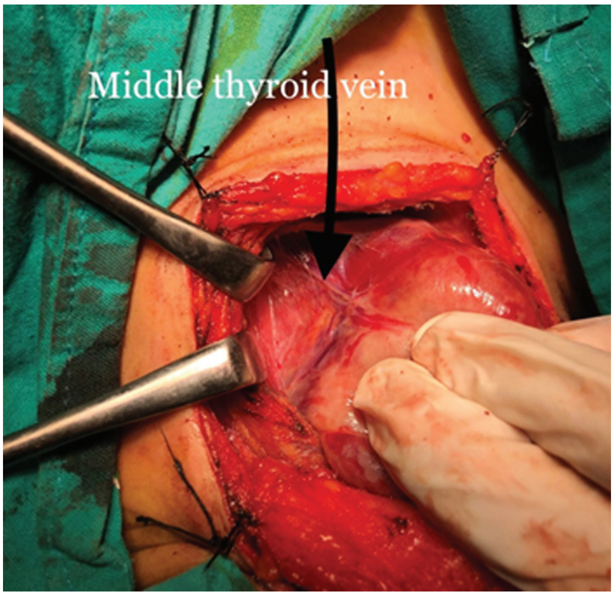
Following induction of general anesthesia, the patients were positioned in supine position with the neck extended.

The skin of neck was prepared using Povidone iodine 1%, and then the operative field was draped. A collar incision was made in a skin crease positioned approximately two finger breadths superior to the sternal notch. The subcutaneous tissues and platysma were divided with electrocautery then followed by elevation of upper and lower flaps. The deep cervical fascia is identified and divided using electrocautery at the midline between the strap muscles.

In most cases of slightly enlarged gland, there is no need for transverse division of the strap muscles. However, in cases of large masses within the superior portion of the thyroid lobe or in a patient with a short neck, a partial division of the upper part of sternothyroid muscle with cautery may improve access to the superior thyroid pedicle.

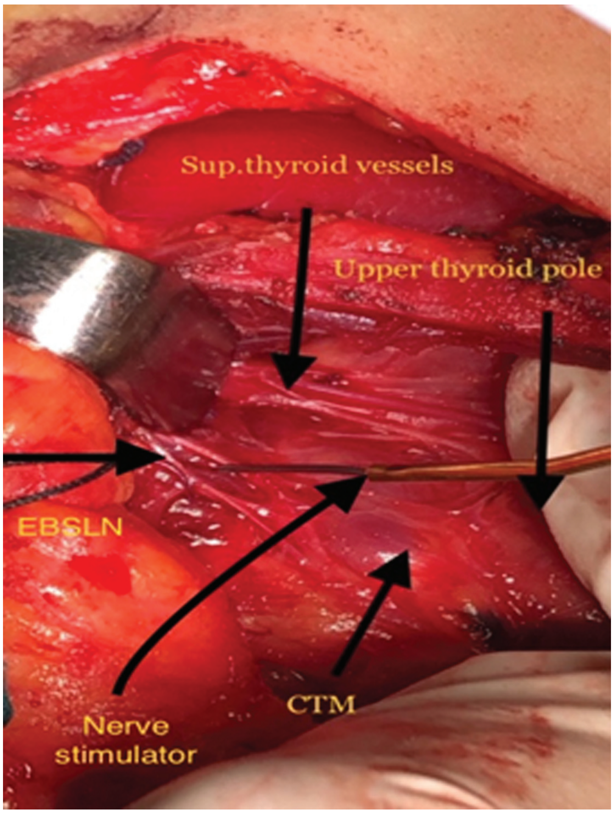
To mobilize the thyroid lobe, the middle thyroid vein is to be identified and ligated first (Fig. 1). Initial blunt dissection of the superior pole of the thyroid lobe should be undertaken in the avascular space between the medial aspect of the superior pole and CTM to obtain good exposure of the sternothyroid laryngeal triangle (Joll's triangle) harboring the EBSLN.

Figure 1



Dissection of the upper pole with identification of middle thyroid vein.

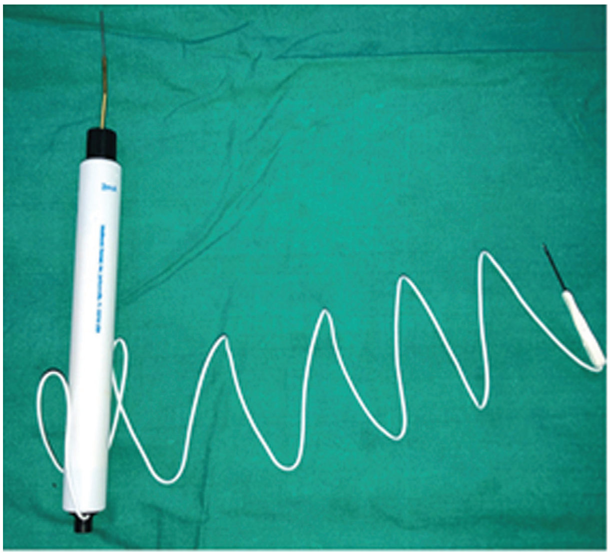
Figure 2



Dissection of upper pole of the gland with identification of Joll's triangle boundaries and searching for the nerve with the aid of the nerve stimulator.

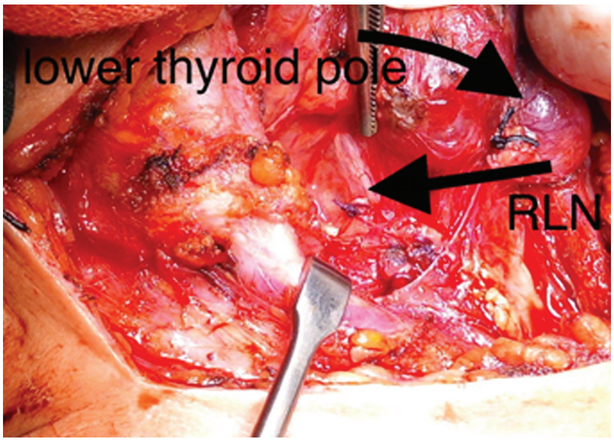
In group 1, EBSLN is searched for at Joll's triangle, and trials for visual identification should be done at both sides (Fig. 2). The following step in this group is the use of nerve stimulator (Fig. 3) and its application on the suspected fiber to confirm whether that fiber is the EBSLN or not. Then observation of CTM twitch was done, and this response serves as a true positive stimulation.

Figure 3



The nerve stimulator that was used in the study.

Figure 4



Dissection of lower pole of the gland and preservation of RLN.

However, the true negative is identified as the absence of neural tissue in the pedicle when nerve stimulator applied, and no CTM twitch is visualized.

In patients where the nerve could not be visualized, the nerve stimulator was applied to the upper pole pedicle. If no CTM twitch could be observed this confirm that the nerve isn't included (true negative).

Stimulation of EBSLN was done with a hand-held disposable Medtronic Varistim III Nerve Stimulator

(Medtronic Inc., Minneapolis, Minnesota, USA) at currents of 1–2 mA on completion of dissection.

In group 2, EBSLN is searched for at Joll's triangle, and trials for visual identification should be done at both sides.

All known operative steps of thyroidectomy were followed with special care of both parathyroid glands and RLN (Fig. 4).

All thyroid specimens were sent for histopathological examination.

All patients underwent the following postoperative evaluation:

(1) Assessment of operative time of the procedure from skin incision to skin closure.
(2) Operative complications such as RLN or EBSLN injury.
(3) Assessment of postoperative voice changes.

All patients were followed up in terms of perioperative vital data, and prophylactic antibiotics and analgesic were given, to be continued or stopped according to the clinical findings. Oral intake was started soon after recovery of anesthesia. Patients were discharged after confirmation of having normal calcium level, no voice changes, and drain removal. Follow-up postoperative visits were scheduled at one week and one month postoperatively for detection of any postoperative complications.

Results

This prospective study included 22 patients, who were divided randomly into two groups. Each group included 11 patients. Table 1 shows the demographic characteristics of the patients. There was no significant difference between groups 1 and 2 concerning age, sex, BMI, and neck length. All patients in group 1 presented with neck swelling, and six of them presented with disfigurement. None of the patients in group 1 presented with thyrotoxic symptoms. Using neck ultrasound, all patients showed bilateral and isthmus nodularity and enlarged reactive cervical lymph nodes. However, in group 2, all patients presented with neck swelling, and eight of them presented with disfigurement. None of the patients in group 2 presented with thyrotoxic symptoms. Using neck ultrasound, two patients showed diffuse thyroid swelling, and the remaining patients showed bilateral and isthmus nodularity. Retrosternal extension was detected in four patients and seven patients showed enlarged reactive cervical

Table 2 Effect of nerve stimulator on EBSLN identification

Nerve identification	Use of nerve stimulator [*n* (%)]		*P*
	Yes (group 1)	No (group 2)	
Identified EBSLN	10 (91)	7 (63.6)	<0.014
Nonidentified EBSLN	1 (9)	4 (45.4)	<0.09

EBSLN, external branch of the superior laryngeal nerve.

Table 3 Results of a univariate model for the association between selected factors and visibility of nerve

Factors	Nerve visibility		*P*
	Yes	No	
Age (years)			
<40	10	3	–
>40	7	2	0.096
Neck length			
Short obese	5	5	–
Thin tall	4	0	NA
Average	8	0	0.042
Gland size (cm^3)			
<100	13	1	0.04
>100	4	4	–
Gland weight (g)			
<60	13	0	0.03
>60	4	5	–
Retrosternal extension			
Yes	4	4	–
No	13	1	0.041

NA, not applicable.

Table 1 Demographic characteristics of the patients in the study (*n*-22; 11 in each group)

Demographic characteristics	Group 1	Group 2	*t* test/χ^2	*P* value
Age (mean±SD)	41.8±2.9	34.9±2.9	1.6*	0.12
BMI (mean±SD)	33.3±0.8	30.1±1.2	2.2*	0.037
Sex				
Females	11 (100)	9 (82)	9.3**	0.02
Males	0	2 (18)		
Neck length				
Short obese	6 (55)	4 (36)	0.9**	0.74
Thin tall	2 (18)	2 (18)		
Average	3 (27)	5 (46)		

lymph nodes. Two patients showed cystic changes and four patients showed retrosternal extension.

In this study, EBSLN identification rate in group 1 patients (with the aid of nerve stimulator) was significantly higher than that of group 2 patients: 91 vs 63.6%, respectively (P<0.014; Table 2). The Vari-Stim 3 probe was able to stimulate only the nerves that were exposed and visually identified. The electrostimulatory identification rate of the EBSLN of the group 1 patients was also significantly higher than visual identification of the EBSLN in group 2 patients (P<0.014).

Intraoperatively, the identified nerves were classified according to the Cernea classification, which is based on the potential risk of EBSLN injury. In G1, 7 patients were Cernea class 2a and three patients were Cernea class 1, which is relatively safe during upper pole dissection. However, in G2, four patients were Cernea class 1 and three patients were Cernea class 2a.

Throughout this study, it was observed that some variants show a significant effect on EBSLN identification. Regarding neck length, significant increases in nerve identification were in patients with average neck length (P<0.042), in patients with gland size less than 100 cm^3 (P<0.04), in patients with gland weight less than 60 g (P<0.03), and in patients with no retrosternal extension (P<0.041) (Table 3).

Use of nerve stimulator does not show any statistically significant difference between both groups regarding operative time (P<0.387) (Table 4).

Table 4 Effect of nerve stimulator on operative time

Factors	Usage of nerve stimulator		P
	Group 1	Group 2	
Operation time (min)			
<120	8	6	<0.387
>120	3	5	
Mean±SD	125±16.3	115±15.9	<0.17

Regarding postoperative voice changes, all patients in G1 showed mobile vocal fold on examination after extubation, and none of them reported loss of high pitch. The patient in whom the EBSLN could not be visualized and negative method was used showed hoarseness of voice postoperatively. In G2, left vocal fold immobility was detected on examination after extubation, hoarseness of voice, and lost high pitch in one patient, and other two patients reported lost high pitch. In all patients who showed voice changes postoperatively in G2, the EBSLN could not be visualized (Table 5).

Discussion

Protection of the laryngeal nerves (RLN and EBSLN) and preservation of vital parathyroid glands are the two main technical challenges for the operating surgeon [11]. It was proposed firstly by Lahey, in 1938, routine visualization method and dissection of the laryngeal nerves before and during the beginning of glandular dissection [12].

In fact, the anatomical integrity does not always guarantee the functional one, and for this reason, in the past 2 decades, various devices for the intraoperative nerve function monitoring have been proposed, applied, and affirmed [13].

Masuoka *et al.* [14] also reported similar results, which are in accordance with our study that there was no significant difference between groups concerning sex, age, disease, the extent of surgery, or the extent of lymph node dissection. Similar results regarding the usefulness of electrostimulation in the identification rate of EBSLN were also reported.

Aina *et al.* [15] also used a nerve stimulator for identification of the EBSLN in 151 consecutive patients and 218 nerves at risk. The identification rate of the EBSLN was very high in this study, at 92.7%, and this supports the finding in our results.

Table 5 Postoperative voice quality

	Group 1	Group 2	χ^2	P
Postoperative hoarseness				
Yes	1 (9)	1 (9)	3.2*	0.036
No	10 (91)	10 (91)		
Pitch quality				
Normal	11 (100)	8 (72.7)	0.38*	0.04
Loss of high pitch	0	3 (27.3)		
Mobility of vocal cord				
Mobile	11 (100)	10 (91)	1.5*	0.5
Fixed (unilateral or bilateral)	0	1 (9)		

Moreover, Claudio and colleagues had confirmed that effective prevention of iatrogenic EBSLN lesions during thyroidectomies was achieved by the intraoperative identification of the nerve with the nerve stimulator [16].

In contrast, Masuoka *et al.* [14] randomly assigned 252 patients with 405 EBSLNs at risk to undergo thyroid surgery with a conventional technique assisted by a VariStim III nerve stimulator or with IONM, both set at a 1 mA stimulus. They concluded that IONM significantly improved not only the visual identification rate of the EBSLN but also the stimulatory identification rate as compared with the VariStim III nerve stimulator.

In addition, Barczyński *et al.* [17] reported that the use of IONM with EMG significantly improved the identification rate of the EBSLN during thyroidectomy, as well as reduced the risk of early phonation changes after thyroidectomy.

Although IONM has been widely accepted as an alternative modality to preserve and make sure that the nerve integrity either anatomical or functional is intact, it is a complicated costly method as proposed by Goretzki *et al* [18].

It was supposed by Barczyński *et al.* [17] that nerve stimulation technique has a substantial advantage in identifying all nerve types, including Cernea type 1, which is found at a higher position and sometimes is crowded under the laryngeal head of the sternothyroid muscle, as well as descending types 2A and 2B, which are most vulnerable to surgical manipulation injury.

Regarding the different variants that have an effect on EBSLN identification, in this study, it was found to be large gland size, large gland weight, retrosternal extension, and short obese neck. Pagedar and Freeman [19] also saw Cernea type 2b nerves in 48% and the specimen weighted more than 50 g.

In this study, nerve stimulator has no effect on operative time in G1 when compared with visual identification only in G2. Moreover, Delbridge [20] reported that the nerve search did not significantly increase the operative time in the studied cases.

Avoiding voice changes is a challenge in thyroid surgery. The prevalence of EBSLN injury varies widely from 0 to 58%, depending on different factors. The way to protect patients from iatrogenic injury of the EBSLN remains a subject for debate [21].

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Nil.

Conflicts of interest

There are no conflicts of interest.

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