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ORIGINAL ARTICLE

Transcutaneous laryngeal ultrasonography: a reliable, non-invasive and inexpensive preoperative method in the evaluation of vocal cords motility—a prospective multicentric analysis on a large series and a literature review

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Abstract

Thyroidectomy is a largely performed intervention and its rate has sharply increased. The most feared postoperative complication is the recurrent laryngeal nerve paralysis, which is the most frequent cause of medicolegal litigations. Therefore, surgeons have introduced the preoperative evaluation of vocal cords function through laryngoscopy. Transcutaneous laryngeal ultrasonography has been proposed as a non-invasive indirect examination of vocal cords function. The aim of this study is to assess transcutaneous laryngeal ultrasonography reliability as an alternative painless and inexpensive method in the evaluation vocal folds function in patients amenable of thyroid surgery. We conducted a prospective multicentric study on patients affected by thyroid disease referred to the thyroid surgery divisions of two tertiary hospitals. All patients preoperatively underwent transcutaneous laryngeal ultrasonography and subsequently were evaluated via laryngoscopy by a blinded otolaryngologist. The ultrasonographical and laryngoscopical findings were then compared by an external blinded investigator. Our analysis on 396 patients showed an assessability rate of 96.46%, a sensitivity of 96.8%, a specificity of 95.6%, a positive predictive value of 65.2% and a negative predictive value of 99.7% in the identification of vocal cords alterations. A concordance between transcutaneous laryngeal ultrasonography and laryngoscopy of 95.7% was reported. In 14 patients (3.54%), the investigator reported a hard visualization of vocal cords through ultrasonography. Transcutaneous laryngeal ultrasonography is a valid non-invasive and painless alternative method in the assessment of vocal cords in a selected population; moreover, it could be useful in identifying patients addressable to second-level examination.

Keywords Transcutaneous laryngeal ultrasonography · Flexible fiberoptic laryngoscopy · Vocal cords motility · Thyroid surgery

Abbreviations

BMI	Body mass index
TT	Total thyroidectomy
RLN	Recurrent laryngeal nerve
VCP	Vocal cord paralysis
FFL	Flexible fiberoptic laryngoscopy
ATA	American Thyroid Association
TLUS	Transcutaneous laryngeal ultrasonography
PPV	Positive predictive value

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NPV Negative predictive value
CI Confidence interval

Introduction

Benign and malignant thyroid diseases affect a large population worldwide [1]. Total thyroidectomy (TT) is one of the most commonly performed intervention in general surgery and, since the turn of the century, its rate has sharply increased, along with a general increase of differentiated thyroid cancer incidence [2]. The most feared and dangerous complication of thyroidectomy is the paresis or paralysis of the recurrent laryngeal nerve (RLN), with a wide range of incidence reported in literature (0.5–20% of cases) [3].

Several causes have been advocated as apparent or unapparent mechanism of nerve damage. Among them, the most frequent are compression, crush, stretch, laceration, and thermal or vascular injuries [3]. Unilateral vocal cord paralysis (VCP) generally does not affect voice. Nevertheless, in 30% of patients undergoing TT, without nervous injury, vocal subjective voice alterations are reported [4]. Conversely, a bilateral VCP can be the cause of an acute respiratory distress, requiring temporary or permanent tracheotomy. VCP has become the most frequent cause of medicolegal litigations after thyroid surgery [3]. Therefore, endocrine surgeons have been prompted to include, among the preoperative examinations of patients addressed to TT, the evaluation of vocal cords function through flexible fiberoptic laryngoscopy (FFL).

RLN injuries have a low incidence in referral center with experienced surgeons, and according to several authors, a routine FFL could be uncomfortable for patients and leads to unjustifiable increase of health care costs [5]. According to the American Thyroid Association (ATA) guidelines, a preoperative laryngeal evaluation is required only in selected cases, such as in patients with voice alterations, in patients with extrathyroidal cancer extension, in patients who had already undergone neck surgery with suspicious or certified RLN or vagus nerve lesion [6].

Transcutaneous laryngeal ultrasonography (TLUS) has been proposed as a non-invasive and painless indirect examination of vocal cords function as alternative to direct FFL [7]. TLUS is an easy and feasible technique that can be performed by the endocrinologist or the surgeon during the preoperative ultrasound evaluation; it is inexpensive, rapid, painless, repeatable and well tolerated by the patient [7, 8]. TLUS allows to clearly evaluate vocal cords and arytenoids vibration on real time during the examination. TLUS is not considered an innovative method to evaluate vocal cord movement, but, despite the several advantages, in clinical practice, currently, its use is very limited.

The aim of this study is to assess TLUS reliability as an alternative method to direct FFL in the evaluation vocal folds function in patients candidates to thyroid surgery.

Materials and methods

We conducted a prospective observational multicentric cohort study on consecutive patients diagnosed with benign and malignant thyroid disease referred to the Thyroid Surgery Division of the University of Campania "Luigi Vanvitelli" and to the General and Specialistic Surgery Division of the “Antonio Cardarelli Hospital”, from 1 January 2018 to 31 December 2018. Exclusion criteria were age < 16 years, previous neck surgery and irradiation, presence of tracheostomy, pre-existing diagnosis of vocal cord nodules. Clinical data were collected in a prospective maintain electronic database, including patients’ age, sex, body mass index (BMI), previous cervical surgery, preoperative diagnosis, ability of visualizing both vocal cords, mobility or paralysis of both vocal cords and preoperative FFL findings. In addition, definitive pathology was recorded [Tables 1, 2].

Patients were stratified into two groups according to body mass index (BMI) in a non-overweight group (BMI < 25) and in an overweight or obese group (BMI ≥ 25).

All patients have a diagnosis of benign or malignant thyroid disease and preoperatively. All patients were asked specifically if they had any voice and laryngeal symptoms before TLUS and direct laryngoscopy assessments. They underwent TLUS and subsequently all patients were evaluated via laryngoscopy by a blinded otolaryngologist. The ultrasonographical and laryngoscopical findings were then compared by an external blinded investigator. TLUS was performed by an experienced investigator (MG), skilled in neck ultrasound, in all the participating centers to minimize variability in vocal cord assessment. All patients, in both the divisions, underwent total thyroidectomy (TT) performed by two experienced endocrine surgeons (GD and MDP).

The ethical committee of Campania “Luigi Vanvitelli” University approves the study. All selected patients received an information leaflet on the aims of the study and signed a written informed consent.

Transcutaneous laryngeal ultrasonography

Cervical and thyroid ultrasound has been performed using a 7–13-MHz linear probe (Esaote, MyLab™ X5). The patients were placed in a supine position with neck hyperextension. In overweight patients or in patients with a short neck, we placed a pillow under the shoulder to hyperextend the neck. After applying ample gel over anterior neck, the ultrasonography was carried out identifying vascular neck bundle, both lobes of thyroid gland and isthmus. The probe was firstly

Table 1 Patients' demographic and clinical information

	Overall	BMI < 25 group	BMI ≥ 25 group
Age, mean, range	56.4 (18–82 range)	54.3 (18–81 range)	57.9 (26–82 range)
Gender			
Male	134/396 (34.84%)	45/169 (26.63%)	89/227 (71.53%)
Female	262/396 (66.16%)	124/169 (73.37%)	138/227 (28.47%)
BMI, mean, range	26.4 (16.9–39.6 range)	22.21 (16.9–24.9 range) 169 (42.7%)	29.5 (25–39.6 range) 227 (57.3%)
Preoperative TLUS			
Visualized	382/396 (96.46%)	163/169 (96.45%)	219/227 (96.47%)
Not visualized	14/396 (3.54%)	6/169 (3.55%)	8/227 (3.53%)
Preoperative TLUS			
Correct correlation with FL	349/396 (88.13%)	154/169 (91.12%)	195/227 (85.91%)
Incorrect correlation with FL	47/396 (11.68%)	15/169 (8.87%)	32/227 (14.09%)
Preoperative TLUS			
Unilateral paralysis	46/396 (11.61%)	14/169 (8.28%)	32/227 (14.09%)
Bilateral paralysis	0/396 (0%)	0/169 (0%)	0/227 (0%)
Preoperative FL			
Normal	366/396 (92.42%)	167/169 (98.81%)	209/227 (92.07%)
Vocal cord impairment	30/396 (7.57%)	7/169 (4.14%)	23/227 (10.13%)
Postoperative diagnosis			
Multinodular goiter	251/396 (63.38%)	95/169 (56.2%)	156/227 (68.7%)
Thyroid adenoma	56/396 (14.14%)	30/169 (17.6%)	26/227 (11.8%)
Follicular thyroid carcinoma	22/396 (5.55%)	14/169 (8.2%)	8/227 (3.75%)
Papillary thyroid carcinoma	52/396 (13.13%)	27/169 (15.8%)	25/227 (11.01%)
Medullary thyroid carcinoma	4/396 (1.01%)	0/169 (0%)	4/227 (1.9%)
Microcarcinoma	10/396 (2.52%)	4/169 (2.2%)	6/227 (2.84%)

**BMI* body mass index, *TLUS* transcutaneous laryngeal ultrasound, *FL* fiberoptic laryngoscopy

Table 2 Demographics and clinical variables according to vocal cord visualization on TLUS

	Population, *n* (%)	Vocal cord visualized on TLUS, *n* (%)	Vocal cord with difficult visualized on TLUS, *n* (%)	*p*-value
Female, *n* (%)	262/396 (66.16%)	262/262 (100%)	0/262 (0%)	
Male, *n* (%)	134/396 (34.84%)	120/134 (89.55%)	14/134 (10.45%)	$p < 0.001$*
Mean age, years (range)	56.4 (18–82 years)	56.19 (18–82 years)	61.28 years (55–81 years)	$p = 0.19$
BMI (kg/m^2) < 25	169/392 (43.1%)	163/169 (96.45%)	6/169 (3.55%)	
BMI (kg/m^2) > 25	227/392 (57.9%)	219/227 (96.47%)	8/227(3.53%)	$p = 0.99$
Diagnosis of malignity	88/396 (22.22%)	84/88 (95.45%)	4/88 (4.55%)	
Diagnosis of benignity	308/396 (77.77%)	298/308 (96.75%)	10/308 (3.25%)	$p = 0.52$

**BMI* body mass index, *TLUS* transcutaneous laryngeal ultrasonography

placed transversely over the thyroid cartilage. Craniocaudal scans allowed visualization of the true and false vocal cords movement during spontaneous breathing. Thyroid cartilage was used as acoustic window. The sonographic landmarks of vocal cords, i.e., false cords and arytenoids, were researched and identified for the evaluation of vocal cords' motility. To optimize the image, the greyscale was adjusted until false cords became hyperechoic, while the true cords became hypoechoic (Fig. 1). To assess the vocal cord motility, the patients were instructed and invited to perform three different maneuvers: passive (i.e., quiet spontaneous breathing), active (phonation with a sustained vowel ''aa''and "ii") and Valsalva maneuver. The normal movement of the true vocal cords appeared as a symmetrical vibration in adduction and abduction. During Valsalva maneuvers, patients took a deep breath and then held it and bore down. In case of normal motility, vocal cords appeared adducted symmetrically in midline during Valsalva maneuver. After that, patients were

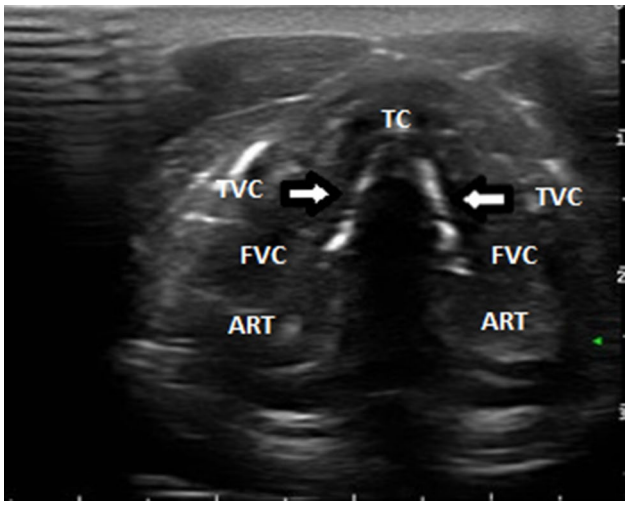

Fig. 1 Anterior-approach midline view. True vocal cords (TVC) are indicated with the white arrow. *TC* thyroid cartilage, *ART* arytenoids, *FVC* false vocal cords

asked to relax and vocal cords would abduct. The paretic vocal cords appeared as still or with a sign of passive movement. In case of hard vocal cords visualizations for the presence of a hypertrophic thyroid cartilage, the ultrasonographic probe was placed in a different acoustic window, laterally to the cartilage [9]. Real-time TLUS lasted less than one minute. After TLUS, all patients underwent routine preoperative FFL by a blinded experienced otolaryngologist, and findings were classified as normal or impaired vocal cord function. Any vocal cord impairment, including weakness, asymmetry and paralysis, was recorded on a digital database. Prospectively, TLUS findings and FFL have been compared as concordant or discordant [10].

Flexible fiberoptic laryngoscopy

FFL was performed with the patient in a semi-recumbent position (the head of the examining chair raised 30°). Before the procedure, the patient was instructed to close his or her mouth and breathe gently through the nose. All patients received topical anesthetic and decongestant before the examination. The fiberoptic laryngoscope (3.6-mm diameter, Olympus, Japan) was then advanced along the floor of the nose, avoiding the nasal septum. As the endoscope was advanced to the nasopharynx, the patient was instructed to breathe through the nose. Then, the instrument was introduced over the soft palate and subsequently the vocal cords were visualized. The same abovementioned three maneuvers (i.e., active, passive and Valsalva maneuvers) were performed, to allow the assessment of vocal cords mobility, making note in a digital database of their incomplete abduction or adduction, weakness, asymmetry and paralysis (Figs. 2, 3).

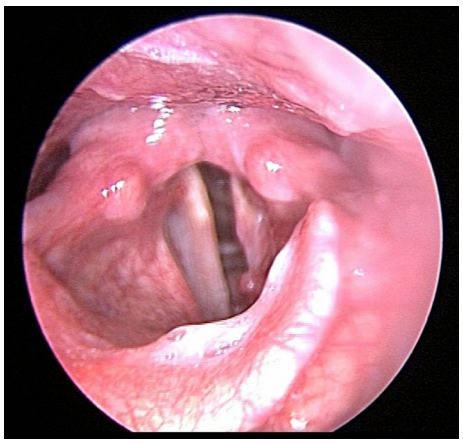

Fig. 3 Left vocal cord paralysis in abduction at fiberoptic laryngoscopy

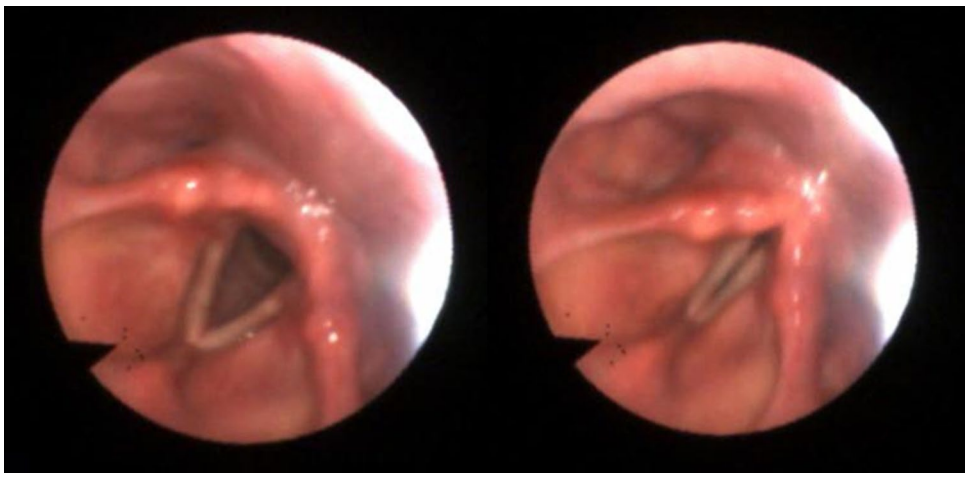

Fig. 2 Normomobile vocal cords to fiberoptic laryngoscopy in adduction and abduction

Statistical analysis

Age and BMI were indicated as mean, while patients' sex, visualization through TLUS and benign and malign diseases were described as number of cases. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were evaluated according to the FFL's results (Table 3). Moreover, the authors calculated the prevalence, the probability to be affected by the vocal cord impairment either if test resulted positive or negative and the concordance with relative Cohen's *K*, by the use of Excel. Statistical significance was defined as $p < 0.05$ with a confidence interval (CI) at 95%. Database has been realized through the use of Excel and *p*-value has been calculated with Fisher exact test and independent samples *t*-test (IBM SPSS-23®).

Results

The current study included 396 patients who underwent a total of 792 vocal cord assessments. The overall mean age was 56.4 years (18–82 years), 262 patients (66.16%) were females and 134 (33.84%) patients were males. The female–male ratio was 1:9. Regarding difficult visualization, in our population, we reported a statistically significant difference ($p < 0.001$) between males and females; in detail, all the cases of hard visualization (14/396) were males. Conversely, no significant difference between the two groups was reported in terms of age ($p = 0.19$), BMI ($p = 0.99$) and definitive diagnosis ($p = 0.52$). One hundred and sixty-nine patients (42.7%) had a BMI < 25 and 227 patients (57.3%) were overweight (BMI ≥ 25). All patients underwent TT. Preoperatively, 316 patients (79.8%) received the diagnosis of benign thyroid disease, 50 patients (12.6%) a diagnosis of malignancy suspicion and 30 patients (7.6%) a diagnosis of malignant thyroid disease. In details, preoperative diagnosis was a non-toxic multinodular goiter in 255 patients (64.39%), a toxic multinodular goiter in 12 patients (3.03%), a toxic adenoma in 49 patients (12.37%); an indefinite cytology nodule in 50 patients (12.62%), a positive cytology for thyroid carcinoma in 26 patients (6.56%) with a diagnosis of medullary thyroid carcinoma in 4 patients (1.01%). Definitive pathology showed 308 cases (77.8%) of benign disease and 88 cases (22.2%) of thyroid carcinoma. Twenty-two patients (5.55%) had a diagnosis of follicular thyroid carcinoma, 52 patients (13.13%) a diagnosis of papillary thyroid carcinoma, 4 patients (1.01%) a diagnosis of medullary thyroid carcinoma and 10 patients (2.52%) were diagnosed as microcarcinoma (Table 1). Patients diagnosed with malignancy were all patients affected by thyroid-limited cancer (T1–T2), without lymph node involvement and metastasis. Patients' demographic and pathological data were collected in Tables 1 and 2.

All patients underwent TLUS and subsequently a FFL. TLUS identified unilateral paralysis in 47 patients (11.8%) with a PPV of 65.2% (60.3–69.9%). FFL diagnosed unilateral paralysis in 30 cases (7.57%). The overall assessability rate through TLUS was 96.46% (382/396). In the remaining 14 patients (3.54%), the investigator reported a hard visualization of vocal cords through ultrasonography. The latter patients were all males with a well-represented thyroid cartilage; 6 of them were in the non-overweight group and 8 in overweight group (*p*-value 0.99). In the former 14 patients, it was not possible to visualize the vocal cords with the conventional transverse front visualization, and the ultrasonographic probe was placed in a different acoustic window, laterally to the cartilage, allowing a correct identification.

Sensitivity was equal to 96.8% (94.4–98.2%), specificity was 95.6% (93–97.3%), positive predictive value 65.2% (60.3–69.9%), negative predictive value 99.7% (98.3–100%). The probability of a vocal cord alteration in case of negative TLUS was 0.3% (< 0.01–10.6%) and if it resulted positive was 65.2% (59.2–71%). In our series, just one false negative has been observed.

The prevalence of VCP in our series was 7.8% (5.5–11%). The results showed a concordance between TLUS and FL of 95.7%, with a Cohen's *K* value of 0.756. Statistical data were collected in Table 3.

Table 3 Statistical data

		CI of 95%	
		Lower limit	Upper limit
Sensitivity	0.968	0.944	0.982
Specificity	0.956	0.930	0.973
Prevalence	0.078	0.055	0.110
PPV+	0.652	0.603	0.699
PNV−	0.997	0.983	1.000
p post-test+	0.652	0.592	0.710
p post-test −	0.003	< 0.001	0.106

**PPV*+ predictive positive value, *PNV*− predictive negative value, *p* post-test+ probability of alteration if the test is positive, *p* post-test− probability of alteration if the test is negative

Discussion

Vocal cords are tendon flaps that vibrate, abduct and adduce with air passage, generating sounds. RLN controls vocal cords movement. Preoperative evaluation of bilateral nerve function in patients addressed to thyroid surgery is controversial. FFL is the widespread technique used to directly evaluate vocal cords movement. Surgeons are not experienced in FFL that, moreover, causes considerable discomfort to patients, who often refuse or complain to undergo the

investigation. Nevertheless, the study of the motility of the vocal cords is a primary information that guide the surgeon in planning the surgical strategy. In preoperative work-up, neck ultrasound plays a primary role in the diagnosis of thyroid disease and it is irreplaceable for the execution of fine-needle aspiration.

American Academy of Otolaryngology and Head and Neck Surgery guideline suggests that all patients who have to undergo thyroid and parathyroid surgery should perform the preoperative and postoperative FFL [11]. Conversely, ATA guideline suggests that only high-risk patients for vocal cord paralysis (extracapsular thyroid carcinoma, large thyroid goiter, patients with voice changes and previous cervical surgery) should undergo preoperative FFL [6]. American Academy of Otolaryngology and Head and Neck Surgery guidelines suggest preoperative FFL because the postoperative vocal outcome is a primary target in thyroid surgery.

Recently, in all medical fields, research has been turned towards less invasive, rapid and painless techniques. Since 1964, several authors have speculated and studied the use of ultrasound in the assessment of vocal cord motility [12]. After its first description, the feasibility of this technique has been described in several studies with a sensitivity and specificity higher than 90% [10, 13–17]. Wong et al., in their multi-institutional analysis on 245 patients, reported an excellent assessability rate > 94% and considered TLUS a reproducible, noninvasive tool with high capacity on evaluating VCP before and after thyroidectomy. Moreover, the authors, in a subsequent paper, underlined the importance of identifying sonographic landmarks during the procedure [14, 18]. These promising data have proposed TLUS as a less invasive and less expensive technique alternative to FFL. Even more satisfactory results were reported by the same Wong on 2014 [16]. The authors reported an assessability rate in the 95% of their cohort. This surprising result was explained analyzing the demographic features of their 581 evaluated patients. In fact, in their series, the cohort was composed mostly of young women (80%) with a low BMI. More conclusive results were reported by Wong, in the largest published series on 1000 patients who had undergone TLUS [17]. The authors reported that vocal cords were evaluable in 92.4% of the studied patients, achieving a high sensitivity of 87.5% and concluding that over 87% of the patients could be saved from a FFL.

On the other hand, several authors have reported a low sensitivity of the method equal to 62% and a specificity of 97% [19]. Borel et al., reported mediocre efficiency of TLUS, with a sensitivity of 33%, a specificity of 95% when used as tool for VCP screening in patients who had already undergone thyroidectomy [20]. Probably, these poor results were linked to the presence of thyroid lodge hematoma and major postoperative laryngeal edema in the early postoperative days. Nevertheless, the authors recognize the role of TLUS in select patients to candidate to FFL. Moreover, Borel reported better results in premenopausal women, which represent a significant proportion of patients requiring total thyroidectomy [20]. Kandil et al. reported, in a study on 250 patients, a harder visualization of vocal cords in patients with BMI > 25, considering TLUS not suitable for replacing FFL [21].

A mild sensitivity value compared with a sensitivity value of 100% of fiberoptic laryngoscopy, the actual gold standard technique, is not acceptable to consider TLUS a valid alternative method. A low sensitivity of a test would lead to underestimate the presence of pathology. Nevertheless, several biases were recognizable in the published studies reporting a low sensitivity value: TLUS was performed by surgeons who usually perform only preoperative diagnostic ultrasound but who were not skilled in ultrasonographic visualization of the vocal cords, the use of multiple investigators and the lack of using a different acoustic window in patients with hard visualizations due, for example, to the prominence of the thyroid cartilage [9].

In our protocol, we enrolled an investigator (MG) who has undergone specific training in thyroid and laryngeal ultrasound, and we used the lateral approach in patients with difficult visualization due to thyroid cartilage hypertrophy. Several authors, such as Carneiro-Pla et al. confirmed that the ability to visualize both vocal cords on ultrasonography depends on the skill of the surgeon performing the examination [22]. Thanks to the standardization of the ultrasound technique, we registered a high overall assessability rate of 96.46%, a sensitivity of 96.8%, a specificity of 95.6%, a positive predictive value of 65.2% and a negative predictive value of 99.7% in the identification of vocal cords alterations. Our results showed a concordance between TLUS and FL of 95.7%, with a Cohen's *K* value of 0.756. These encouraging data allowed us to consider TLUS as part of the routine preoperative screening, as it is absolutely reliable in identifying healthy patients without paresis of the vocal cords. In case of doubts on the motility of the vocal cords, however, TLUS allowed to select patients who should be addressed to FFL. Furthermore, Carneiro-Pla et al. showed that in 24% of the population studied with ultrasound, it was not possible to visualize the vocal cords. In details, the 82% of the hard visualizable patients were males, with hypertrophy and/or calcification of the thyroid cartilage; these data were consistent with the previously reported Literature [8, 13, 19]. Our study confirmed some difficulty in identifying the vocal cords in 14 male patients with hypertrophy of the thyroid cartilage without calcification. This difficulty was solved, thanks to adoption of a different acoustic window in lateral approach, as done by our investigator after a specific training in neck ultrasound. Therefore, the limit of this technique is the low confidence of many endocrine surgeons with ultrasound in their common clinical practice

and so the lack of the adequate skills in performing TLUS, that could potentially replace FFL in low-risk patients. The TLUS, in turn, is an operator-dependent method and has a not-standardized learning curve. Therefore, in many centers, the FFL is still used as standard of care for the preoperative assessment of the vocal cords motility, leading patients to undergo an invasive method, requesting a different specialist (otolaryngologist) and another outpatient appointment.

The current study showed that visualization of both vocal cords depended on patients' characteristics, especially sex. In fact, our work showed a statistically significant difference ($p < 0.001$) between males and females. It showed that all the 14 patients in whom there was a difficult identification were males with hypertrophy of the thyroid cartilage. A hypertrophy of the thyroid cartilage acts as an acoustic barrier in the visualization of the movement of the vocal cords and in these cases, the only solution is the lateral approach, which sacrifices the simultaneous display of both ropes [9, 22–24].

A BMI ≥ 25, related to an increase in subcutaneous fat and, therefore, to a greater distance between skin and thyroid, did not affect the visualization of the vocal cords (p-value 0.99). These data were consistent with literature [21, 22].

The learning curve of the procedure is not still standardized, but surely is directly linked to the physician ultrasonographic skills. Wong et al., reported an analysis on 80 patients undergone TLUS by a group of inexperienced ultrasound assessors, residents in surgery [14]. The authors concluded that the assessors became competent in TLUS after seven examinations and provided proficient and accurate vocal cords assessments after 40 examinations, attesting a short learning curve.

ATA guidelines suggest to submit to a preoperative FFL patients with a high risk of vocal cord paralysis (extracapsular thyroid carcinoma, large thyroid goiter, patients with voice changes and previous cervical surgery). Our data did not show a statistically significant difference between patients with benign disease and those with malignant diseases (p value 0.52). Nevertheless, it should not be neglected that in our series, patients with malignancies were staged as T1 and T2. The latter could be considered a limitation of the current study along with the performance of the procedure by a single physician, determining a questionable reproducibility of our results. In our series, in fact, the operator is the referral consultant for the neck US in all the participating centers and was the sole physician to perform all the procedures. Of course, as any US procedure, TLUS is strictly dependent on the operator skill. Further studies comparing TLUS with FL in a population with high-stage thyroid tumors and involving different operators are needed to achieve definitive results.

TLUS is a valid non-invasive and painless alternative method in the preoperative assessment of vocal cords for a selected population, such as pediatric patients, cardiopathic patients, patients who do not tolerate invasive exams, patients with no diagnosis or suspicion diagnosis of malignancy and patients who do not have voice alterations. It could save a high percentage of patients from FFL and at the same time could accurately select patients amenable of second level examinations. In our series, we reported extremely encouraging results with TLUS showing an assessability rate of over 96%, a sensitivity of 96.8%, a specificity of 95.6% in the identification of vocal cords alterations and a concordance between TLUS and FL of 95.7%. TLUS can be easily performed by the surgeon itself during the preoperative routine diagnostic ultrasound, lasts only 1–2 min, does not require another specialist, is cheap and does not require a dedicated instrumentation.

Author contributions All authors contributed significantly to the present research and reviewed the entire manuscript. GC: participated substantially in conception, design and execution of the study and in the analysis and interpretation of the data; also participated substantially in the drafting and editing of the manuscript. OC: participated substantially in conception, design and execution of the study and in the analysis and interpretation of the data; also participated substantially in the drafting and editing of the manuscript. RRM: participated substantially in conception, design and execution of the study and in the analysis and interpretation of the data. MDP: participated substantially in conception, design and execution of the study and in the analysis and interpretation of the data. RR: participated substantially in conception, design and execution of the study and in the analysis and interpretation of the data. GC: participated substantially in conception, design and execution of the study and in the analysis and interpretation of the data. AP: participated substantially in the drafting, revising and editing of the manuscript. LD: participated substantially in the drafting, revising and editing of the manuscript. MG: participated substantially in conception, design and execution of the study and in the analysis and interpretation of the data. GD: participated substantially in conception, design and execution of the study and in the analysis and interpretation of the data.

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Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. The datasets used and/or analyzed during the current study are available from the VII Division of General Surgery, Second University of Naples, Via Pansini 5 80131 Naples, on reasonable request.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Research involving human participants and/or animals All procedures performed in the study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent All patients gave written informed consent to publish.

Ethics approval and consent to participate The ethical committee of University of Campania "Luigi Vanvitelli" approved the study protocol (Number of protocol 333/2019).

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