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Author(s)	Wong, KP; Lang, HHB; Ng, SH; Cheung, C; Chan, CT; Chan, MY
Citation	World Journal of Surgery, 2014, v. 38 n. 3, p. 607-613
Issued Date	2014
URL	http://hdl.handle.net/10722/193218
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Is vocal cord asymmetry (VCA) seen on transcutaneous laryngeal ultrasonography a significant predictor of voice quality changes after thyroidectomy?

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ABSTRACT

Introduction

Vocal cord asymmetry (VCA) on laryngoscopic examination (LE) may suggest voice impairment after thyroidectomy but LE may cause patient discomfort. We aimed to correlate the presence of postoperative VCA assessed by non-invasive transcutaneous laryngeal ultrasonography (TLUSG) with voice quality changes after thyroidectomy.

Methods

One hundred and sixty-nine patients scheduled for thyroidectomy completed two validated voice symptoms questionnaires, namely the GRBAS (grade, roughness, breathiness, asthenia, strain) scale and voice impairment score (VIS), TLUSG and LE one day before and 7-10 days after thyroidectomy. Of these patients, 51 had postoperative VCA on TLUSG (group I) while the other 118 patients did not (group II). Their GRBAS scale and VIS were compared between two groups.

Results

Before operation, both groups had comparable preoperative GRBAS and VIS. After operation, group I had significantly worse "grade" (0.24 vs. 0.07, p=0.016) and "roughness" (0.33 vs. 0.14, p=0.022) components on the GRBAS scale than group II. In group I, "grade" and "roughness" in GRBAS scale significantly worsened after operation (0.04 to 0.24, p=0.008 and 0.02 to 0.33, p=0.001, respectively, but not in group II. In addition, overall VIS was significantly worse after thyroidectomy in group I (4.97 vs. 12.97, $p<0.001$)

Conclusion

VCA seen on TLUSG significantly correlated with "grade" and "roughness" components on GRBAS scale and overall VIS. It might be used as a surrogate of postoperative voice changes.

INTRODUCTION

Thyroidectomy is one of the most commonly performed elective surgical procedures with a low morbidity in experienced hands. However, debilitating voice changes after elective thyroidectomy are not uncommon even in the absence of vocal cord paresis or palsy (VCP) but are often overlooked by clinicians.[1, 2] Previous studies have found that up to 30% of patients with normal vocal cord function after thyroidectomy would still have subjective voice changes.[1, 2] Although the exact cause for these voice changes remains unclear, it has been noted that relative to those without voice impairment, patients with subjective voice impairment were more likely to have vocal cord asymmetry (VCA) due to shortening of the vocal cord (VC) on one side relative to the other side.[3, 4] Although VC symmetry could be assessed by flexible direct laryngoscopy (DL), it is generally invasive and causes patient discomfort.[5, 6]

Surgeon-performed transcutaneous laryngeal ultrasonography (TLUSG) was shown in an assessor-blind fashion that it could be used as an alternative to DL in VC assessment.[7] With increasing experience, we have also noted that TLUSG could estimate the length of each VC by measuring the distance between specific landmarks and assess VC symmetry and asymmetry by looking at the relative height or position between the two arytenoid cartilages. To our knowledge, only one brief report has described VCA on TLUSG as a surrogate for voice impairment [8]. Given that VCA is a potential surrogate and a predictor for voice impairment after thyroidectomy, our study was aimed to correlate between the presence of VCA on postoperative TLUSG and voice quality changes after thyroidectomy as measured by two different standardized questionnaires, namely the GBRAS (Grade, Roughness, Breathiness, Asthenia, Strain) scale and Voice Impairment Score (VIS).

PATIENTS AND METHODS:

Patients

Over a 10-month period, 223 consecutive patients underwent elective thyroidectomy. All underwent standardized voice questionnaires and vocal cord assessment by TLUSG and direct laryngoscopy (DL) one day before and 7-10 days after thyroidectomy. To have a more accurate assessment on voice quality, patients with VCP or concomitant laryngeal abnormalities seen on DL before (n=2) and after surgery (n=20) were excluded. VCP was defined as any impaired movement in ≥1 vocal cord seen on DL. Flowchart 1 shows the patient flowchart. Of these, 28 were excluded because one or both VCs were not clearly visualized on TLUSG either preoperatively (n=15) or postoperatively (n=13). When both VCs were clearly visualized, the distance between the anterior commissure to the ipsilateral arytenoid was measured to the nearest 0.1 mm. This was taken as the length of the VC. On TLUSG, horizontal level of the two arytenoids was compared by one person (KPW). If the two arytenoids failed to align on the same horizontal plane, it was defined as a VCA.(see Figure 1) Figure 2 shows a patient with normal vocal cord length, or without postoperative VCA. In this cohort, there were 4 (2.3%) patients with preoperative VCA while the rest did not. To evaluate the relationship between postoperative VCA and voice quality changes after thyroidectomy, these 4 patients with preoperative VCA were excluded. Therefore, there were 169 patients analyzed. Based on the postoperative TLUSG assessment, 51 (30.2%) had VCA (group I) while 118 (69.8%) did not have VCA (group II). To evaluate the relationship between postoperative VCA on TLUSG and voice quality changes after surgery, the individual score of the postoperative GRBAS scale and VIS results were compared between group I and II.

GRBAS and VIS

After obtaining consent, all patients were given both GRBAS and VIS questionnaires one day before and 7-10 days after thyroidectomy. GRBAS is a perceptual scale in evaluating patient's voice. It is a widely used tool for perceptual assessment of voice quality by clinicians and speech therapists.[9-11] This scale was used for assessing perception of voice quality by the patient. Each

of the 5 parameters in the GRBAS scale was given a score (0 = normal, 1 = mild impairment, 2 = moderate impairment, 3 = severe impairment). Therefore, higher the score meant more severe the voice impairment. To further assess the frequency of voice complaints and their effects on daily living, the VIS was used. VIS is a specifically designed questionnaire in evaluating voice symptoms after thyroidectomy. It was designed by a group of Italian surgeons and had been described and used by previous investigators.[12-14] It consists of 10 questions. The VIS aggregate score ranges from a minimum of 0 (meaning no voice alterations) to maximum of 40 (greatest voice impairment).

TLUSG and DL assessments

After the GBRAS and VIS questionnaires, patients were directed to another room where the TLUSG and DL were performed. The surgeon responsible for the TLUSG was unaware of the patient's GRBAS/VIS scores. All TLUSG examinations were performed by one endocrine surgeon (KPW) using the same portable ultrasound (USG) machine (iLookTM 25 Ultrasound System, Sonosite®, SonoSite Inc., Washington, United States) and 5-10MHz linear transducer (L25). During the assessment, the patient was positioned flat with the neck slightly extended and arms on the side. After applying ample amount of gel over anterior neck, an USG transducer was placed transversely over the middle portion of the thyroid cartilage and scanned cranio-caudally until both true and false VCs were visualized. To optimize the images, the grey-scale was adjusted until false VC became hyperechoic while true VCs became hypoechoic. Both passive (i.e. quiet spontaneous breathing) and active (phonation with a sustained vowel "aa") movement of the VCs were assessed during the assessment. Immediately after the TLUSG, the patient underwent a flexible direct laryngoscopy (DL) (Olympus BF-P40, Bronchoscope, Olympus®, Tokyo, Japan) performed by an experienced endoscopist who was also unaware of the patient's GRBAS/VIS scores and TLUSG findings.

Surgery and postoperative management

The same operative and postoperative strategies were adopted to all patients.[15] In brief, thyroidectomy was performed through a collar incision under general anesthesia with endotracheal intubation. The strap muscles were separated in the midline and retracted laterally. The strap muscles were not routinely transected. The recurrent laryngeal nerve (RLN) was routinely identified at the Berry's ligament and traced along its entire course. Intra-operative neuro-monitoring was used routinely. The EBSLN was not routinely identified but to reduce iatrogenic EBSLN injury, each branch of the superior thyroidal vessel was ligated close to the capsule. All relevant clinical, demographic, pathological data, GRBAS and VIS and TLUSG and DL findings were prospectively collected.

Statistics

The statistical analysis was performed using the SPSS (version 18.0, SPSS, Inc., Chicago, IL, USA) software package. A Chi-square test and the Fisher's exact test were used for comparison of dichotomous variables and the Mann-Whitney U test was used for comparison of continuous variables between group I and II. Mann-Whitney U test was used for comparison of continuous variables of voice symptoms scaled score between the group I and II. Wilcoxon signed-rank test was used for comparison of voice symptoms scaled scores before and after operation. P values <0.05 was considered statistically significant.

RESULTS

Table 1 shows comparison of patient demographics, surgical indication, type of operation preformed and TLUSG findings between the two groups. There were no significant difference in age at operation (p=0.877) and male to female ratio (p=0.151). Surgical indication (p=0.723) and type of operation (p=0.638) were also comparable. Overall, the mean length of the right and left VC during relaxation was 20.1mm and 20.2mm, respectively. Group I had significantly greater VC length difference than group II (1.2mm vs. 0.2mm, p< 0.001). Among the 51 with VCA, VC shortening with length difference ≥ 5mm was noted in 22 patients on the right and 29 patients on the left.

Table 2 shows comparison of GRBAS and VIS between group I and group II before and after operation. Before operation, both groups had comparable GRBAS and VIS. However, after operation, group I had significantly worse score in "grade" (0.24 vs. 0.07, p=0.016) and "roughness" (0.33 vs. 0.14, p=0.022) along the GRBAS scale.

Table 3 shows a comparison of GRBAS scale and VIS score before and after operation of patients when stratified by group I and II. In group I, both "grade", "roughness" and "asthenia" along the GRBAS scale significantly worsened after operation (from 0.04 to 0.24, p=0.008, 0.02 to 0.33, p<0.001 and 0.08 to 0.27, p=0.008, respectively) whereas in group II, only 'asthenia" significantly worsen after operation (0.03 to 0.18, p<0.001). The proportion of patients with worsen "grade" along GRBAS scale after operation was significantly more in group I than II (8/51 vs. 6/118, p=0.022). A similar finding was seen with "roughness" after operation between group I and II (13/51 (25.5%) vs. 11/118 (9.3%), p=0.006). On the other hand, the "asthenia" component along the GRBAS scale worsened after operation in group I and II (p=0.008 and p<0.001, respectively). However, the proportion of worsen "asthenia" did not show significant difference. (8/43 vs 19/99, p=0.946). Overall, 115 (68.0%) patients had a worsen VIS after operation while 54 (32.0%) had either no change or improved VIS. Although the proportion of patients with worsen VIS after operation was comparable between group I and II (39/51 (76.5%) vs. 76/118 (64.4%), p=0.276), the

VIS after operation in group I tended to be poorer than group II (8.00 vs. 4.77, p=0.078). There were no significant correlations between VC length of either cord and degree of voice changes (i.e. changes in GRBAS and VIS).

DISCUSSION:

Voice alteration or impairment after elective thyroidectomy is not only relatively common but can be debilitating even in patients who are not singers or voice professionals.[11, 12] Previous studies have found that up to 30% of patients with preserved or normal vocal cord mobility after thyroidectomy would still complain of subjective voice changes.[1, 2] In our study, if voice impairment was measured by VIS, 115/169 or 68.0% (i.e. over half) of patients had some degree of voice impairment after thyroidectomy. Although it remains unclear what is the exact cause for this impairment, different causes had been proposed and they included division and injury to external laryngeal muscle and strap muscle, development of adhesion between these muscle[16], intubation related injuries (such as hematoma, edema of vocal cord and subluxation of arytenoid cartilage)[17] and external branch of superior laryngeal nerve (EBSLN) injury.[18] By an experienced otolaryngoloist, subtle morphological changes on laryngoscopic examination after thyroidectomy could be detected. However, its application was limited by high inter-observer varibility and procedure related patient's discomfort.[6, 19] While this subtle feature could be more prevalence in patient with voice impairment, a simpler morphological assessment might be worthwhile.[2] With increased experience in TLUSG, we could evaluate not only VC motility but also anatomy and symmetry of VC.[7, 20] The aim of our study was to correlate the presence of postoperative VCA detected on TLUSG with voice alteration as measured by GRBAS and VIS.

In our study, despite having similar baseline characteristics and preoperative GRBAS and VIS, we found that after operation, group I (i.e. those with VCA on TLUSG) had significantly worse score in the "grade" (0.24 vs. 0.07, p=0.016) and "roughness" (0.33 vs. 0.14, p=0.022) components in the GRBAS scale than group II (i.e. those without VCA). However, it was interesting to find that only the "grade", "roughness" and "asthenia" were significantly worse in group I after operation and not the other 2 components, namely breathiness and strained. But since grade may only reflect an overall assessment while roughness is more related to the pitch of the voice [21], we postulate the finding of VCA on TLUSG might be more related to the pitch of the voice rather than the strength

of the voice. When the preoperative and postoperative GRBAS and VIS were compared, it is clear that group I suffered from significantly worse scores than group II. Although both grade and roughness worsen after operation in group II, they were not significantly worse. In contrast, both components significantly worsen after operation in group I. Although the asthenia component worsen in both groups after operation, the greater difference was seen in group I. Therefore, overall group I had worse voice impairment. This was further supported by the fact that the worsening in VIS was also more evident in group I (8.00 vs. 4.47).(Table 3)

We think the significance of these findings is two folds. Firstly, we found not only there was a significant association between morphological changes in VC/larynx and voice impairment as measured by GRBAS and VIS but also these changes were apparent by non-invasive TLUSG. Secondly, perhaps in the future, we could potentially use VCA seen on TLUSG both as a surrogate or predictor of postoperative voice changes without the need for GBRAS and VIS. From our data, VCA on TLUSG was a particularly strong predictor of “grade” and “roughness” components in the GBRAS scale. The alternative approach would be to use VCA together with well-validated tools like GRBAS and VIS to assess post-thyroidectomy voice changes in the future.

Use of TLUSG in detecting presence of VC paresis or palsy have been reported by various groups. [7, 22-25] According to our previous study, about 96% pre-operative patients and 86% of post-opeative patients could be exempted from routine laryngoscopic examination if we applied TLUSG as a screening tool in detecting VC paresis or palsy. [7] Compared to our previous study on use of TLUSG in detection of vocal cord paresis or palsy (3.9~5.3%), the present rate of VC un-assessability was slightly higher. [7] Fifteen out of 201 patients (7.5%) in pre-operative TLUSG and additional 13 out of 182 (7.1%) patient in post-operative TLUSG could not be clearly visualized and assessed for the presence of VCA. This might be because better sonographic image of vocal cord details is needed in assessing VCA.

There were several shortcomings with our study. Since only one dedicated person performed all TLUSG, it remains uncertain whether our results are reproducible. Also because of this, it is

unknown what the inter-observer variability is. Apart from inter-observer variability, we would like to emphasize that our results could also potentially affected by the intra-observer variability. Nevertheless, we believe the technique of TLUSG could be mastered with appropriate training and feedback. Despite the fact that VCA or VC shortening/bowing might be a result of EBSLN injury, other conditions like subluxation and subtle laryngeal pathology may lead to VCA. In this study, only self-precept voice outcome was analyzed. Electromyography of cricothyroid muscle, videostrobolarygnoscope and other objective assessment like auditory perceptual analysis and acoustic analysis of voice were not performed. Therefore, we could not completely rule out other causes of VCA.

However, despite these findings, there remains many unanswered questions which need to be addressed by future studies. For example, since our study was only able to evaluate a snap-shot of the VCs by TLUSG at 7-10 days after thyroidectomy, it would be very interesting to follow-up these patients with VCA and see if their VCA and voice impairment improve with time. It would also be interesting to see if VCA was directly related to unilateral or bilateral EBSLN injury, although more sophisticated equipments such as electromyography of crico-thyroid muscle, electroglottography, video-strobo-laryngoscopy would be necessary.[26] Use of TLUSG might provide another non-invasive way of assessing the larynx and voice changes after thyroidectomy.

CONCLUSION

TLUSG is a potential modality in assessing structural laryngeal changes after thyroidectomy. Presence of VCA on TLUSG may serve as a clinical surrogate or predictor of post-operative voice changes, especially in assessing “grade” and “roughness” of voice. Further studies are required to explore its application and evaluate the long-term implication of VCA.

Table 1. A comparison of patient demographics, surgical indication, type of resection and length difference of the two vocal cords between patients with vocal cord asymmetry (VCA) (Group I) and with no VCA (Group II) on transcutaneous laryngeal ultrasound (TLUSG).

	Group I (n=51)	Group II (n=118)	*p*-value
Age at operation (years)	50 (13-83)	51 (19-78)	0.877
Sex (Male: Female)	4:47	19:99	0.151
Surgical indication/final pathology			0.723
- Benign nodular goiter	32 (62.7%)	74 (62.7%)	
- Thyrotoxicosis	11 (21.6%)	21 (17.8%)	
- Suspicious of malignancy/ malignancy	7 (13.7)	19 (16.1%)	
- Thyroid nodule hyperplasia with parathyroid adenoma	1 (2.0%)	1 (0.8%)	
- Benign goiter with renal hyperparathyroidism	0 (0%)	3 (2.5%)	
Type of operation			0.638
- TT	29 (56.9%)	59 (50.0%)	
- Hemithyroidectomy	18 (35.3%)	44 (37.3%)	
- Reoperative completion TT	3 (5.9%)	11 (9.3%)	
- Hemithyroidectomy with parathyroid adenoma excision	1 (2.0%)	1 (0.8%)	
- TT with total parathyroidectomy and auto-transplantation	0 (00%)	3 (2.5%)	

Mean vocal cord length - Right - Left	2.02		
Length difference of the two vocal cords on TLUSG (mm)	1.2 (0.5-2.2)	0.2 (0.0-0.5)	**<0.001**

Abbreviations: TT = total thyroidectomy

Table 2. A comparison of grade, roughness, breathiness, asthenic and strained (GRBAS) scale and voice impairment score (VIS) between patients with vocal cord asymmetry (VCA) (Group I, n=51) and with no VCA (Group II, n=118) on pre-operative assessment and post-operative assessment

	Pre-operative			**Post-operative**		
	Group I (n=51)	Group II (n=118)	*p*-value*	Group I (n=51)	Group II (n=118)	*p*-value*
	GRBAS scale			**GRBAS scale**		
Grade**	0.04 +/-0.20	0.03 +/- 0.16	0.628	0.24 +/- 0.55	0.07 +/- 0.28	**0.016**
Roughness**	0.02 +/- 0.14	0.08 +/- 0.30	0.200	0.33 +/- 0.62	0.14 +/- 0.39	**0.022**
Breathiness**	0.02 +/- 0.14	0.01 +/- 0.09	0.540	0.10 +/- 0.36	0.03 +/- 0.18	0.205
Asthenia**	0.08 +/- 0.34	0.03 +/- 0.18	0.445	0.27 +/- 0.57	0.18 +/- 0.38	0.465
Strained**	0.04 +/- 0.20	0.02 +/- 013	0.383	0.16 +/- 0.51	0.06 +/- 0.24	0.328
	VIS			**VIS**		
Overall score[#]	4.97 +/- 6.84	4.08 +/- 4.44	0.642	12.97 +/- 12.79	8.55 +/- 6.66	0.216

*between group I and II by Mann-Whitney U test

**expressed as mean +/- SD, ranging from 0 (no impairment) to 3 (severe impairment)

[#] expressed as mean +/- SD, ranging from 0 (no voice alterations) to 40 (greatest voice impairment).

Table 3. A comparison of preoperative and postoperative grade, roughness, breathiness, asthenic and strained (GRBAS) scale and voice impairment score (VIS) in patients with vocal cord asymmetry (VCA) [Group I] and without VCA [Group II].

	Group I (n=51)			**Group II (n=118)**		
	Pre-operative	Post-operative	Difference between pre- and post-operative	Pre-operative	Post-operative	Difference between pre- and post-operative
	GRBAS scale			**GRBAS scale**		
Grade**	0.04 +/- 0.20	0.24 +/- 0.55	**+0.20***	0.03 +/- 0.16	0.07 +/- 0.28	+0.04
Roughness**	0.02 +/- 0.14	0.33 +/- 0.62	**+0.31***	0.08 +/- 0.30	0.14 +/- 0.39	+0.06
Breathiness**	0.02 +/- 0.14	0.10 +/- 0.36	+0.08	0.01 +/- 0.09	0.03 +/- 0.18	+0.02
Asthenia**	0.08 +/- 0.34	0.27 +/- 0.57	**+0.19***	0.03 +/- 0.18	0.18 +/- 0.38	**+0.15***
Strained**	0.04 +/- 0.20	0.16 +/- 0.51	+0.12	0.02 +/- 013	0.06 +/- 0.24	+0.04
	VIS			**VIS**		
Overall score[#]	4.97 +/- 6.84	12.97 +/- 12.79	**+8.00***	4.08 +/- 4.44	8.55 +/- 6.66	**+4.47***

**p*-value < 0.05 when preoperative and postoperative score were compared by Wilcoxon signed-rank test

**expressed as mean +/- SD, ranging from 0 (no impairment) to 3 (severe impairment)

[#]expressed as mean +/- SD, ranging from 0 (no voice alterations) to 40 (greatest voice impairment).

Legends

Flowchart 1. Flowchart of 235 patients undergoing thyroidectomy and selection of 169 patients for final analysis.

Figure 1. A sonographic view of shortening of vocal cord length, or presence of asymmetry of vocal cord (VCA) [Group I].

Abbreviation: FC = false cord; Remark: solid line = vocal cord length, dot line = horizontal level of right arytenoid

Figure 2. A sonographic view of normal vocal cord length, or absence of asymmetry of vocal cord (VCA) [Group II]

Abbreviation: FC = false cord; Remark: solid line = vocal cord length, dot line = horizontal level of right arytenoid

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