Scholarly Journal of Otolaryngology
DOI: 10.32474/SJO.2023.09.000323
ISSN: 2641-1709
Research Article

Laryngoscopic and Electromyographic Findings after Thyroidectomy

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Received: March 13, 2023 **Published:** March 27, 2023

Abstract

Objective: To determine the prevalence rates of vocal changes, nerve injury and vocal cord immobility in patients after thyroidectomy and compare the results with phonatory parameters, surgical data and laryngeal electromyography (LEMG) data.

Study design: Cross-sectional.

Methods: Seventy-seven patients were selected after thyroidectomy and evaluated for post-operative vocal complaint (POVC), videolaryngoscopy (VL), maximum phonation time (MPT) and surgical parameters. Forty-three patients were also subjected to LEMG to evaluate the thyroarytenoid (TA) and cricothyroid (CT) muscles.

Results: Sixty-nine (89.6%) patients were evaluated 6-42 months after surgery. Regarding POVC, 35 (45.4%) patients were presented with hoarseness, and the most common complaint was loudness impairment. On VL, 21 (n=27.3%) patients presented signs of laryngeal immobility. In these patients, a statistically significant association with POVC (p=0.002) and lower rates of MPT /a/ (p=0.026) was observed. In addition, no association was found between the surgical side and the palsy side in VL. Regarding LEMG, 97.7% of patients presented chronic axonal injury in at least one muscle, even after short post-operative periods; this finding did not correlate with any other parameter.

Conclusion: POVC and neurological injury are common findings after thyroidectomy, and no correlations were observed between VL and LEMG. Patients with vocal complaints have a 6.58-fold greater risk for laryngeal immobility on VL. Pre-surgical factors may be related to neurological injuries. Therefore, prospective studies are required.

Keywords: Laryngeal electromyography; thyroid surgery; thyroidectomy; laryngoscopy and hoarseness

Abbreviations: SLN: Superior Laryngeal Nerve; RLN: Recurrent Laryngeal Nerve; VL: Video Laryngoscopy; LRMG: Laryngeal Electromyography; CT: cricothyroid; POVC: Post-Operative Vocal Changes; V-RQOL: Voice Related Quality of Life; VHI: Voice Handicap Index; MPT: Maximum Phonation Time; TA: Thyroarytenoid

Introduction

Neurological injury is a challenging complication in thyroidectomy because the superior laryngeal nerve (SLN) and recurrent laryngeal nerve (RLN) are located near the thyroid gland. Such injuries may cause problems with vocalization, breathing and swallowing [1]. Two studies have identified thyroidectomy as the most likely surgery to lead to vocal fold palsy [2,3]. Vocal fold immobility can present with no symptoms or mild symptoms and eventually be discovered by videolaryngoscopy (VL). However, patients who require their voice to perform their work may present more post-operative symptoms, such as decreased voice quality and resistance. For example, one study cited evidence of decreases in the highest vocal pitches in singing voices after thyroid surgeries [4]. For the SLN, diagnosing vocal palsy is relatively difficult because the symptoms often go unnoticed. In this case, impairment in high pitch phonation and loudness, especially in singers, may be induced. In contrast, RLN impairment causes restriction in the glottic area and can be asymptomatic or generate fatigue and loss of resistance [5]. Vocal symptoms are common after thyroidectomy, even in patients with normal laryngoscopy [6]. Therefore, to better evaluate and understand this issue, laryngeal electromyography (LEMG) is an essential technique to identify neurologic injuries [7-10]. In LEMG, polyphasic, large and high potentials suggest reinnervation and fibrillation is related to denervation, providing important information about the prognostic value of neurogenic lesions [11]. Despite recent advances in LEMG techniques and laryngeal visualization, no consensus about laryngoscopic findings, phonatory parameters or superior laryngeal damage exists [11]. This study aimed to identify the prevalence of vocal changes, nerve injury and vocal cord palsy/paresis in patients after thyroidectomy and compare the results with phonatory parameters, type of surgery and gland weight at removal.

Materials and Methods

In this sectional study, patients who underwent total or partial thyroidectomy were randomly selected. All surgeries were performed in a university hospital, between 2011 and 2014 using the open technique without nerve monitoring. Patients with laryngeal cancer, ankylosis of the cricoarytenoid joint, laryngeal surgery or systemic neurological disease were excluded. In the interview, patients were assessed for post-operative vocal changes (POVC), which were defined as any changes in vocal pattern after surgery. The voice-related Quality of Life (V-RQOL) and Voice Handicap Index (VHI)-30 were also assessed in the post-operative period. VL was performed using a laryngoscope 10.0 mm autoclavable 70° Henke-Sass, Wolf GmbH (Tuttlingen, Germany) after two jets of Lidocaine 10%. A camera system Watec WAT-231S2 (Yamagata, Japan) was connected to the laryngoscope, and all films were stored on a 500-GB hard disc in a computer with an Intel Core i3 2120 processor. Voice recordings were made by asking the subjects to count from one to ten and to say complete sentences. All films and voice recordings were presented to two laryngologists. One was blind to the patients' clinical data, and each was unaware of the other's analysis. In case of disagreement, a third laryngologist was consulted for the correct diagnosis. During VL, patients were asked to vocalize the vowels /a/ and /i/ in regular pitch and ascending pitch, to take a deep breath and to cough. During vocalizations in ascending pitch, posterior glottic rotation or limitations in laryngeal elevation were rated as SLN injury, and the abduction or adduction restriction of the vocal folds was classified as RLN injury.

Participants also underwent Maximum Phonation Time (MPT) tasks while sitting upright. They were instructed to vocalize /a/, /e/, /i/, /s/ and /z/ as long as they possibly could at their normal speaking pitch and intensity after maximal inhalation. The normal range was considered to be 16.06 s to 26.27 s for men and 14.4 s to 26.96 s for women [12]. LEMG was conducted blindly by a neurologist who is board certificated in electrophysiology and an otolaryngologist. The readings were obtained using a two-channel Nihon Kohden Neuropack M1 (MEB9400) apparatus (Tokyo, Japan) with a common mode rejection ratio of less than 94 dB and a noise level of 0.6 mVrms. The amplifier input impedance was 1000 MU. The band-pass filter was set to 10–10 000 Hz, and the sensitivity was 100 mcV/cm for motor units action potentials (MUAPs) and interference analysis. The sweep speed was 10 ms/cm. A 0.45 X 50 mm concentric bipolar needle electrode (NM-151T) was used. All data were saved on the hard disk of a Dell CCY computer (Intel 2 Core), and Neuropack Manager v. 8.33 software was used for data analysis. The ground electrode was positioned in the left arm. Initially, the patient was placed on his back with his neck extended. Lidocaine 2% (2 to 5 ml) was applied in the puncture sites to avoid pain.

To evaluate RLN function, the thyroarythenoid (TA) muscle was accessed through the cricothyroid membrane. In the middle line of this structure, the needle was inserted with a deflection of 45 degrees relative to the skin and 30 degrees relative to the middle line. Patients were asked to vocalize /e/ at regular pitch and loudness to evaluate the MUAPs and at high intensity to record the interference pattern. To determine SLN function, the cricothyroid (CT) muscle was accessed above the cricothyroid membrane, 1.5 cm lateral to the middle line, with the needle in a perpendicular orientation. The MUAPs were registered during the vocalization of /i/ at high pitch and low loudness. Then, maximum loudness was recorded to analyze the interference pattern. The needle was correctly positioned by listening to the noise of the MUAPs and observing their morphology during vocalization. In the ideal position, few or no MUAPs were observed when the patient breathed. The criteria used to diagnose neurological injury were as follows:

a) Abnormalities in the recruitment pattern: defined as absence of activation or partial activation of interferential pattern (4+/4+), depending on the number of MUAPs seen in the maximum vocalization;

b) Abnormalities in waveform morphology, amplitude or duration;

c) Evidence of spontaneous activity;

d) Abnormal insertional activity.

Insertion activity, positive waves, fibrillation or other spontaneous patterns were evaluated as the patients breathed. During vocalization, the number of phases, amplitude and duration of the MUAPs were assessed. For each muscle, at least three potentials were detected. The three most representative were chosen based on the sound and configuration of the wave. For statistical analysis, the average values of these potentials were calculated. The values for the normal Brazilian population were used for comparison [13]. To obtain the wave duration, the interval between the beginning and end points was calculated. The amplitude and number of phases were automatically determined by the software. Descriptive analysis was performed using central tendency measures for continuous variables and absolute and relative frequencies for categorical variables. To evaluate the factors associated with the categorical outcomes, univariate logistical regression was performed using odds ratios and their respective 95% confidence intervals. To evaluate continuous outcomes, we performed t tests, where $p < 0.05$ was statistically significant. For these analyses, we used SPSS software. This study was approved by the Brazilian ethical board.

Results

In total, 106 patients were contacted by telephone; 29 did not accept the conditions to participate. Therefore, this study included 77 patients, (72 females and 5 males) aged 22-86 years (mean 56 years). Sixty subjects (77.9%) underwent total thyroidectomy, and 17 (22.1%) underwent partial thyroidectomy. The post-operative period was 3 weeks to 3.5 years (mean: 15 months), and most patients were evaluated after six months (89.6%). The weight of the thyroid tissue removed ranged from 4 g to 227 g (mean: 43.8 g). Regarding the thyroid hormone level before surgery, 61% of patients had normal levels, 28.6% had hypothyroidism and 10.4% had hyperthyroidism. The most frequent thyroid disease was nodular hyperplasia (Table 1). Regarding POVC, 30 (38.9%) patients reported that their voice pattern was the same, 35 (45.4%) reported worsened patterns and 12 (15.6%) continued to experience hoarseness, as presented before surgery. The most common complaint was loudness impairment (Table 1). In the evaluation of the MPT of the vowels /a/, /e/ and /i/, low values were found in 50.6%, 58.4% and 49.4%, respectively. The s/z ratio was abnormal in 24.7% of patients.

Table 1: Prevalence rates of thyroid disease, vocal complaints and immobility on VL.

Thyroid Disease	Frequency	Percentage
Nodular hyperplasia	24	31.2
Follicular adenoma	19	24.7
Cancer	14	18.2
Hashimoto's thyroiditis	14	18.2
Graves' disease	6	7.8
POVC		
Absent	30	39
Loudness impairment	12	15.6
Pitch impairment	11	14.3
Pain/fatigue	9	11.7
Dysphonia/roughness/breathiness	8	10.4
Others	6	7.8
Dyspnea	1	1.3
Immobility (Paresis/Palsy) in VL		
Absent	56	72.7
CT	8	10.4
Right TA	5	6.5
Left TA	5	6.5
CT + Left TA	2	2.6
Bilateral TA	1	1.3

In VL, 21 (27.3%) patients presented signs of abnormality in vocal mobility. Five had palsy/paresis of the left TA, five had palsy/paresis of the right TA, one had bilateral CT paresis, eight had CT paresis and two had left TA with CT paresis (Table 1). After statistically adjusting for the type of surgery and thyroid malignancy, an association was found between laryngeal immobility and POVC (OR=6.58; CI 95% 2.00 – 21.59; p=0.002). Immobility was also associated with lower rates of MPT of /a/ (p=0,026). No statistically significant differences were found in comparisons of laryngeal immobility to the other variables presented in Table 2. In addition, no association between the surgical side and the palsy side was identified because all laryngeal abnormalities were found after total thyroidectomy. A significant association was also found between POVC and MPT /a/. Patients with POVC had a mean time of 7 s, whereas those without POVC had a mean time of 34 s (p=0.017) (Table 2). The mean values of the VHI-30 and VORL-Q were compared with POVC and immobility. Significant correlations were found between POVC and the mean values of both vocal tests, however, the vocal assessments did not correlate with vocal immobility (Table 3).

Table 2: p values comparing multiples variables.

	POVC	Immobility
Gland weight	0.916	0.246
Age > 65 years	0.841	0.195
Surgery	0.688	0.104
Thyroid function	0.768	0.664
Postoperative time > 6 months	0.421	0.493
Thyroid cancer	0.706	0.148
Smoking	0.916	0.177
MPT /a/	0.017*	0.026*
MPT /e/	0.102	0.053
MPT /i/	0.213	0.402
s/z ratio	0.387	0.281

Table 3: Relationships between voice questionnaire results and POVC, APVA and immobility.

POVC	Mean VHI-30	Mean V-RQOL
Absent	7.02	97.3
Present	34	77.6
p value	<0.001	<0.001
APVA - dysphonia	Mean VHI-30	Mean V-RQOL
No	8.63	95.6
Yes	37.93	75.63
p value	<0.001	<0.001
Immobility on VL (paresis/palsy)	Mean VHI-30	Mean V-RQOL
No	7.24	11.1
Yes	32.33	18.72
p value	0.272	0.109

Comparing MPTs with vocal assessments revealed an association between VHI-30 and MPT /a/ (p=0.046).

Among the patients subjected to LEMG (n=43), only one presented normal data in the four muscles examined. The other 42 exhibited signs of neurogenic injury in at least one muscle. No signs of myopathy were found. Three patients had a post-operative period of less than 3 months (22, 22 and 48 days). These subjects presented signs of chronic neurogenic injury with reinnervation without spontaneous activity. Two patients underwent LEMG evaluation between three and six months after surgery. One of these patients showed a complex discharge in the TA muscle, whereas the other exhibited signs of chronic denervation with reinnervation of the TA and CT. No fasciculation or positive waves were observed. No patient displayed signs of complete palsy. Table 4 presents the prevalence of abnormalities identified per nerve. When the LEMG findings were compared with other parameters, no association was found between axonal damage and type of surgery, gland weight, side of palsy on VL, thyroid function, thyroid disease, MPT, voice assessments, POVC or APVA. Additionally, no association between LEMG abnormality in the laryngeal nerves and suspicion of paresis on VL was found. The concordance between these two methods was not significant (6 cases, 14.2%). Trends relating axonopathy of the RLN with a decay in the V-RQOL score (p=0.09) were observed.

Table 4: Percentages of neurological injury in the laryngeal nerves on LEMG.

Nerve	Normal	Injured
Right SLN	16.7	83.3
Left SLN	31.7	68.3
Right RLN	25.6	74.4
Left RLN	19	81

Discussion

As a sectional study performed only during the post-operative period, the data obtained in the interview (POVC) may not be precise since it is a subjective evaluation. This methodological design does not allow us to associate neurological injury with the surgical procedure, nerve compression or other factors that can influence nerve conduction. The association identified between MPTs and POVC could indicate the importance of this phonation measurement in vocal quality. However, Robinson, Mandel and Sataloff did not observe a significant decrease in MPT in RLN injury [14]. Because evidence suggests that the number of nerve fibers in the RLN and SLN decreases with age after 60 years, statistical analyses were performed to consider age [15]. Some authors found a low incidence of post-operative hoarseness and laryngeal immobility related to thyroidectomy after assessing VL and vocal parameters [16,17]. Other studies using similar methods revealed a low prevalence of pre-operative laryngeal palsy in VL [18,19]. However, data from Sataloff et al. [20] suggest that VL alone is not sufficient to diagnose neuromuscular laryngeal dysfunction. Other authors reported that the incidence of complications after surgery was higher [6,21]. The high prevalence of hoarseness and paresis in this study may be attributable to selection bias because patients with complaints tended to exhibit better acceptance.

According to a recent review, LEMG can distinguish between dysphonia caused by arytenoid dislocation after intubation and neurological injury [22]. In this context, traumatic lesions after intubation were not considered. Data from another paper corroborates the absence of an association between malignancy and immobility, as observed in this study [23]. Our study suggested an association between the MPT value of the vowel /a/ and immobility but no association with the type of surgery. However, Maeda et al. [24] observe a significant decrease in this measure in total thyroidectomies relative to partial surgeries. The technique utilized to place the needles was similar to that used by Kim et al. [25]. In three patients (7%), the manipulation of all four muscles was not possible because of pain. Surprisingly, unlike Lombardi et al. [26] who detected one instance of neurogenic injury, this study revealed a high prevalence of axonal damage on LEMG. These findings could be caused by a pre-operative factor, similar to the results of Caroline et al. [27] who reported pre-operative lesions in 100% of laryngeal nerves on LEMG but only 41.2% of patients exhibiting symptoms. The abnormalities found on LEMG and VL on the contralateral side relative to the procedure support this hypothesis. The low prevalence of spontaneous potentials may be explained by the long post-operative times of most patients. However, the two patients who were evaluated within 22 days after surgery showed no signs of acute injury but did show chronic signs of reinnervation, which may reflect damage that occurred before thyroidectomy.

Conclusions

POVCs were frequently observed in this study. Axonal damage followed by reinnervation appears to be prevalent in patients after thyroidectomy. Patients with vocal complaints after thyroidectomy have a six-fold higher risk of presenting with laryngeal palsy or paresis evaluated by laryngoscopy. POVCs seem to be more significantly related to APVA for the prediction of endoscopic immobility. LEMG abnormalities cannot be associated with phonation parameters, removed gland weight or type of surgery. No concordance was found between the imaging method (VL) and the neurophysiological examination (LEMG). Other pre-surgical factors may be related to the neurological injuries observed. Therefore, prospective studies with LEMG should be performed before and after thyroidectomy.

Acknowledgments

We would like to thank Dr. Paulo Kimaid, Dr. Agricio Crespo, and Dr. Natalia Vilella for supporting the LEMG examinations and the Federal University of the State of Rio de Janeiro (UNIRIO), especially in memory of Dr. Adão Henrique Gomes Diniz for providing support during all stages of this study. The authors Caio Simas and Marcos Sarvat supported all financial sources.

Conflict of Interest/Financial Disclosures

The authors have no conflicts of interest.

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DOI: 10.32474/SJO.2023.09.000323