

Original Research Article

Comparative analysis of voice changes after thyroidectomy; mass versus individual ligation of superior thyroid artery with reference to identification of external branch of superior laryngeal nerve

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ABSTRACT

Background: The external branch of the superior laryngeal nerve innervates the cricothyroid muscle to promote lengthening and thinning of the vocal fold, thus increasing voice pitch. The close relation with the superior thyroid vessels puts the external branch of the superior laryngeal nerve in risk every time the superior pole of the thyroid is dissected.

Methods: This randomized controlled study was undertaken at SMS Medical College, Jaipur between February 2013 to November 2014 to evaluate the impact of isolating and ligating the superior thyroid vessels near the upper pole of the gland as compared to conventional mass ligation of the superior pole regarding external branch of superior laryngeal nerve injury in hemi or subtotal thyroidectomy. Total 120 patients were taken and divided into two groups A and B. Group A including mass ligation of superior pole of thyroid and group B includes individual ligation of superior thyroid vessels.

Results: Our study observed normal voice in 51 cases (85%) in individual ligation of superior thyroid vessel group and 27 cases (45%) in mass ligation group on auditory perceptual test by GRBAS scale one month postoperatively. Normal electromyography findings after 1 month post-operatively was observed in 57 cases (95%) in individual ligation group as compared to 40 cases (66.67%) in mass ligation group.

Conclusions: Our study conclude that careful ligation of superior thyroid vessels is a safe technique to preserve the external branch of superior laryngeal nerve than mass ligation of superior pole of thyroid.

Keywords: External branch of superior laryngeal nerve, Superior thyroid vessel, Auditory perceptual test, GRBAS scale, Electromyography

INTRODUCTION

The external branch of the superior laryngeal nerve (EBSLN) is at risk of injury during thyroid operations when dissection of the superior pole and ligation of the superior thyroid vessels (STV) are carried out. The rates of injury to this nerve are highly variable in the literature, but can be as high as 58%.¹ The EBSLN is the sole motor nerve to the cricothyroid muscle (CTM), is functionally important to the pitch of the voice, which adduct and

tense the vocal folds during phonation and its dysfunction results in lowered voice fundamental frequency, lowered voice projection, fatigue and inability to achieve high-frequency sounds. It comes into play at frequencies above 150 Hz. It is therefore particularly involved in the production of high tones of the female voice range. The EBSLN is not ordinarily seen or exposed during thyroidectomy in contrast to the recurrent laryngeal nerve (RLN) due to the more alarming sequela associated with trauma of the latter, which may lead to temporary or

permanent hoarseness, aphonia, stridor, or laryngeal obstruction.²

Anatomy of the EBSLN

The superior laryngeal nerve originates at the inferior ganglion of the vagus nerve (nodose ganglion) near the jugular foramen. At the level of the greater cornu of the hyoid it divides into a large internal branch and a smaller external branch. The internal branch courses between the thyrohyoid muscle and the thyrohyoid membrane, piercing the latter along with the superior laryngeal artery and vein. The internal branch supplies sensation to the supraglottis and pyriform sinus.^{3,4} At the level of the superior horn of the thyroid cartilage, the external branch turns medially and runs posterior and parallel to the oblique line. It can penetrate the inferior constrictor and run along its deep surface at any point along this course, or remain on its surface.^{3,5} The external branch is typically deep to the superior thyroid artery, but can cross anterior or between branches as the artery enters the gland 14 to 18% of the time.^{3,6}

The nerve is variable in its relationship to the highest point of the superior pole of the thyroid gland. A classification of the external branch with respect to the superior pole, described by Cernea and colleagues.^{3,7} Iatrogenic injury is possible during thyroid, parathyroid, carotid, or cervical spine surgery.^{3,8} The reported incidence of superior laryngeal nerve injury after thyroidectomy ranges from 0 to 58%, and is most likely underdiagnosed.^{3,9}

Video stroboscopy of unilateral injury reveals posterior glottic rotation to the affected side, vocal cord bowing, and decreased mucosal wave with inferior displacement of the ipsilateral vocal cord.^{3,10} Laryngeal electromyography is the gold standard evaluation of injury to the external branch of the superior laryngeal nerve, as shown by an absence of interference patterns with high-pitched vocalization and electrical silence.^{3,9} Steps to maximize identification and preservation of the nerve are division of the sternothyroid muscle, careful dissection in the cricothyroid space that lies between the medial surface of the thyroid lobe and the cricothyroid muscle, and meticulous isolation and division of superior thyroid vessels.^{3,8}

Our study was conducted to evaluate the impact of isolating and ligating the superior thyroid vessels near the upper pole of the gland as compared to conventional mass ligation of the superior pole regarding EBSLN injury and postoperative voice changes using GRBAS scale and electromyography.

Aims and objectives

To detect the difference in voice after thyroidectomy by GRBAS scale with reference to mass ligation VS individual ligation of superior thyroid artery after

identification of EBSLN. Evaluation of cricothyroid muscle function by way of electromyography one month post-operatively.

METHODS

The study was conducted on the patients of thyroid swelling planned for hemi or subtotal thyroidectomy in the department of otorhinolaryngology and head and neck surgery, Sawai Man Singh Medical College and Hospital, Jaipur during the period from February 2013 to November 2014. It was a tertiary care hospital based randomized controlled study in which 120 cases were enrolled, and divided into group A and group B using odd even method, each containing 60 cases after taking clearance from ethical committee of institute.

Inclusion criteria

Patients undergoing hemi and subtotal thyroidectomy for various thyroid pathologies such as thyroid nodule, multi nodular goiter, carcinoma.

Exclusion criteria

Patients with preoperative voice changes due to any cause like laryngeal disorder or vocal cord paralysis. Patients with post-operative voice changes due to recurrent laryngeal nerve injury leading to vocal cord paralysis. All revisions surgery cases are benign/malignant.

All patients included in study, were subjected to either hemi/subtotal thyroidectomy as indicated. Patients in group A had conventional mass ligation of the superior pole while those in group B had individual ligation of the branches of the superior thyroid artery after identification of the EBSLN whenever possible.

After going through detailed clinical examination and history, and routine blood investigation for surgery under general anaesthesia, patients underwent following.

Pre-operative thyroid assessment

Patients in both groups had their T3, T4 and TSH levels estimated prior to surgery in addition to thyroid ultrasound and FNAC (fine needle aspiration cytology) in all cases.

Pre-operative voice analysis

Indirect laryngoscopy, telescopic examination, auditory perceptual assessment (APA) and many scales are available for analyzes the character of the voice but in this study, we were analyzed according to a modified GRBAS scale.^{11,12} It assesses grade (the overall degree of voice abnormality), roughness, breathiness, asthenia (voice weakness), and strain. Under this scheme, each parameter is quantified on a 4 point scale, where 0=normal, 1=mild, 2=moderate, and 3=severe.^{2,13}

Surgical procedure

All patients were subjected to either hemi or subtotal thyroidectomy as indicated. In group A patients, the superior thyroid pole was dealt with the conventional method of mass ligation without identification of the EBSLN. In group B patients, the EBSLN was meticulously searched. The nerve was sought medial to the superior pole vessels when entering the gland after gentle traction of the vascular pedicle downwards. If not found, it was sought in between the branches of the superior thyroid artery (STA) or vein.

If EBSLN still not found, then at least its safety was ensured by careful skeletonization and ligation of the branches of the superior thyroid artery and vein was done. The operation was completed in the standard fashion.¹⁴

Post-operative assessment

Indirect laryngoscopy examination (IDL) was done at 1 week and 1 month, telescopic examination done at 1 week and 1 month, auditory perceptual test by GRBAS scale, and electromyography (EMG) at 1 month. All laryngeal function assessments were repeated at one month post-operatively. In addition, percutaneous electromyography (EMG) of both cricothyroid muscles using a concentric bipolar needle electrode was done. The electrode was inserted in the midline, between the cricoid and thyroid cartilages, and directed superiorly, laterally and obliquely until the muscle was reached.

The patient was asked to produce the vowel 'e' in the highest possible frequency. If the EBSLN was intact, a substantial increase in the electrical activity of the muscle was noted, whereas an 'electrical silence' was observed if a complete lesion of the nerve had occurred.¹¹

Statistical analysis

The qualitative data was presented as proportion and percentage, and the quantitative data was presented as mean and standard deviation. Student's t test was used to find out the significance of study parameters on continuous scale and the difference in proportion were analyzed by using chi square test. Significance is assessed at 5% level of significance. P value <0.05 was considered significant. The statistical software SPSS 20 and primer were used for the data analysis and Microsoft word and MS excel have been used to generate graphs and tables.

RESULTS

Our study was conducted on the patients of thyroid swelling planned for hemi or subtotal thyroidectomy during the period from February 2013 to November 2014. Total 120 patients were taken who were randomized by odd and even method into two groups of 60 each. Pre-

operative voice, indirect laryngoscopy and telescopic findings, GRBAS scale, EMG findings were found normal in all patients of both groups.

The mean age of patients in group A and B was comparable being 37.53 ± 13.57 years with the ranging from 16 to 71 years and 37.65 ± 12.07 years with the ranging from 16 to 65 years respectively. There were 51 cases (85%) female and 9 cases (15%) males in both groups. The M: F ratio was 1:5.67 in each group.

In our study most common complaint was unilateral neck swelling. There were 36 cases of right sided neck swelling and 22 cases of left sided neck swelling in group A. The cases of left and right neck swelling were almost equal in group B. 2 cases of diffuse neck swelling were present in each group.

According to FNAC finding, group A included 33 cases (55%) of colloid nodule, which was most common followed by 14 cases (23.3%) of benign follicular nodule, 3 cases (5%) of colloid cyst, 3 cases (5%) of follicular neoplasm, 4 cases (6.7%) of benign follicular neoplasm and 3 cases (5%) of multinodular goiter. Group B included 40 cases (66.7%) of colloid nodule, which was most common followed by 11 cases (18.3%) of benign follicular nodule, 2 cases (3.3%) of follicular neoplasm, 1 case each of benign follicular neoplasm, hurthle cell neoplasm and Hashimoto's thyroiditis (Table 1).

In mass ligation group 11 cases (18.33%) presented with change of voice as compared to 2 cases (3.33%) in individual ligation group which was statistically significant. Inability to raise voice was seen in 11 cases (18.33%) in mass ligation group as compared to one case (1.67%) in individual ligation group which was statistically significant (Table 2).

In present study on indirect laryngoscopy and telescopic findings, normal vocal cord was observed in 57 cases (95%) in individual ligation as compared to 48 cases (80%) in mass ligation group which was statistically significant. Tilted glottis was observed in 6 cases (10%) in mass ligation as compared to no case in individual ligation which was statistically significant. Bowed cord was observed in 6 cases (10%) in mass ligation group as compared to 3 cases (5%) in individual ligation which was statistically not significant (Table 3).

In present study abnormal voice was observed in 33 cases (55%) and normal voice was seen in 27 cases (45%) in mass ligation group using GRBAS scale. Among the abnormal voice, decrease intensity was observed in 9 cases (15%) and breathy voice in 6 cases (10%) and decrease pitch was seen in 18 cases (30%) in mass ligation group (Table 4). In contrast in group B, abnormal voice was in 9 cases (15%) and normal voice was in 51 cases (85%) in our study. Among the abnormal voice, decrease intensity which was in 4 cases (6.67%) and 3 cases (5%) presented with breathy voice and decrease

pitch were seen in 2 cases (3.33%) in individual cases (Table 4). In our study post-operative EMG was done in all patients after 1 month. Normal EMG findings were observed in 40 cases (66.67%) in mass ligation group

while in 57 cases (95%) in individual ligation group. Denervation was observed in 20 cases (33.33%) in mass ligation group as compared to 3 cases (5%) in individual ligation group (Table 5).

Table 1: Distribution of the cases according to FNAC observations.

FNAC finding	Individual ligation group		Mass ligation group		Total	
	Number	%	Number	%	Number	%
Benign follicular nodule	11	18.3	14	23.3	25	20.83
Benign follicular neoplasm	1	1.7	4	6.7	5	4.17
Colloid cyst	4	6.7	3	5.0	7	5.83
Colloid nodule	40	66.7	33	55.0	73	60.83
Follicular neoplasm	2	3.3	3	5.0	5	4.17
Hurthle cell neoplasm	1	1.7	0	0	1	0.83
Hashimoto's thyroiditis	1	1.7	0	0	1	0.83
Multinodular goiter	0	0	3	5	3	2.5

Table 2: Post-operative voice as per patient.

Voice character	Individual ligation group		Mass ligation group		Total	
	Number	%	Number	%	Number	%
Normal voice	57	95.00	38	63.33	95	79.17
Change of voice	2	3.33	11	18.33	13	10.83
Inability to raise voice	1	1.67	11	18.33	12	10.00
Total	60	100.00	60.00	100.00	120.00	100.00

Chi-square= 18.364 with 2 degrees of freedom; p<0.001.

Table 3: Distribution of the cases according to post-operative indirect laryngoscopic and telescopic examination finding.

Telescopic finding	Individual ligation group		Mass ligation group		Total		P value
	Number	%	Number	%	Number	%	
Normal vocal cord	57	95.00	48	80	105	87.5	0.027 S
Bowed cord	3	5.00	6	10.00	9	7.5	0.48 NS
Tilted glottis	0	0.00	6	10.00	6	5.00	0.036 S

S- significant, NS- non significant.

Table 4: Distribution of the cases according to auditory perception test (by GRBAS Scale).

Post-operative GRBAS	Individual ligation group		Mass ligation group		Total (n=120)	
	Number	%	Number	%	Number	%
Abnormal voice	9	15	33	55	42	35
Breathy voice	3	5	6	10	9	7.5
Decrease intensity	4	6.67	9	15	13	10.83
Decrease pitch	2	3.33	18	30	20	16.67
Normal voice	51	85	27	45	78	65
Total	60	100	60	100	120	100

Chi-square= 19.377 with 1 degree of freedom; p<0.001.

Table 5: Distribution of the cases according to electromyography (EMG) after 1 month.

EMG after 1 month	Individual ligation group		Mass ligation group		Total	
	Number	%	Number	%	Number	%
Denervation	3	5	20	33.33	23	19.17
Normal	57	95	40	66.67	97	80.83
Total	60	100	60	100	120	100

Chi-square = 13.770 with 1 degree of freedom; p=0.000.

DISCUSSION

The EBSLN carries motor fibers to the cricothyroid muscle, which functions to tilt the thyroid cartilage and tense the vocal cord. Injury to the EBSLN results in changes both in the quality of the voice and the production of high pitched sounds.^{15,16} Clinically, a patient with EBSLN palsy may have a hoarse voice, decreased range of volume, and vocal fatigue and may demonstrate aspiration due to bowing and inferior displacement of the vocal fold.^{17,18} Voice symptoms are more noticeable in women, professional speakers, and most especially, singers.¹⁸

In our study, the superior thyroid vasculature was individually ligated on the thyroid capsule and no further dissection in search of EBSLN was undertaken when it could not be readily identified in order to avoid injury to the nerve.

In our study 120 patients were taken, who were randomized by odd and even method into two groups of 60 each group. Group A of mass ligation of superior pole of thyroid lobe and group B of individual ligation of superior thyroid vessels.

Koraitim et al studied 40 cases randomized into group A (mass ligation) and group B (individual ligation) using closed envelop method.¹¹ Aluffi et al studied 45 patients who had undergone thyroid surgery (6 total lobectomy, 5 subtotal thyroidectomy, and 34 total thyroidectomy) 12-18 months postoperatively.⁹ Teitelbaum et al studied twenty consecutive patients with thyroidectomy during a 9 months period underwent evaluation for superior laryngeal nerve injury 3 months postoperatively.¹⁹ Stojadinovic et al studied fifty-four patients after thyroidectomy; 50 and 46 were evaluable at 1 week and 3 months, respectively.¹⁰

In our study the mean age was 37.65 ± 12.07 in individual ligation group with the ranging from 16 years to 65 years and 37.53 ± 13.57 years in mass ligation group with ranging from 16 to 71 years. In Koraitim et al study mean age of patients in group A and B was 36.27 ± 10.96 years and 35.53 ± 13.00 years respectively.¹¹

There were 51 cases (85%) female and 9 cases (15%) males in both groups. The M: F ratio was 1:5.67 in each group. Koraitim et al study male and female ratio in group A was 1.8:2 and group B was 1.7:3.¹¹ In Stojadinovic and others study male to female ratio was 1:4.¹⁰

In our study most common complaint was unilateral neck swelling. There were 36 cases of right sided neck swelling and 22 cases of left side neck swelling in mass ligation group. The cases of left and right neck swelling were almost equal in individual ligation group. 2 cases of diffuse neck swelling in each group.

According to FNAC finding, group A included 33 cases (55%) of colloid nodule, which was most common followed by 14 cases (23.3%) of benign follicular nodule, 3 cases (5%) of colloid cyst, 3 cases (5%) of follicular neoplasm, 4 cases (6.7%) of benign follicular neoplasm and 3 cases (5%) of multinodular goiter. Group B included 40 cases (66.7%) of colloid nodule, which was most common followed by 11 cases (18.3%) of benign follicular nodule, 2 cases (3.3%) of follicular neoplasm, 1 case each of benign follicular neoplasm, Hurthle cell neoplasm and Hashimoto's thyroiditis.

Koraitim et al in their study included 40 cases in group A in which 11 patients presented with multinodular goiter (MNG), 6 patients with controlled toxic goiter (CTG), 3 patients with cancer; two of them had papillary carcinoma and one had follicular carcinoma. Group B included 13 patients with MNG, 5 patients with CTG and 2 patients with cancer thyroid, one had papillary and other had follicular carcinoma.¹¹

In our study, conventional mass ligation of the superior pole of the thyroid gland (group A) resulted in post-operative change of voice in 11 cases and inability to raise the voice was seen in 11 cases. Koraitim et al reported change of voice in 4 patients (20%) and inability to raise voice in 5 patients (25%).¹¹ Kark et al reported an incidence of 11-18%, respectively, and Lekacos reported similar complaints in 3 patients out of 27 (11.1%).^{20,21} On the other hand, in individual ligation of superior thyroid artery group resulted in change of voice in 2 cases and inability to raise voice was seen in 1 case. Koraitim et al reported post-operative change of voice and inability to raise voice in only one patient out of 20 (5%).¹¹

Our findings of indirect laryngoscopy and telescopic examination showed normal vocal cords in 57 cases (95%) in individual ligation group and 48 cases (80%) in mass ligation group. Tilted glottis was observed in 6 cases (10%) in mass ligation as compared to no case in individual ligation group. Bowed cord was observed in 6 cases (10%) in mass ligation group as compared to 3 cases (5%) in individual ligation.

Koraitim et al reported 3 cases (15%) in group A had post-operative glottis chink shifted to right side and 5 cases (25%) showed incomplete phonatory coaptation.¹¹ In group B incomplete phonatory coaptation was seen in only one case (5%).

Saeed et al as well as Guindy et al reported a reduced incidence of EBSLN palsy with nerve identification as diagnosed by stroboscopy.^{22,23} Their findings included oblique chink of the glottis during phonation with decreased amplitude of the stroboscopic wave on the affected side, and bowed appearance plus inferior displacement of the affected fold respectively.

Auditory perceptual assessment by GRBAS scale

The auditory perceptual assessment (APA) of our patients showed abnormal voice in 33 cases (55%) and normal voice in 27 cases (45%) in mass ligation group. Among the abnormal voice, decrease intensity was observed in 9 cases (15%) and breathy voice in 6 cases (10%) and decrease pitch was seen in 18 cases (30%) in mass ligation group.

Koraitim et al reported that in auditory perceptual assessment (APA) test 5 patients (25%) had decreased pitch, 4 patients (20%) had decrease intensity and 2 (10%) had breathy voice character, one of them had rough voice quality.¹¹

Saeed and colleagues in a similar study, reported that APA showed mild dysphonia in two patients, one with breathy character of voice and the other with a mild degree of roughness of voice.²² Pitch was lowered in both cases.

In contrast in group B, abnormal voice was present in 9 cases (15%) and normal voice was present in 51 cases (85%) in our study. Among the abnormal voice, decrease intensity which was observed in 4 cases (6.67%) and 3 cases (5%) presented with breathy voice and decrease pitch were seen in 2 cases (3.33%) in individual cases. Koraitim et al in their study showed only one patient (5%) had breathy quality of voice and another one (5%) had decrease pitch and two others (10%) had decreased intensity.¹¹ Guindy et al reported an incidence of (2.5%) for this last complaint.²³

EMG findings

In our study post-operative EMG was done in all patients after 1 month. Normal EMG finding was observed in 40 cases (66.67%) in mass ligation group while in 57 cases (95%) in individual ligation group. Denervation was observed in 20 cases (33.33%) in mass ligation group as compared to 3 cases (5%) in individual ligation group.

Koraitim et al reported that in group A patients revealed signs of nerve injury in 5 patients (25%), denervation in 3 (15%) and demyelination in 2 (10%).¹¹ In contrast, signs of nerve injury were absent in group B patients. Cernea et al reported that EMG was the most important method of evaluation used in their study, a strong association was observed between complete EBSLN lesion and poor vocal performance, especially in high tones, 0% of nerve injury by EMG in their group of patients with nerve search.⁷

Guindy et al reported that EMG of the affected cricothyroid muscle showed low amplitude fibrillation potentials at rest and absent interference pattern with phonation of a high pitch.²³ These results showed no signs of nerve injury in all patients of the individual ligation group (group B) in this study.

In our study denervation was seen in both groups. Possible explanation for the EMG findings could be because of variable direction and depth of needle insertion. If it is too deep beyond the inner surface of the thyroid cartilage, it may be entered into the lateral cricoarytenoid muscle, giving false reading. If the penetration is too superficial, one may get activity from the sternohyoid muscle. Abnormal EMG finding could also be because of electro diathermy used closed to the cricothyroid muscle area.

When performing thyroidectomy, it may be advisable to identify and preserve the ELN to prevent critical alterations in the quality of one's voice. This is particularly important in patients whose voice is important in their profession.¹¹

CONCLUSION

Our study conclude that individual ligation of superior thyroid vessels is a safe method to preserve external branch of superior laryngeal nerve than mass ligation of superior pole pedicle in terms of preserving quality of voice post operatively.

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