Factors Associated With Injury to Recurrent Laryngeal Nerve in Patients Undergoing Surgery for Thyroid Cancer: A Single-centre Study Using Translaryngeal Ultrasound

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Summary: Aims. Intraoperative injury to the recurrent laryngeal nerve (RLN) is a serious complication occurring more frequently in patients with thyroid cancer than in those with benign thyroid diseases. However, data on the risk factors for RLN injury among patients with thyroid cancer are scarce. Currently, RLN injury is diagnosed by laryngoscopy, but translaryngealultrasonography (TLUS), which is less invasive, appears to have a similar accuracy. Herein, we analysed risk factors ofintraoperative RLN injury in patients with thyroid cancer and assessed the diagnostic performance of TLUS.

Patients and methods. In this prospective study, we enrolled patients undergoing surgery for thyroid cancer from October 2020 to October 2021. Medical and surgical variables were analysed as risk factors of RLN injury. TLUS was compared with laryngoscopy in diagnosing RLN injury.

Results. There were 185 patients who underwent 196 surgeries. Of all surgeries, 23 (11.7%) caused RLN injury ascertained on laryngoscopy. Compared with laryngoscopy, TLUS displayed high sensitivity (97.7%; 95%CI: 94.3%−99.4%) and specificity (100%; 95% CI: 82.4%-100%). Before surgery, medical and surgical characteristics did not differ significantly between patients with or without RLN injury, but RLN entrapment by tumour was more frequent in those with the injury ($P < 0.001$). The risk of RLN injury was increased in patients undergoing thyroidectomy with lateral neck dissection (OR = 4.53; 95% CI: 1.29−14.32) and in those with lymph node metastases (OR = 2.76; 95% CI: 1.03−7.01).

Conclusion. Intraoperative RLN injury in patients with thyroid cancer is more common after operations requiring greater resections and with lymph node involvement. TLUS could be used to diagnose RLN injury.

Keywords: Thyroid cancer−Recurrent laryngeal nerve−Vocal folds−Translaryngeal ultrasound.

INTRODUCTION

More and more patients need surgery for thyroid cancer, partly because of a growing incidence and because thyroid cancer is diagnosed at early stages due to a broad access to ultrasonography.[1] With a greater number of operations, the complications of thyroid surgery, particularly injury to the recurrent laryngeal nerve (RLN), are seen more frequently. RLN injury causes substantial disability by affecting important functions, including speech (vocal fold dysfunction) and swallowing. RLN injury after thyroid surgery is seen most frequently in patients with thyroid cancer, who often require major operations involving extensive resections or two-stage procedures.[2−5] However, risk factors of RLN injury in these patients remain unclear, with most studies assessing complications regardless of the indication for thyroid surgery.[6] RLN injury is typically diagnosed by laryngoscopy, which may visualize vocal fold dysfunction However, laryngoscopy requires substantial experience, is unpleasant to the patient, and may not be available in some centres. Trans-laryngeal ultrasound (TLUS) is a non-invasive method that can be used by surgeons themselves to assess vocal fold function instead of laryngoscopy, but validation of TLUS is needed.[7] An early diagnosis of RLN injury should prompt referral to a laryngologist for further evaluation and management.[8] In this study, we analysed the risk factors of intraoperative RLN injury and used TLUS to assess postoperative vocal cord function in a cohort of patients undergoing surgery for thyroid cancer.

METHODS

Study setting and patients

This was a prospective cohort study. From October 2020 to October 2021, we enrolled all consecutive patients undergoing surgery in our hospital for confirmed thyroid cancer, suspected thyroid cancer (fine needle aspiration biopsy categories 3−6), lymph node metastases of thyroid cancer, and local recurrent thyroid cancer confirmed by biopsy and thyroglobulin in washout fluid. Inclusion criteria were as follows: age above 18, patient's consent, lack of distant metastases. Exclusion criteria were as follows: previous RLN injury (unless the same patient was already enrolled to the study and required another surgery), trachea or larynx disease, cancerous infiltration of larynx, FNAB − 2nd

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Informed consent was obtained from all individual participants included in the study.

The study was approved by the appropriate institution research (National Institute of Oncology) ethics committee.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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category. All patients were operated on by the same surgical team. Informed consent was collected from all patients. The study received approval from a Bioethics Committee from The Maria Sklodowska-Curie National Research Institute of Oncology number 67/2020.

Procedures

Age, sex, anthropometric variables, comorbidities, laboratory examinations, and indications and type of surgery, and postoperative results were gathered. Ultrasound was used to measure the volume of the thyroid lobes and to assess the echogenicity of thyroid tissue. Moreover, tumour location in the thyroid and entrapment of RLN (the nerve encased with cancer and deliberately sacrificed for cancer clearance) by the tumour or thyroid was assessed during surgery. Central neck dissection was routinely performed in both lobectomy and thyroidectomy in all patients, whilst lateral lymph node dissection was done in those with confirmed metastases and in one patient with medullary thyroid carcinoma and high calcitonin level preoperatively.

Histopathological reports were analysed for variables such as tumour size, TNM classification, and histological type of cancer. We used neuromonitoring of the vagus nerve (intermittent neurostimulation) in all surgeries, recording latencies, amplitudes, and instances of signal loss. TLUS was performed with a linear probe in a transverse position over the front of the thyroid cartilage to assess the symmetry, mobility, and position of vocal folds during breathing, coughing, and phonation by image observation. RLN injury was defined as vocal fold paresis (decreased movement of vocal folds on TLUS) or paralysis (complete immobility).

TLUS was performed with a linear probe in a transverse position over the front of the thyroid cartilage to assess the symmetry, mobility, and position of vocal folds during breathing, coughing, and phonation by image observation. It was assessed by observing images on ultrasound, when the patient was phonating, breathing, coughing, performing Valsalva maneuver. The sonographer was the main author of the study, endocrinology resident, with experience of 5 years in ultrasonography, with certificate of Polish Ultrasonography Society.

Standard laryngoscopy was performed under local anaesthesia (2% lignocaine spray) with a 70-degree oral endoscope (Fiegert-Endotech, Tuttlingen, Germany). Direct laryngoscopy by the same experienced ENT specialist was performed, which is the gold standard for vocal fold abnormality detection. RLN injury on laryngoscopy was defined as vocal fold paralysis or paresis. Investigators performing TLUS or laryngoscopy were blinded to the results of the other method. TLUS and laryngoscopy were performed in all patients before surgery and 1−3 days after surgery. One month after surgery, we repeated TLUS and laryngoscopy in the first 100 patients. We did not repeat the assessments after 1 month in the remaining patients without immediate RLN injury because we noticed that these patients did not have any dysfunction 1 month later as well.

Statistical analysis

Variables were presented as counts (percentages), means ± standard deviations (SD), or medians (interquartile range, IQR) as appropriate. Normality was checked with the Shapiro-Wilk test and based on skewness and kurtosis. Variables were compared between patients with or without RLN injury on laryngoscopy with the chi-squared test, Fisher exact test, *t* test, or Mann-Whitney *U* test as appropriate. Variables that differed significantly between the two groups were analysed by univariate logistic regression and multivariate stepwise logistic regression. All significant predictors of RLN injury from univariate analyses were entered to the stepwise model. We excluded predictors that were significantly correlated (based on variance inflation factors). The diagnostic performance of TLUS was compared with that of laryngoscopy: sensitivity, specificity, positive and negative predictive values, and accuracy were calculated together with respective 95% confidence intervals (CI). A $P < 0.05$ was considered significant. All analyses were conducted in the R software, V ersion 4.0.5.

RESULTS

Patient characteristics, frequency of RLN injury, and diagnostic performance of TLUS

There were 185 patients who underwent 196 thyroid surgeries. Of all surgeries, 23 (11.7%) caused RLN injury diagnosed on laryngoscopy. Of the RLN injuries, 4 (17,4%) were permanent and 19 (82,6%) were transient, whereas 16 (69.6%) caused vocal cold paralysis and 7 (30.4%) caused palsy.

Before surgery, patients with or without RLN injury had similar clinical characteristics, with no significant differences in age, proportion of women, frequency of comorbidities, and previous thyroid or neck surgery (Table 1). Laboratory characteristics were also similar in the two groups (Table 1). The frequency of RLN entrapment by the tumour or thyroid was more frequent in patients with RLN injury (35% vs. 0, $P < 0.001$; Table 1). Other characteristics of the tumour and thyroid were similar in the two groups (Table 1).

Before surgery, all variables assessed on TLUS were similar in the two groups (Table 2), whereas after surgery, abnormal findings were seen significantly more frequently in patients with RLN injury (Table 2). On TLUS after surgery, vocal folds were visible in 22 (95.7%) patients with RLN injury and in 161 (93.1%) patients without RLN injury.

TLUS identified RLN injury in 19 out of 23 patients who had the injury on laryngoscopy, whereas all patients with no RLN injury on laryngoscopy had normal TLUS (sensitivity, 97.7% (95% CI: 94.3% −99.4%); specificity, 100.0 (95% CI: 82.4%−100%); positive predictive value, 100% (95% CI: 100%), negative predictive value, 82.6% (95% CI: 64.3%−92.6%)), and accuracy 97.9% (95% CI: 94.9% −99.4%).

TABLE 1.
Characteristics of Patients With or Without Injury to the Recurrent Laryngeal Nerve

Characteristics		RLN Injury	No RLN Injury	Test Statistics	*P*
Clinical	Patients / surgeries, n	22 / 23	163 / 173	–	–
	Women, n (%)	16 (72.7)	129 (79.1)	χ2 = 0.17 df = 1	0.682[1]
	Age (years), mean ± SD	43.96 ± 12.64	47.40±16.05	t = 1.19 df = 32	0.244[2]
	BMI, mean ± SD	29.22 ± 6.60	27.87±6.22	t =-0.93 df = 27	0.359[2]
	Asthma / COPD, n (%)	2 (9.1)	4 (2.5)	χ2 = 1.02 df = 1	0.313[1]
	Hypertension, n (%)	5 (22.7)	47 (28.8)	χ2 = 0.19 df = 1	0.623[1]
	Stroke / TIA, n (%)	0	0	–	–
	Diabetes / prediabetes, n (%)	2 (9.1)	24 (14.7)	–	0.744
	Previous hoarseness, n (%)	0 (0.0)	4 (2.3)	–	>0.999
	Previous neck surgery, n (%)	7 (30.4)	54 (31.2)	χ2 = 0.01 df = 1	>0.999[1]
	Repeated thyroid surgery, n (%)	2 (8.7)	12 (6.9)	–	0.672
Laboratory	WBC before surgery, mean ± SD	6.92 ± 2.06	6.78±2.35	t = -0.29 df = 30	0.776[2]
	TSH before surgery, median (IQR)	1.61 (1.27;2.30)	1.56 (0.86;2.34)	W = 1731	0.518[3]
	fT3 before surgery, median (IQR)	3.22 (2.90;3.43)	3.23 (2.96;3.63)	W=2194	0.398[3]
	fT4 before surgery, mean ± SD	1.38 ± 0.49	1.38 ± 0.29	t = -0.03 df = 24	0.977[2]
	Ca^{2+} before surgery, mean ± SD	2.40 ± 0.10	2.42 ± 0.11	t = 0.83 df = 30	0.413[2]
	Ca^{2+} after surgery, mean ± SD	2.12 ± 0.14	2.17 ± 0.13	t = 1.59 df = 28	0.124[2]
Tumor and thyroid	FNAB category, n (%)				
	1	0 (0.0)	1 (0.7)*	–	0.362
	2	0 (0.0)	2 (1.4)*		
	3	2 (11.8)	12 (8.5)		
	4	4 (23.5)	36 (25.4)		
	5	2 (11.8)	44 (31.0)		
	6	8 (47.1)	31 (21.8)		
	7	0 (0.0)	1 (0.7)		
	8	1 (5.9)	15 (10.6)		
	Lesion location, n (%)				
	Left	8 (38.1)	60 (37.0)	–	>0.999
	Right	10 (47.6)	74 (45.7)		
	Both	1 (4.8)	6 (3.7)		
	Parathyroid	0 (0.0)	2 (1.2)		
	Isthmus	1 (4.8)	8 (4.9)		
	Lymph node	1 (4.8)	12 (7.4)		
	Right lobe volume (cm^3), median (IQR)	9.15 (7.64;12.56)	7.59 (4.18;11.28)	W=1540	0.204[3]
	Left lobe volume (cm^3), median (IQR)	7.98 (4.22;9.11)	5.64 (3.38;9.36)	W = 1538	0.215[3]
	Homogenous echogenicity, n (%)	9 (40.9)	78 (47.3)	χ2 = 0.11 df = 1	0.751[1]
	Retrosternal thyroid, n (%)	0 (0.0)	13 (7.6)	–	0.371
	RLN entrapment, n (%)	7 (35.0)	0 (0.0)	–	**<0.001**

Notes: Data presented as n (%) for nominal variables and as mean±SD or median (Q1;Q3) for continuous variables, depending on normality of distribution. Groups compared with Fisher exact test or chi2 test1 or for nominal variables and with t test2 or Mann-Whitney U test3 for continuous variables.
* patients with category 1 and 2 in contralateral lobe, had previously thyroid carcinoma and lobectomy and were scheduled for radicalisation procedure.
Abbreviations: BMI, body-mass index; COPD, chronic obstructive pulmonary disease; df, degrees of freedom; FNAB, fine needle aspiration biopsy; fT3, free triiodothyronine; fT4, free thyroxine; IQR, interquartile range; RLN, recurrent laryngeal nerve; TIA, transient ischemic attack; TSH, thyroid stimulating hormone; WBC, white blood count.
Bold value indicate <0.001 for bolt RLN entrapment.

Risk factors for RLN injury

Thyroidectomy with lateral dissection was performed more frequently in patients with RLN compared to those without RLN injury (21.7% vs. 5.8%, *P* = 0.019), whereas the frequencies of other surgery types were similar in the two groups (Table 3). Moreover, the following characteristics were significantly more frequent in patients with RLN injury: any lymph node involvement (*P* = 0.043), lateral lymph node involvement (*P* = 0.022), and 1a and 1b lymph node involvement (*P* = 0.008, Table 3). On univariate logistic regression, thyroidectomy with lateral neck dissection was the strongest predictor of RLN injury (OR = 4.53; 95% CI: 1.29−14.32; Table 4) and it remained the only significant predictor on stepwise logistic regression (Table 4)

Neuromonitoring of the vagal nerve

Before surgery, only left vagus nerve latency was significantly longer in patients with intraoperative RLN injury (*P* = 0.004), whereas other neuromonitoring variables were

TABLE 2.
Translaryngeal Ultrasound Assessment in Patients With or Without Injury to the Recurrent Laryngeal Nerve After Thyroid Surgery

Variable	RLN Injury	No RLN Injury	Test Statistics	*P*
Before surgery				
Visible vocal folds	22 (95.7)	162 (94.2)	–	>0.999
Normal vocal fold movement	22 (100.0)	158 (100.0)	–	>0.999
Vocal fold symmetry - still	21 (100.0)	154 (100.0)	–	>0.999
Symmetry during - cough	21 (100.0)	154 (100.0)	–	>0.999
Symmetry during - phonation	21 (100.0)	154 (100.0)	–	>0.999
Symmetry during - swallowing	21 (100.0)	154 (100.0)	–	>0.999
Arytenoid symmetry	21 (100.0)	154 (100.0)	–	>0.999
1–3 days after surgery				
Visible vocal folds	22 (95.7)	161 (93.1)	–	>0.999
Normal vocal fold movement	3 (13.6)	161 (100.0)	–	**<0.001**
Vocal fold symmetry - still	3 (13.6)	160 (99.4)	–	**<0.001**
Symmetry during - cough	3 (13.6)	160 (99.4)	–	**<0.001**
Symmetry during - phonation	3 (13.6)	160 (99.4)	–	**<0.001**
Symmetry during - swallowing	3 (13.6)	160 (99.4)	–	**<0.001**
Arytenoid symmetry	3 (13.6)	160 (99.4)	–	**<0.001**

Data presented as n (%). Groups compared with Fisher exact test.
$P < 0.05$ is statistically significant and highlighted in bold font.

similar in the two groups. During surgery, loss of neuromonitoring signal was significantly more common in patients with RLN injury (73.9% vs. 2.9%, $P < 0.001$). After surgery, there were no significant differences in neuromonitoring variables (Table 5).

DISCUSSION

This study showed that the risk of intraoperative RLN injury in patients with thyroid cancer was increased in those who had RLN entrapment before surgery, had lymph node involvement, and underwent thyroidectomy with lateral dissection. Loss of vagus nerve signal during surgery also predicted RLN injury. Other factors, such as TNM stage or histological tumour type, were not significantly related to the risk of intraoperative RLN injury.

Preoperative TLUS assessment did not predict RLN injury, but after surgery, TLUS variables were abnormal in ~~all~~ patients with the injury who were correctly diagnosed with this method. ~~Compared to laryngoscopy~~TLUS proved to be highly sensitive and specific in detecting RLN injury. Thyroid cancer is increasingly diagnosed at early stages, and the management of low-risk thyroid cancer has become less aggressive (eg, lobectomy), partly because of frequent ultrasound monitoring of the remaining lobe and a high sensitivity of serum thyroglobulin in detecting recurrence. Although lobectomy may increasingly be the treatment of choice, it too can cause RLN injury. Therefore, it is vital to search for risk factors of and ways to prevent this debilitating complication. The incidence of vocal fold dysfunction caused by intraoperative RLN injury differs between studies. In our study, the frequency of RLN injury was similar to the figures from most previous reports. We have observed that RLN injury after the surgery for thyroid cancer occurred in nearly 12% of procedures, but the injury was permanent in 2% only. Jeannon et al., based on a review of 27 studies, reported that, on average, transient RLN injury occurred after ~10% of operations, whereas it was permanent in 2.3%.[9] Another analysis of 920 thyroid surgeries revealed an average rate of intraoperative RLN injury of 5.6%; however, in patients with thyroid cancer, the rate was substantially higher (22%).[2] A recent study among over 11,000 patients who had undergone thyroid surgery found an overall rate of RLN injury of 6%[10]; higher rates were seen in patients with cancer (9%), aged 65 years or older, after total thyroidectomies, and after operations without neuromonitoring.[10]

Steurer et al who investigated 608 patients after thyroidectomy or parathyroidectomy, reported transient RLN injury in ~15% of patient-malignancies and permanent injury in more than 2%.[11] These investigators found also that RLN injury was more common in patients with malignancies than in those with benign thyroid diseases, but the extensiveness of operation or lateral neck dissection (vs. central) were not related significantly to the risk of RLN injury.[11] In contrast, Rocke et al, in a study of over 50,000 total thyroidectomies, reported that lateral neck dissection was associated with more than twice the risk of RLN injury compared with other surgery types (8.3% vs. 3.3%).[12] Our results also suggest that lateral neck dissection may be a risk factor for RLN injury.

Nyyar et al found that the pathological stage pT4 was significantly associated with an increased risk of intraoperative RLN injury in patients undergoing surgery for thyroid

TABLE 3.
Surgery Type and Tumor Characteristics on Pathology in Patients With or Without Injury to the Recurrent Laryngeal Nerve

Variable	RLN Injury	No Injury	Test Statistics	*P*
Type of surgery, n (%)				
Thyroidectomy with central neck dissection	2 (8.7)	41 (23.7)	–	0.116
Hemithyroidectomy with central dissection	15 (65.2)	103 (59.5)	$\chi2$ = 0.09 df = 1	0.657[1]
Thyroidectomy with lateral dissection	5 (21.7)	10 (5.8)	–	**0.019**
Lymph nodes metastatic	1 (4.3)	10 (5.8)	–	>0.999
Repeated surgery in previous postoperative bed	0 (0.0)	4 (2.3)	–	>0.999
Isthmectomy	0 (0.0)	3 (1.7)	–	>0.999
Parathyroid	0 (0.0)	3 (1.7)	–	>0.999
Trachea release	0 (0.0)	1 (0.6)	–	>0.999
Radicalization, n (%)	7 (30.4)	39 (22.8)	$\chi2$ = 0.30 df = 1	0.434[1]
Tumor volume, cm^3, median (IQR)	2.46 (0.57;5.23)	0.83 (0.19;4.57)	W = 1042	0.233[2]
Malignant tumor (vs. benign), n (%)	15 (65.2)	133 (76.9)	$\chi2$ = 0.93 df = 1	0.300[1]
T, n (%)				
1a	3 (20.0)	55 (45.5)	–	0.237
1b	6 (40.0)	33 (27.3)		
2	3 (20.0)	17 (14.0)		
3a	2 (13.3)	13 (10.7)		
3b	1 (6.7)	2 (1.7)		
4a	0 (0.0)	1 (0.8)		
Lymph node metastases, n (%)	8 (34.8)	28 (16.2)	–	**0.043**
Lateral	6 (26.1)	15 (8.7)	–	**0.022**
Central	2 (8.7)	14 (8.1)	–	>0.999
N category, n (%)				
0	5 (38.5)	84 (75.0)	–	**0.008**
1a	2 (15.4)	13 (11.6)		
1b	6 (46.2)	15 (13.4)		
Type of cancer, n (%)				
Papillary	10 (66.7)	92 (68.7)	–	0.903
Follicular	2 (13.3)	9 (6.7)		
Medullary	2 (13.3)	14 (10.4)		
Hurthle	0 (0.0)	4 (3.0)		
Anaplastic	0 (0.0)	1 (0.7)		
Other cancer	0 (0.0)	4 (3.0)		
Parathyroid	0 (0.0)	1 (0.7)		
Border-line tumors group 1	1 (6.7)	9 (6.7)		

Notes: Data presented as n (%) for nominal variables and as median (Q1;Q3) for continuous variables without normal distribution. Groups compared with Fisher exact test or chi2 test[1] for nominal variables and with Mann-Whitney U test[2] for continuous variables.
$P < 0.05$ is statistically significant and highlighted in bold font.
Abbreviations: df, degrees of freedom; IQR, interquartile range; RLN, recurrent laryngeal nerve.

cancer.[13] However, in our study, only one patient had a pT4 tumour, which might explain why we did not find any significant association between pathological tumour stage and the risk of RLN injury. In our study, we found that lateral, but not central, lymph node involvement was significantly associated with the risk of RLN injury. This may be related to characteristics of lateral nodes surgery, which is more extensive, longer and complicated due to cancer advancement/extensiveness. In contrast, Nayyar et al observed that central lymph node involvement was associated with RLN injury.[13]

In contrast to two-step procedures, repeated thyroid surgery is performed on the same side of the neck as a previous operation. Therefore, some postoperative complications, such as RLN injury and hypoparathyroidism, occur significantly more frequently after repeated surgery, which tends to be more difficult due to scar tissue and greater tissue fragility. However, repeated surgery was not significantly associated with the risk of RLN injury in our study, which is in contrast to some studies,[14–16] but in line with others.[13,17] Similar complication rates after the first and repeated surgery may be attributed to high surgeon experience and the use of neuromonitoring. Neuromonitoring enables a two-stage thyroidectomy. When single loss from RLN is observed in a patient with previous contralateral RLN injury, surgery can be stopped to prevent bilateral nerve injury and a need for tracheotomy. During the time before repeated surgery, the nerve can regenerate.[18] Using this

TABLE 4.
Logistic Regression Models for Predicting Injury to the Recurrent Laryngeal Nerve

Variable	Univariate Models			Multivariate Stepwise Model		
	OR	95% CI	*P*	OR	95% CI	*P*
Thyroidectomy with lateral neck dissection (other = reference)	4.53	1.29−14.32	0.012	4.53	1.29 to 14.32	0.012
Any lymph node metastases	2.76	1.03−7.01	0.036			
Lateral lymph nodes metastases	3.39	1.09−9.62	0.026			
N (0 = reference)						
1a	0.94	0.13−4.13	0.939			
1b	2.44	0.73−7.70	0.131			

Multivariate model assessment: chi-square test confirm good model fit: p = 0.020, Negelkerke R^2 = 0.05, GOF test confirm good model fit: $P > 0.999$.
Abbreviations: CI, confidence interval; OR − odds ratio, Multivariate model based on stepwise approach with AIC criterion (due to high intercorrelation lateral lymph nodes metastases was excluded from range on input predictors to multivariate model).

TABLE 5.
Vagal Nerve Monitoring Before, During, and After Thyroid Surgery

Variable	RLN Injury	No RLN Injury	Test Statistics	*P*
Before surgery				
Signal amplitude − left	0.64 (0.27;1.11)	0.73 (0.35;1.20)	W = 736	0.714[1]
Latency − left	6.78 (6.36;7.19)	6.20 (5.75;6.65)	W = 366	**0.004**[1]
Signal amplitude − right	0.48 (0.38;1.08)	0.84 (0.38;1.62)	W = 665	0.447[1]
Latency − right	3.70 (3.38;3.90)	3.88 (3.65;4.24)	W = 759	0.101[1]
After surgery				
Signal amplitude − left	0.81 (0.27;1.04)	0.53 (0.28;0.97)	W = 361	0.617[1]
Latency − left	6.40 (6.03;7.05)	6.35 (5.85;6.90)	W = 381	0.794[1]
Signal amplitude − right	0.78 (0.47;1.06)	0.76 (0.28;1.26)	W = 411	0.708[1]
Latency − right	4.00 (3.43;4.13)	4.00 (3.75;4.35)	W = 447	0.426[1]
Loss of signal during surgery	17 (73.9)	5 (2.9)	−	**<0.001**

Data presented as n (%) for nominal variables and median (Q1;Q3) for continuous variables without normal distribution. Groups compared with Fisher exact test for nominal variables and with Mann-Whitney *U* test1 for continuous variables.
$P < 0.05$ is statistically significant and highlighted in bold font.
Abbreviation: RLN, recurrent laryngeal nerve

approach, we did not observe any bilateral RLN palsy. It is also a case of diagnostic lobectomy with subsequent second lobe resection if the histopathologic examination reveals a need of radioiodine treatment. Neuromonitoring is also particularly applicable in a scarred surgical field during repeated procedures on the thyroid gland.[19]

In the study by Moreira et al., RLN injury (overall rate, 8.3%) was significantly associated with male sex and longer operative time.[20] RLN in our study occurred at similar frequency in men and women and it did not depend on age, which is in line with other reports.[13,21,22] Moreover, similar to previous studies, RLN injury risk was not related to comorbidities in our cohort.[13,23] In a study of over 16,000 surgeries, permanent RLN injury was associated with recurrent benign and malignant goitre, thyroid malignancy, lobectomy (vs. subtotal resection), lack of nerve identification, low- or medium-volume hospitals, and low-volume surgeons[24] Hence, it is vital that thyroid surgeries be performed by experienced surgeons and with the use of neuromonitoring surveillance; moreover, and vocal fold function should be monitored before and after surgery

We observed a high concordance between TLUS and laryngoscopy, which is in line with previous studies with a concordance rate of 89%-100%.[25−27] In our study, we missed only 4 cases of vocal fold dysfunction (all transient; vocal cords were not visible on TLUS in 2 patients with RLN injury). The non-visualization of VFs with TLUS when assessing RLN injury were found among older men, as their thyroid cartilage becomes calcified with age.[28] Thus, TLUS appears as a promising method to assess vocal fold dysfunction, particularly when laryngoscopy is not available. TLUS may be advantageous to laryngoscopy in certain situations because it does not generate aerosols, which may contain transitable pathogens, such as the severe acute respiratory coronavirus 2. TLUS could be used instead of laryngoscopy when the risk of virus transmission is high.[29,30] However, TLUS has some weaknesses as compared to laryngoscopy. It fails to identify the fixed position of paresis/paralysis of VF, thereby lacking laryngeal findings such as glottic insufficiency, mucosal wave, and probable hyperfunction or to collect diagnostic information regarding appropriateness for speech therapy candidacy through tasks administered by laryngoscopy (connected speech, sustained phonation, pitch glides, diadochokinetic rate). Obviously, detailed phoniatric parameters as mentioned above cannot be examined with TLUS. If there is a suspicion of VFs dysfunction clinically or on TLUS, patient is referred to the ENT specialist for a thorough evaluation. TLUS is meant to serve as a screening method to improve cost-effectiveness.

Our study had limitations. The follow-up period was short, while RLN recovery can occur as late as 2 years after injury.[11] Laryngoscopy may miss some RLN injuries or can give false positive results. Moreover, we did not analyse certain surgery-related variables, such as surgery duration or mechanism of RLN injury (eg, traction, thermal, compression, clamping, and nerve transection,).[31] Our study had strengths. Most previous studies investigating the frequency of RLN injury after thyroid surgery included patients with malignant and benign thyroid diseases, whereas analyses among individuals with suspicion or confirmed malignancy were lacking. Moreover, we used TLUS to diagnose RLN injury in these patients, finding encouraging results that add evidence validating TLUS.

RLN injury is a serious complication of thyroid surgery that occurs more frequently in patients with thyroid cancer. Other risk factor for RLN injury may include extensive resections, lymph node involvement, and nerve entrapment. Detection of vocal fold dysfunction can be done in most patients by TLUS, which is nearly as accurate as laryngoscopy. TLUS may be done during a routine ultrasound examination, does not require expensive equipment, and may reduce the risk of virus transmission. Early recognition of RLN injury may enable effective speech therapy preventing permanent dysfunction.

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DECLARATION OF COMPETING INTEREST

None

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