Intraoperative identification versus nonidentification of external branch of superior laryngeal nerve on post-thyroidectomy voice changes: a prospective comparative study

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Background
External branch of superior laryngeal nerve (EBSLN), which is the motor supply of the cricothyroid muscle, is closely related to superior thyroid vessels with multiple anatomical variations. Thyroidectomy may be complicated with EBSLN injury with postoperative voice changes. This study aimed to compare between identification and nonidentification of EBSLN on post-thyroidectomy voice changes.
Patients and methods
A prospective comparative study was conducted at Ain Shams University Hospitals between March 2018 and March 2021. It included 150 cases of total thyroidectomy who were divided sequentially into two groups, group A (cases with nonidentification of EBSLN) and group B (cases with identification of EBSLN). We excluded from group B the cases of failed identification of the nerve (even unilateral) after trial of dissection and identification. Preoperative demographics, operative and postoperative data were collected and compared between two groups. EBSLN affection as the main outcome was assessed by a combination of postoperative voice changes and laryngoscopic finding.
Results
Group A included 75 cases and group B included 66 cases after exclusion of nine (12%) cases due to failure of intraoperative identification. There was a nonsignificant difference between both groups as regards preoperative demographics and operative data (blood loss, operative time, and complications). As regards postoperative EBSLN affection, we did not find any significant difference between both groups (6.7% in group A vs. 4.5% in group B).
Conclusions
Visual identification of EBSLN in thyroidectomy is feasible by an experienced surgeon with no significant benefits over individual ligation of superior thyroid vessels close to the thyroid capsule without identification of the nerve.

Keywords:
external laryngeal nerve, thyroidectomy, voice changes, superior thyroid vessels

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Background

Total thyroidectomy is considered one of the most common operations in our surgical practice with different indications such as nodular goiter, toxic goiter, and malignant thyroid nodule. Total thyroidectomy carries multiple morbidities such as hypocalcemia and nerve injury [recurrent laryngeal nerve (RLN) and external branch of superior laryngeal nerve (EBSLN)] [1,2].

Superior laryngeal nerve originates from the inferior ganglion (nodose ganglion) of the vagus nerve. About 1.5 cm below its origin, it is divided into an internal and external branch. EBSLN is the motor nerve supply of cricothyroid muscle (CTM), which is the tensor of vocal folds and responsible for a high pitched voice. Its injury can develop voice fatigue and decrease in voice range [3].

Some cases of voice changes after thyroidectomy are due to EBSLN affection; it ranges from 0–6% and up to 58% in some literatures according to the method of injury assessment [subjective or objective as electromyography (EMG)] [2,4,5]. Intraoperative identification of EBSLN is considered a challenge to many surgeons preferring close ligation of superior thyroid vessels (STVs) in close proximity to the upper pole without identification of the nerve [1,2].

Theoretically, intraoperative exposure of EBSLN is effective for its protection as it was standardized in RLN. Many prospective studies have shown less incidence of EBSLN affection after thyroidectomy with nerve dissection and exposure than nonidentification [6,7].

On the other side some surgeons debate against searching of the nerve due to increased risk of injury. Dionigi *et al.* [8] conducted a study to assess the effect of EBSLN dissection on its amplitude of electrical response by a nerve stimulator. They found that the amplitude significantly decreased after dissection.

Different techniques were reported for EBSLN preservation, including identification and ligation of STV branches close to the thyroid capsule, visual identification before ligation of STVs, and the use of nerve stimulator or nerve monitoring [9].

Our aim in this study was to compare between identification versus nonidentification of EBSLN and its effect on the nerve injury in thyroidectomy.

Patients and methods

Study design

This study was a prospective comparative study conducted at Ain Shams University Hospitals between March 2018 and March 2021. It included 150 cases of total thyroidectomy. An informed consent was taken from all patients including the surgical procedure, possible complications, and participating in the study. We got approval from the ethics committee of the General Surgery Department, Ain Shams University to conduct this study.

Eligibility criteria for the study

The study included all patients indicated to total thyroidectomy from the age of 18–65 years and fit for general anesthesia. We excluded cases of completion thyroidectomy, previous thyroid surgery, presence of preoperative voice changes, any preoperative laryngoscopic findings (abnormality of vocal folds or any masses or polyps), and malignant thyroid cases with extra thyroid extension to any surrounding structures or needed cervical lymph node dissection. The included cases were divided sequentially into two groups: group A (cases with nonidentification of EBSLN) and group B (cases with identification of EBSLN). Also, we excluded from group B the cases with failed identification of the nerve (even unilateral) after trial of dissection and identification.

Preoperative workup

History taking, general and neck examination, routine laboratory investigations including thyroid hormonal profile and neck sonography were done. Fine needle aspiration and cytology for suspicious thyroid nodule were done. The patient's voice was examined preoperatively by the phoniatric doctor (who shared in this study) to confirm no voice abnormality without knowing in which group the patient would be included. All patients underwent preoperative videolaryngeoscopic examination before the surgery to exclude any voice or vocal fold disorders.

Surgical procedure

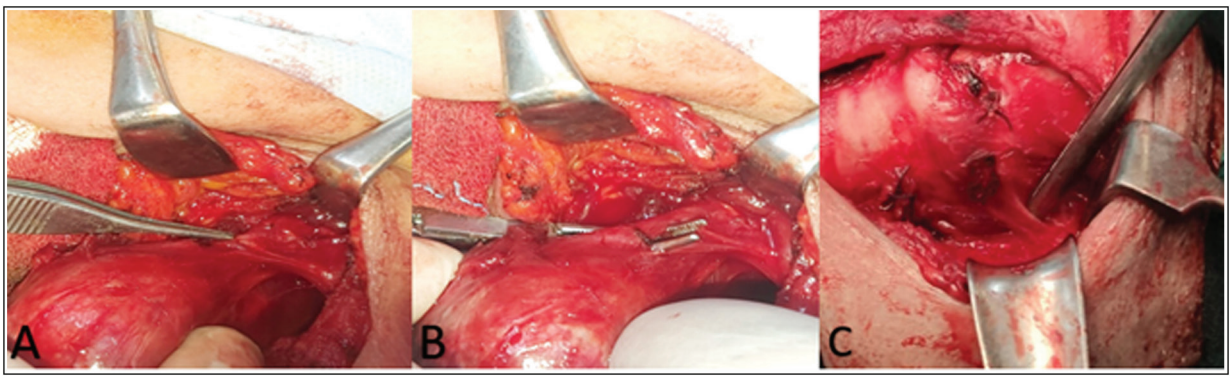
The patient lied in supine position after general anesthesia with full neck extension. Low collar transverse skin incision was done followed by raising the sub-platysmal flap just above the upper thyroid cartilage. Investing deep fascia was opened by electrocautery at the midline. Strap muscles were separated laterally and then proceeding superiorly to the upper pole. We standardized the following approach for the upper pole. The sternothyroid and sternohyoid muscles were retracted laterally and the lobe was retracted inferolaterally. In group A, individual ligation of STVs close to the thyroid capsule was done while in group B, complete exploration of STVs with individual ligation of the vessels was done after complete exposure of EBSLN (Fig. 1). We could identify EBSLN in Joll's triangle, which is formed laterally by the upper thyroid pole and STVs, superiorly by the attachment of the sternothyroid to the thyroid cartilage and medially by the larynx. Dissection in this triangle exposes its floor which is formed by CTM [10]. Dissection was performed gently by blunt or bipolar diathermy with no monopolar diathermy avoiding injury to the CTM.

In both groups, ligation of inferior thyroid veins was done at the lower pole. Then exposure of RLN was done at the tracheoesophageal groove, and then we ligated the terminal branches of the inferior thyroid artery to preserve the vascularity of the parathyroid gland (PTG). Then good hemostasis was done with insertion of the closed suction drain before closure.

Postoperative workup

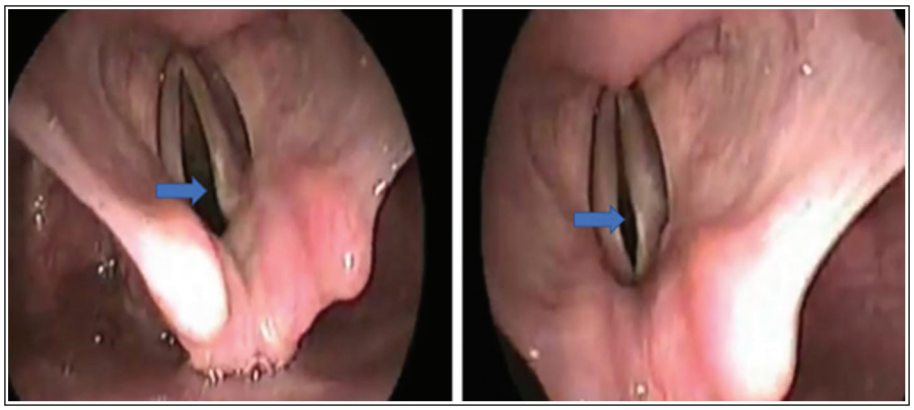
Postoperative care in the ward was done with follow up of the drain output (which was removed once the output is <50 ml in 24 h), vital data, and postoperative complications as hypocalcemic manifestation, voice changes including voice fatigue, loss of high pitched voice, dysphonia, and aphonia. The cases complicated with voice changes due to nerve affection were managed conservatively by the phoniatric unit. Postoperative adjusted serum calcium level (normal 8.5–10.5 mg/dl) was measured for cases with symptomatic hypocalcemia.

Figure 1



(a) Identified EBSLN, (b) dissected superior thyroid artery at capsule, (c) preserved EBSLN after lobectomy. EBSLN, external branch of superior laryngeal nerve.

Figure 2



Postoperative laryngoscopy showing left vocal fold bowing.

Follow-up

After hospital discharge at the seventh postoperative day, the patient was sent to the phoniatric doctor to detect any voice changes compared with the preoperative voice and to do direct video-laryngoscopy to assess the vocal folds. Laryngoscopic signs suggestive of EBSLN injury include bowing of the vocal fold, inferior displacement of the affected fold, and rotation of the posterior glottis toward the site of lesion when using the voice in high pitch [11,12] (Fig. 2). The cases presented to our outpatient clinic at 1, 3, and 6 months to follow up the management of voice changes and hypocalcemia.

Data collection and outcomes

Collection of the data was done including preoperative demographics of the patients (age, sex, and etiology), operative data (operative time, blood loss, intraoperative injury of RLN or PTG), and postoperative data including hypocalcemia, bleeding, hospital stay, voice changes, and the video-laryngoscopic findings. EBSLN affection (the main outcome) was documented by a combination of voice changes suggestive of EBSLN injury (as voice fatigue or loss of high pitched voice) and laryngoscopic findings suggestive of EBSLN injury because neither of both is specific for EBSLN injury. We considered the voice changes documented by a phoniatric doctor (not the surgeons) who assessed the patient's voice at the preoperative period and seventh day postoperatively.

Data analysis

Data was revised, coded, and entered into a computer and analyzed using SPSS, version 26 for Windows (SPSS Inc., Chicago, Illinois, USA). Quantitative data was described as mean and SD. Student's t test was used for comparing quantitative variables between two study groups. Qualitative data was expressed as frequencies (n) and percentage (%). χ^2 and Fisher's exact tests were used to test the association between qualitative variables. P value less than or equal to 0.05 was considered significant.

Results

Our prospective study included 150 patients operated for total thyroidectomy between March 2018 and March 2021 at Ain Shams University Hospitals. Patients were divided into two groups:

Table 1 Preoperative demographics

Variables	Group A (75)	Group B (66)	Test value	*P* value	Significance
Age in years (mean±SD)	47.53 ± 13.24	44.55 ± 12.23	1.386*	0.168	NS
DM [*n* (%)]					
Yes	30 (40)	24 (36.4)	0.196**	0.658	NS
No	45 (60)	42 (63.6)			
Sex [*n* (%)]					
Male	15 (20)	18 (27.3)	1.036**	0.309	NS
Female	60 (80)	48 (72.7)			
Etiology [*n* (%)]					
SMNG	45 (60)	30 (45.5)	5.917**	0.116	NS
TNG	10 (13.3)	12 (18.2)			
Graves	10 (13.3)	6 (9.1)			
Malignant	10 (13.3)	18 (27.3)			

DM, diabetes mellitus; NS, nonsignificant; SMNG, simple multinodular goiter; TNG, toxic nodular goiter. *Student's *t* test. **χ^2 test.

Table 2 Operative data

Variables	Group A (75)	Group B (66)	Test value	*P* value	Significance
Operative time min (mean±SD)	92.87 ± 23.88	90.46 ± 16.70	0.701*	0.484	NS
Blood loss ml (mean±SD)	56 ± 24.33	59.14 ± 19.03	0.857*	0.393	NS
RLN injury [*n* (%)]	1 (1.3)	0	0.886**	0.346	NS
PTG injury [*n* (%)]	3 (4)	1 (1.5)	0.786**	0.375	NS

NS, nonsignificant; PTG, parathyroid gland; RLN, recurrent laryngeal nerve. *Student's *t* test. **χ^2 test.

Group A: included 75 cases without the identification of EBSLN.

Group B: included 66 cases with the identification of the EBSLN, after exclusion of nine patients due to intraoperative failure of nerve identification (even unilateral).

As regards preoperative demographic data, the difference between both groups was nonsignificant as shown in Table 1.

We had nonsignificant difference between both groups regarding the operative time (92.87 ± 24 min in group A vs. 90.46 ± 16 min in group B). Intraoperative blood loss was 56 ± 24 ml in group A while in group B it was 59.14 ± 19 ml with no statistically significant difference. The difference between both groups regarding the intraoperative injury of RLN or PTG was statistically nonsignificant (Table 2).

As regards postoperative data, we had a nonsignificant difference between groups A and B in voice changes (dysphonia and loss of high pitched voice) as shown in Table 3. Hypocalcemia (symptomatic and biochemical) was found in 12 (16%) patients in group A versus nine (13.6%) patients in group B with nonsignificant difference (Table 3 and Fig. 3). We had a nonsignificant difference between both groups in postoperative laryngoscopic findings as shown in Table 3 and Fig. 4.

All cases of RLN or EBSLN affection in our study were managed conservatively and resolved before 6 months with no cases of permanent injury. Permanent hypocalcemia developed in one case in group A with no cases in group B.

Discussion

Thyroidectomy is the best management for many thyroid disorders. Voice changes following this operation are not uncommon, which may be due to laryngeal edema from difficult intubation or aggressive surgical dissection, traction on nerves (RLN and EBSLN) or direct injuries [13]. Stojadinovic *et al.* [13] reported voice changes in 30% of patients of total thyroidectomy at 1 week postoperatively, while the Manish *et al.* [14] study reported voice changes in 23% of patients.

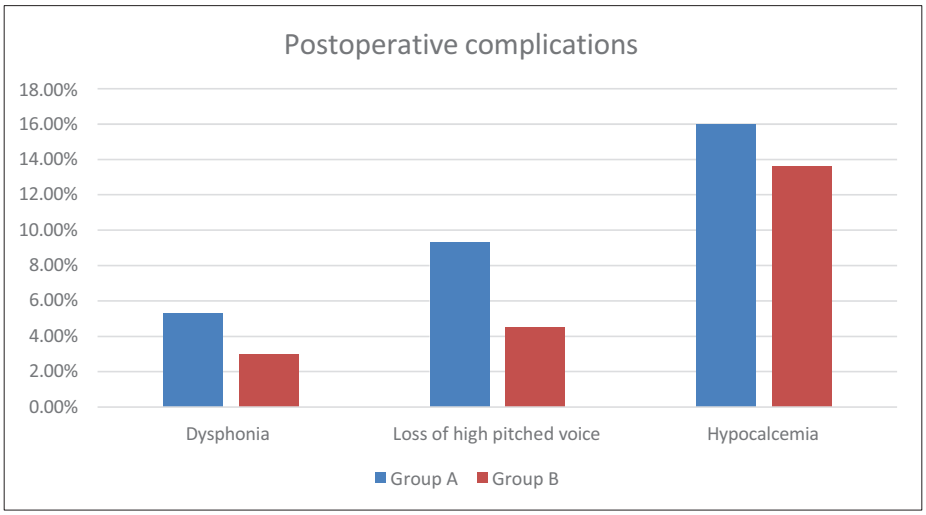
The close location of EBSLN to superior pedicle makes it liable to be affected. Cernea *et al.* [15] classified EBSLN into type 1: the nerve crosses STVs more than 1 cm above the superior thyroid pole, type 2 a: it crosses STVs less than 1 cm above the superior thyroid pole, and type 2 b: it crosses STVs under cover of the superior thyroid pole (Fig. 5). The suggestive symptoms associated with EBSLN injury are breathy voice, loss of high pitch of the voice, and decreased voice range, and these postoperative voice changes are put in consideration by professional voice users. While most of surgeons give major attention to RLN, low attention is directed to EBSLN identification [1].

Table 3 Postoperative data

Variables	Group A (75)	Group B (66)	Test value	*P* value	Significance
Dysphonia [*n* (%)]	4 (5.3)	2 (3)	0.457**	0.499	NS
Hypocalcemia [*n* (%)]	12 (16)	9 (13.6)	0.155**	0.694	NS
Loss of high pitched voice [*n* (%)]	7 (9.3)	3 (4.5)	1.221**	0.269	NS
Laryngoscope finding [*n* (%)]					
Normal	62 (82.7)	58 (87.9)	1.173***	0.821	NS
Bowing of VF	5 (6.7)	4 (6.1)			
Inferior displacement of VF	3 (4)	1 (1.5)			
Weak mobility of VF	5 (6.7)	3 (4.5)			
EBSLN affection [*n* (%)]					
Yes	5 (6.7)	3 (4.5)	0.295**	0.587	NS
No	70 (93.3)	63 (95.5)			

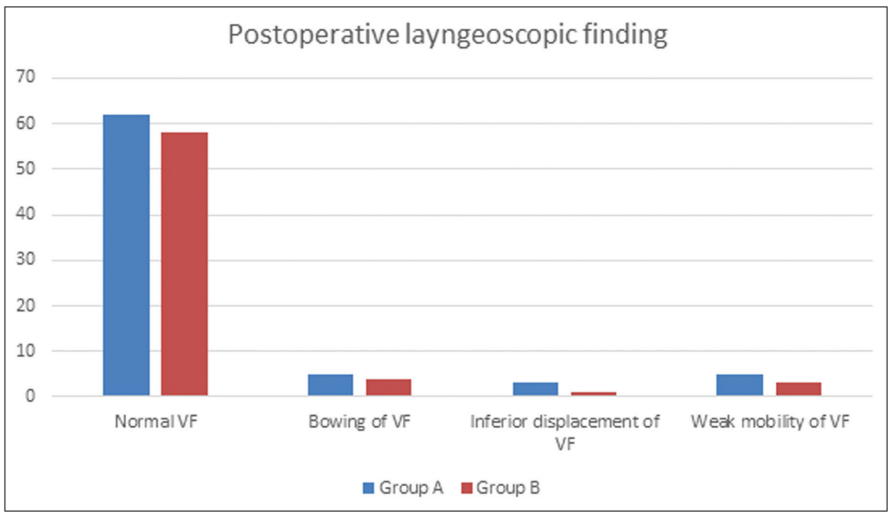
EBSLN, external branch of the superior laryngeal nerve; NS, nonsignificant; VF, vocal folds. **χ^2 test. ***Fisher's exact test.

Figure 3



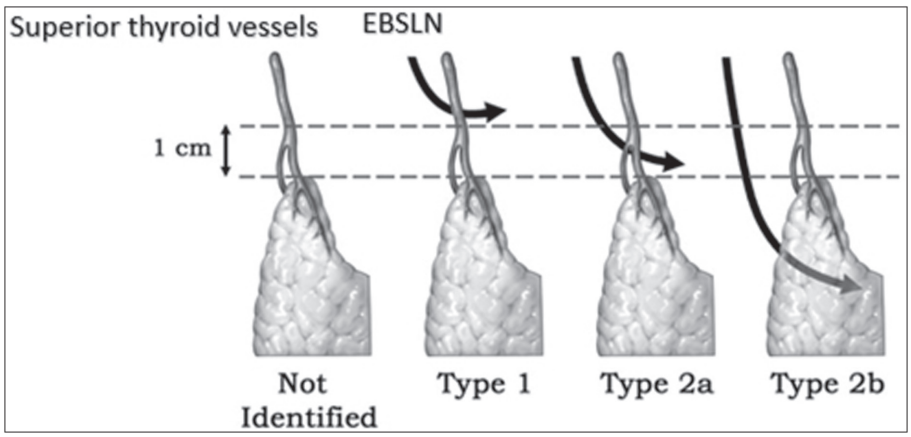
Graph showing postoperative complications.

Figure 4



Graph showing postoperative laryngoscopic findings.

Figure 5



Cernea classification of the external branch of the superior laryngeal nerve (EBSLN) according to relation to superior thyroid vessels [16]. EBSLN, external branch of superior laryngeal nerve.

There is a debate between thyroid surgeons about the clinical importance of identification of EBSLN. This prospective study aimed to compare between identification versus nonidentification of EBSLN and its effect on the nerve injury in thyroidectomy.

Our study included 75 cases in both groups, and we exclude nine (12%) cases from group B due to intraoperative failure of identification of EBSLN to become 66 cases in group B. In the study conducted by Patnaik and Nilakantan [17], they failed to identify the nerve in about 17% of cases. Ravikumar *et al.* [18] conducted a retrospective cohort study showing that visual identification (only) of EBSLNs was successful in 93% of the cases.

Intraoperative failure of identification of EBSLN at the superior thyroid pole may be attributed to the type 3 Friedman variant in which Friedman *et al.* [19] classified the nerve anatomically into type 1: the nerve passes superficial to the inferior constrictor muscle, type 2: it penetrates the muscle, and type 3: it passes deep into the muscle.

We had a nonsignificant difference between both groups regarding preoperative demographics data and intraoperative data. As regards postoperative EBSLN affection, a nonsignificant difference was found between groups A and B (6.7 vs. 4.5%, respectively). We had no permanent EBSLN affection after 6 months.

There is a small number of literatures discussing the incidence of EBSLN affection in thyroidectomy with identification of EBSLN in comparison to nonidentification with variable results between them. This variation may be due to multiple factors: different techniques of intraoperative identification (visually or neuromonitoring) and also due to anatomical variation of the nerve, surgeon experience, and methods of postoperative assessment (laryngoscopic or EMG) [6].

There are many methods for intraoperative identification of EBSLN. Visual identification by an experienced surgeon is effective and comparable to other methods as neuromonitoring. Barczyński *et al.* [9] reported a study to compare between surgical visualization and neuromonitoring of EBSLN and concluded that the difference between both methods in delayed postoperative voice changes was nonsignificant.

The Shaaban *et al.* [20] study (including 200 cases of hemi or total thyroidectomy without identification of EBSLN) had 5% of EBSLN affection detected by laryngoscopy. Their result was less than 6.7% in our nonidentification group mostly because they included hemithyroidectomy cases in their study.

Aluffi *et al.* [21] reported about 14% incidence of EBSLN injury in 45 patients with different thyroid surgeries. Teitelbaum and Wenig [22] did not routinely identify the EBSLN and reported 5% of permanent EBSLN injury in 20 cases of thyroidectomy. Both previous studies have shown larger results than ours, but they depended on both laryngoscopy and EMG of CTM for the assessment of EBSLN injury while in our study we depended on laryngoscopic findings with patient symptoms [21,22].

Page *et al.* [23] studied 50 thyroidectomies; they could identify EBSLN by neuromonitoring in 20% of cases with only one case complaining of postoperative nerve affection. They concluded that intraoperative identification of EBSLN even with neuromonitoring is not essential.

Bellantone *et al.* [24] conducted a prospective study on 289 thyroidectomy patients randomized to visual identification of the EBSLN (with 11.6% of failure identification) and individual ligation of STVs at the capsule with nonidentification of the nerve. They did not find vocal or endoscopic changes suggestive to EBSLN affection (by video-laryngoscopy and spectrographic analysis).

On the other side, Hurtado-López *et al.* [7] conducted a prospective randomized study between identification and nonidentification, and they found a statistically significant difference in favor of identification (20 vs. 8%, respectively). They concluded that EBSLN should be identified to decrease the risk of injury. But they depended on EMG to assess the injury.

Although EMG is the most objective method to recognize EBSLN affection, it is not used routinely because it is invasive, not widely available, operator dependent, and patients with nerve affection may be reluctant to have an invasive test especially when their symptoms are subtle [25].

We had many limitations in our study. It was a nonrandomized one and we need a randomized study with a larger sample size for better statistical results. We need a more objective postoperative voice assessment (as voice analysis or EMG) to assess EBSLN affection.

Conclusion

Visual identification of EBSLN in thyroidectomy is feasible by an experienced surgeon with no significant benefit over individual ligation of STVs close to the thyroid capsule with nonidentification of the nerve.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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