Med. J. Cairo Univ., Vol. 87, No. 7, December: 4371-4377, 2019
www.medicaljournalofcairouniversity.net

Ultrasound Diagnostic Value in Assessment of Vocal Cord Mobility before Neck Surgery

HAYTHAM MOHAMED NASSER, M.D.* and MOHAMMED ALEEM, M.D.**

The Departments of Radiology and Otorhinolaryngology**, Faculty of Medicine, Ain Shams University*

Abstract

Background: The preoperative assessment of vocal cord mobility in patient scheduled for neck surgery is mandatory. The diagnostic approach differs from traditional ones as flexible fiberoptic, indirect laryngoscopy, to less tradition ones as CT and MRI.

Ultrasound is non invasive, safe, repeatable, bedside, non ionizing radiation dependent technique together with the advancement of technology providing high resolution real time images and short cine videos. This is hand to hand with good patient compliance for the technique.

Aim of Study: To evaluate the diagnostic value of ultrasound in the assessment of vocal cords mobility before neck surgeries.

Patients and Methods: This cross section study was carried out between October 2016 and November 2018 on 60 patients (25 males and 35 females) in Ain Shams University Hospitals. They were all scheduled for neck surgeries for different reasons. After taking full clinical history, complete head and neck examination, flexible fiberoptic and/or indirect laryngoscopy, patients underwent sonographic examination. Patients were divided into two groups. The first group (I) with no clinical symptoms or signs suggestive of vocal foldparalysis. The second group (II) with unilateral abductor vocal fold paralysis. The acquired static photos and dynamic cine videos were accurately examined to delineate various laryngeal structures and to assess interarytenoid distances and arytenoid cartilage mobility during full inspiration and during phonation.

Results: After identification of laryngeal structures, we could identify in recorded cine videos immobile arytenoids cartilage on the paralytic side during both inspiration and phonation with sensitivity (80%), specificity (90%), PPV (80%) and NPV (90%). Another important finding is noted that the percent of change in interarytenoid distances was much less in group II than in group I.

Conclusion: Preoperative ultrasound examination of vocal cord mobility proved to be valid identifying the various laryngeal structures with high potency in judging vocal cord mobility either by short real time cine videos or measuring interarytenoid distances. We recommend to consider laryngeal ultrasound as reliable imaging modality in preoperative assessment of vocal cord mobility prior to neck surgery.

Key Words: *Ultrasonography – Vocal cord paralysis – Laryngeal imaging – Airway.*

Correspondence to: Dr. Haytham Mohamed Nasser,
E-Mail: Hmnh1980@gmail.com

Introduction

MULTIPLE diagnostic approaches have been used to evaluate vocal cord mobility prior to neck surgery. Starting by through history and physical examination passing through traditional approaches as flexible fiberoptic, indirect laryngoscopy, less tradition ones as CT and MRI. There is always a need for more practical techniques which ideally should be minimally or non invasive, well tolerated with good patient compliance, safe, non dependent on ionizing radiation and with reliable results. Where the results should be accurate, reproducible and recordable for medico legality and future reference **[1]**.

Using traditional radiographic approaches as CT and MRI can provide accurate data as regards both true and false vocal cord yet the dependence on radiographic anatomical landmarks sometimes for precise visualization of the vocal folds may be very difficult. In additional to radiation exposure with CT and relative long exam duration in MRI with motion artifact caused by swallowing, respiration and patient mobility degrading image quality causing decreased diagnostic accuracy **[2]**.

Over- and under- diagnosis of vocal fold paralysis is quite common because of splinting of the larynx which may occur with a rigid laryngoscope; poor visualization due to supraglottic collapse; cricoarytenoid fixation and paradoxical vocal fold movements resulting from the Bernoulli effect of air flow through the glottis during respiration **[3]**.

Ultrasound technology refers to mechanical ultrasound waves with frequency beyond 20,000Hz. Frequencies used for medical use usually ranges from 2- 15MHz. US probe contain crystal having peso electric effect which acts as both transmitter and receiver. Where each cycle varies between generation of US waves and receiving echoes. Each type of tissue has different acoustic impedance with different ultrasound waves reflectivity. Ultrasound wave is reflected at the interface between tissues. Where bone reflects all waves and fluid facilitate waves transmission [4].

Preoperative routine neck ultrasound assessment is usually done as in goiter to identify type of goiter and extension, in laryngeal tumors to assess cervical LN metastasis. The promising results of ultrasound assessment of the vocal cord mobility make it beneficial to add it in the preoperative ultrasound assessment. US is superior on CT and MRI in assessing the mobility of vocal cords [5].

Laryngoscopy is considered the golden standard to evaluate vocal fold mobility preoperatively. As it can demonstrate a paralysis of the recurrent laryngeal nerve, as well as evaluation of anatomic or functional variations after previous neck or thoracic surgery. Yet it is not common practice for many endocrine surgery teams because it is time-consuming, imposes extra costs, and is in general, an unpleasant experience for some patients. Together with lacking the assessment of extra luminal causes of vocal cord paralysis [6].

Head and neck ultrasonography is a cost effective imaging tool that is currently used as an extension of patient physical examination. That is based on its safety (non invasive and non ionizing radiation dependent), repeatability, availability and good patient compliance (pain less and require no sedation). Together with accuracy comparable to laryngoscope which is the gold standard, especially in children [7].

Recently portable ultrasound devices became widely available with dramatic improvement of the imaging quality rendering to increased diagnostic accuracy. Availability, usability and mobility of the devices encourage bedside examination which is essential in non mobile patient and ICU patient [8].

Aim of this work:

Is to evaluate the validity of sonography as an imaging tool in identifying normal ranges and abnormalities of laryngeal dynamics and anatomic structures. Also to determine the optimal scanning technique in terms of transducer selection and orientation.

Subjects and Methods

During the period from October 2016 and November 2018 at Al-Demerdash Hospital and Ain Shams University Specialized Hospitals, 60 patients were enrolled in the cross section study (25 males and 35 females). Patients were scheduled for neck surgery for different causes all of them underwent either indirect laryngoscopy or fiberoptic to assess vocal cord mobility and results were compared to laryngeal ultrasound. Their ages ranged from 21 to 62 years. Patients were divided into two groups. The first group (30 patients) included patients with no clinical symptoms or signs suggestive of vocal fold paralysis or any laryngeal pathologies. The second group (30 patients) included patients with unilateral vocal fold paralysis (abductor type).

Inclusion criteria:

1- Patients scheduled for neck surgery.
2- Patients with unilateral vocal cord abductor paralysis (group 2).
3- No age predilection.
4- No sex predilection.

Exclusion criteria:

1- Patient with history of laryngeal surgery.
2- Any patient with bilateral vocal fold paralysis.
3- Any patient with unilateral adductor paralysis.
4- Any patient with laryngeal mass.

All included patients were subjected to the following after taking their written informed consent:

- Full detailed clinical and surgical history history taking.
- Thorough head and neck examination.
- Fibropticnasopharyngolaryngoscopic examination.
- Ultrasound examination.

The sonographic examination was done in the following order:

- All patients were asked to lie down in supine position with neck extended
- All were asked to expose their neck and upper chest.
- All patient were examined using linear 7-12MHz high-frequency ultrasound transducer.

• The larynx and was scanned in different planes:
  - Transversely mid line (the transverse view).
  - Transverse oblique (oblique transverse view).

Initially various laryngeal structures are systemically identified in the previously mentioned planes hyoid bone, laryngeal cartilages, vocal folds, pre-epiglottic space, paraglottic space, thyroid gland, subglottic region, neck vessels and neck nodes.

Patients were asked to do full inspiration and full expiration (phonation). Static images and real time cine videos were acquired and edited using built in software in ultrasound device (Logiq P5). To obtain other static image and get measurements required.

The acquired photo and cine movies are analyzed and processed using built software in the ultrasound device (logiq P5) where the interarytenoid distance is measured by measuring the distance between the hyperechoic arytenoids cartilages which is seen in the transverse oblique (caudal oblique). In addition to assessing the mobility of each cord separately visually on real time ultrasound and documented by cine videos.

Results

Acquired images and cine videos are analyzed first to identify anatomy of different laryngeal structures (Figs. 1,2), visual observation of vocal fold and arytenoid cartilage mobility, identify the affected side in case of unilateral paralysis and sensitivity and specificity of laryngeal US in assessment vocal cord paralysis (Tables 1,2), then Built in software is used to calculate interarytenoid distance during phonation (length min) and during respiration (length max) (Fig. 4), (Table 3).

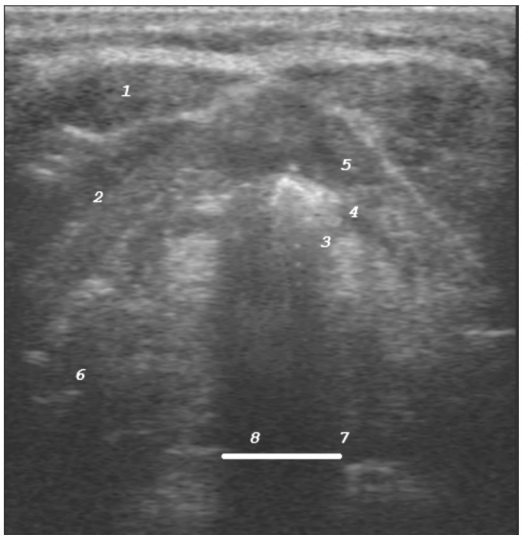

Fig. (1): An ultrasound image of a male patient 30 years old with no signs or symptoms of vocal cord paralysis showing normal anatomy of different laryngeal structures: 1-Strap muscles, 2-Outer thyroid plate, 3-Ventricular folds, 4-Paraglottic space, 5-Inner thyroid plate, 6-Pyriform sinus, 7-Arytenoid cartilage, 8-Inter-arytenoid distance.

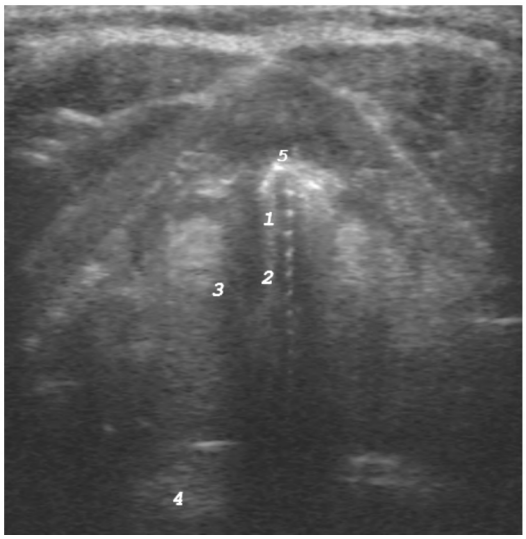

Fig. (2): Another ultrasound image of the same patients showing normal anatomy of different laryngeal structures: 1-Anterior part of vibrating vocal fold, 2-Posterior part of vibrating vocal fold, 3-Thyroarytenoid muscle, 4-Posterior cricoid plate, 5-Anterior commissure.

Table (1): Showing the results of visual analysis of cine videos.

	Known paralyzed	Known normal	
	No. (%)	No. (%)	
Laryngeal US:			
Positive	24 (80%)	3 (20%)	27
Negative	6 (10.0%)	27 (90%)	33
	30	30	60

Table (2): Showing sensitivity and specificity of laryngeal ultrasound in diagnosis of unilateral vocal cord paralysis.

	Sensitivity	Specificity	PPV	NPV	Accuracy
Laryngeal US	80%	90%	80%	90%	85%

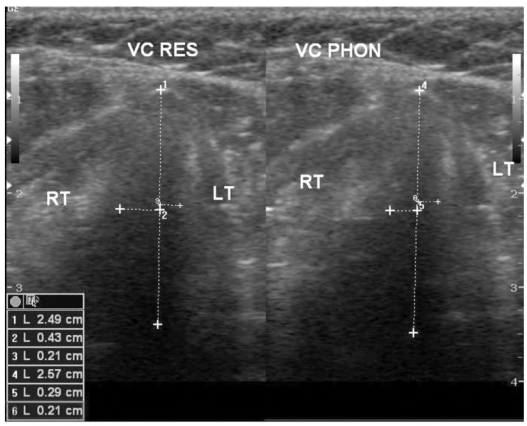

Fig. (3): Another ultrasound image of 32 years old female with clinical signs and symptoms of vocal cord paralysis ultrasound images shows left vocal cord abductor paralysis during both (a) Inspiration the right cord is abducted and the left cord is adducted. (b) During phonation where both cords are adducted yet the left one is nearer to the mid (unopposed adductor).

Analyzed images showed that the mean length min in patients with normal cord mobility was 0.43±0.18cm. The mean length of length max showed to be 0.99±0.23cm. Yet in group II with unilateral cord paralysis mean length min was 0.39±0.21cm. The mean length max to be 0.78± 0.3 1cm. (Table 1). Also, the percent of change in length was much less in group 2 (unilateral abductor vocal cord paralysis) than group 1 (Fig. 4). (Table 3).

Table (3): Shows mean length min, mean length max and percent of change in length in both groups.

	Control (Gr1)		Vocal Fold Paralysis (Gr2)		*p*	Sig.
	Mean	±SD	Mean	±SD		
Length min.	0.43	0.18	0.39	0.21	0.036	S
Length max.	0.99	0.23	0.78	0.31	0.381	NS
Length % of change	57.57	14.41	48.21	17.17	0.006	HS

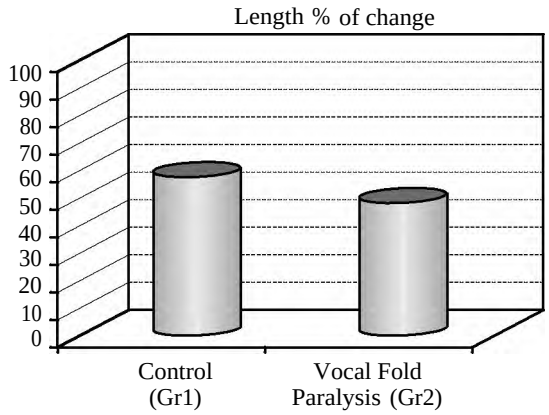

Fig. (4): Shows percent of change in length is less in group II with vocal cord paralysis.

Another finding after data analysis is that the age is significantly correlated with the length min. i.e.: The more the age, the less the length min. (r=0.494). (Table 4).

Table (4): Shows percent of change in length with aging.

	Length min	Length max.	Length % of change
Age:			
r	0.494	0.162	–0.561
p	0.044	0.534	0.019
Sig.	S	NS	S

Discussion

Great thanks for the pioneer Manuel Garcia (1805-1906) who was the first to perform laryngoscope in vivo. Which was then followed by gradual upgrade in the basic approach of examining the pharynx and larynx, this upgrade was greatly aided by the dramatic improve in the available technology **[9]**.

Starting with indirect mirror examination which has some limitations including archiving and documentation difficulties in addition to subjective difficulties in reliably recognizing side of lesion and learning curve in acquiring maintaining skills with a significant failure rate which mandates direct endoscopy prior to the era of readily available flexible endoscopy.

Where endoscopic assessment, either with a rigid or flexible laryngoscope remain the gold standard which has replaced mirrors due multiple reasons including better resolution and higher sensitivity. In addition to better documentation based on Video recording which in term have many advantages including the displayed anatomy is magnified, Recognition of the anatomical structures and anomalies is easier, and manipulation of airway devices is facilitated. All this advantages made video techniques the optimum method for teaching. Although there is no series complication caused by the use of fiberopticlaryngoscope yet it still lakes the diagnosis of extra luminal causes (eg. Thyroid, lymphnodes etc.)and hidden laryngeal spaces as paraglottic and pre epiglotic. In addition to decreased patient compliance due to discomfort which occur with variable degrees and occasional epistaxis **[10]**.

With the increasing need for the diagnosis of extra luminal cases of vocal cord paralysis cross sectional imaging (CT and MRI) is increasingly used to assess the vocal cord with established

features as in cases recurrent laryngeal nerve paralysis which may be explained by atrophy of the thyroarytenoid muscle and an enlarged ventricle, ipsilateral enlargement of the pyriform sinus, para median position, decreased size and/or fatty infiltration of the true vocal cord **[11]**.

Yet cross section imagining (CT & MRI) was still deficient in real time assessment of vocal cold mobility in addition to respiratory movement which will affect image quality, other considerations such as uncooperative patients and children which may require Sedation other disadvantages in CT is radiation dose delivered and in MRI time consumed which increase the possibility of motion artifact together With other limitation such as claustrophobia and some non MRI compatible devices eg. Cochlear implants, cardiac pacemaker **[12]**.

In 1984, Shawker and others used real-time ultrasound to assess the motion of tongue, hyoid bone and larynx during swallowing in ten normal subjects **[13]**.

Nowadays laryngeal us has become a power full dependable bed side non invasive more or less ideal diagnostic tool For the assessment of vocal cold mobility pre operatively not only for good tissue differentiation but also for proving real time dynamic vocal cord evaluation with records. Another essential advantage that must be put in consideration, is diagnosis of vocal cord paralysis in pediatric. First, it is safe (non radiation dependent, painless and non-invasive) and so it's well-tolerated by infants and children. The presence of portable US devices made it possible to do the US bedside or in the operating room. Second, judgment of vocal fold immobility is reliable. Third, laryngeal US is recordable where we can calculat the angles of glottic structures in normal and paralyzed children **[6]**.

The aim of our study is to evaluate the validity of sonography as an imaging tool in identifying normal ranges and abnormalities of laryngeal dynamics and anatomic structures and to determine the optimal scanning technique in terms of transducer selection and orientation. We managed to achieve these goals by: (1) Anatomical identification of laryngeal structures, (2) Visual judgment of vocal cord and arytenoids cartilage movement, (3) Measurements of interarytenoid distances, (4) Calculating the percent of change in length min and length max in individuals with normal cord mobility and in patients with unilateral vocal fold abductor paralysis, (5) Assessment of age variations in normal individual.

Going through our results, we concluded that laryngeal US is a reliable technique to judge vocal mobility before neck surgery with sensitivity(80%), specificity (90%), PPV (80%) and NPV (90%). This results were comparable with another study by done by, Wong et al,2013, China when assessing the sensitivity, specificity, positive predictive value, and negative predictive value of laryngeal US which was 93.3%, 97.8%, 77.8%, and 99.4% respectively **[14]**.

Miguel et al., 2017, spain also agreed with our study on laryngeal US in assessing vocal cord for mobility post thyroidectomy, with sensitivity (93.3%), specificity (96.1%), and predictive value (positive, 82.3; negative, 98.6) **[15]**.

Going through our analysis, we found that interarytenoid distance vary obviously between the phonation and inspiration stages, being greater in respiration more than during phonation with a mean percent of change in interarytenoid length of 57.57± 14.41%. We also found that the interarytenoid distances during phonation to be lower in unilateral cord abductor paralysis patients with mean value of 0.39±0.21cm with statistically significant difference than normal group 0.43 ±0.18. This finding is due to the fact that in case of unilateral abductor paralysis the vocal cord is fixed near mid line due to unopposed adductor effect, so the distance will be less than the control group. Also the percent of change in length was less in group II (unilateral vocal cord palsy) than group I. This could be attributed to limited mobility of the paralyzed vocal cord.

By studying the effect of age on laryngeal measurements. We found that, there is a statistically significant inverse correlation between age and the change in length which was more evident in males (r=–0.49), i.e.: the more the age, the less the change in length between phonation and respiration. This could be attributed to many possible factors such as ossification of the laryngeal skeleton, reduced muscle volume with a preferential loss of type I (slow contracting) muscle fibres, arthritic changes in the cricothyroid and cricoarytenoid joints, an increase in density of collagen deposition and decreased hyaluronic acid in the lamina propria, and atrophic changes in the epithelial layer and last but not least, the gradual diminution of lung capacity.

We faced multiple limitations in our study including non fitting surface of the linear probe to neck contour. Another limitation evolved during our work, which is with concurrent movement of

the thyroid cartilage, it is difficult to stabilize the transducer. Our patients were instructed not to hold their breath and avoid swallowing movement. Usually vocal cord movement can be plainly observed during quiet respiration. Laryngeal cartilage calcification can also lead to variable imaging and poor visualization of intra laryngeal structure such as the vocal cords and arytenoid cartilage.

Borel et al., 2016, France also agreed with US were they reported non visualization of the vocal folds occurred in 27.2% of cases which was attributed to thyroid cartilage calcification(more in male gender and with age), weight and short neck **[16]**.

Conclusion:

Laryngeal ultrasound proved to a valid technique to identifying laryngeal structures, measures various distances inside the larynx and diagnose vocal cord paralysis. We recommend to consider laryngeal ultrasound as a reliable imaging modality to judge vocal cord mobility before neck surgery.

References

1- FRIEDMAN E.: Role of Ultrasound in the Assessment of Vocal Cord Function in Infants and Children. Annals of Otology, Rhinology & Laryngology, 106 (3): pp. 199-209, 1997.

2- CHO W., HONG J. and PARK H.: Real-Time Ultrasonographic Assessment of True Vocal Fold Length in Professional Singers. Journal of Voice, 26 (6): pp.819.e1-819.e6, 2012.

3- VATS A., WORLEY G., de BRUYN R., PORTER H., ALBERT D. and BAILEY C.: Laryngeal ultrasound to assess vocal fold paralysis in children. The Journal of Laryngology & Otology, 118 (6): pp. 429-431, 2004.

4- KRISTENSEN M.: Ultrasonography in the management of the airway. Acta Anaesthesiologica Scandinavica, 55 (10): pp. 1155-1173, 2011.

5- HU Q., LUO F., ZHU S., ZHANG Z., MAO Y. and HUI GUAN X.: Staging of laryngeal carcinoma: Comparison of high-frequency sonography and contrast-enhanced computed tomography. Clinical Radiology, 67 (2): pp. 140-147, 2012.

6- DEDECJUS M., ADAMCZEWSKI Z., BRZEZIN´SKI J. and LEWIN´SKI A.: Real-time, high-resolution ultrasonography of the vocal folds-a prospective pilot study in patients before and after thyroidectomy. Langenbeck's Archives of Surgery, 395 (7): pp. 859-864, 2010.

7- HOLTEL M.: Emerging Technology in Head and Neck Ultrasonography. Ultrasound Clinics, 7 (2): pp. 239-244, 2012.

8- SNIEZEK J.: Head and Neck Ultrasound: Why Now?. Otolaryngologic Clinics of North America, 43 (6): pp. 1143-1147, 2010.

9- MERATI A. and RIEDER A.: Normal endoscopic anatomy of the pharynxand larynx. The American Journal of Medicine, 115 (3): pp. 10-14, 2003.

10- KAPLAN M., WARD D. and BERCI G.: A new video laryngoscope-an aid to intubation and teaching. Journal of Clinical Anesthesia, 14 (8): pp. 620-626, 2002.

11- BECKER M., ZBÄREN P., CASSELMAN J., KOHLER R., DULGUEROV P. and BECKER C.: Neoplastic Invasion of Laryngeal Cartilage: Reassessment of Criteria for Diagnosis at MR Imaging. Radiology, 249 (2): pp. 551-559, 2008.

12- WANG L., ZHU Q., MA T., LI J., HU R., RONG X., XU W. and WANG Z.: Value of ultrasonography in diagnosis of pediatric vocal fold paralysis. International Journal of Pediatric Otorhinolaryngology, 75 (9): pp. 1186-1190, 2011.

13- SHAWKER T., SONIES B., HALL T. and BAUM B.: Ultrasound Analysis of Tongue, Hyoid, and Larynx Activity During Swallowing. Investigative Radiology, 19 (2): pp. 82-86, 1984.

14- WONG K.P., LANG B.H., NG S.H., CHEUNG C.Y., CHAN C.T. and LO C.Y.: A prospective assessor-blind evaluation of surgeons-performed transcutaneous laryngeal ultrasonography in vocal cord examination before and after thyroidectomy. Surgery, 154 (6): 1158-1164, 2013.

15- De MIGUEL M., PELAEZ E.M., CAUBET E., GONZALEZ O., VELASCO M. and RIGUAL L.: Accuracy of transcutaneous laryngeal ultrasound for detecting vocal cord paralysis in the immediate postoperative period after total thyroidectomy. Minerva Anestesiol., 83 (12): 1239-1247, 2017.

16- BOREL F., DELEMAZURE A.S., ESPITALIER F., SPIERS A., MIRALLIE E. and BLANCHARD C.: Transcutaneous ultrasonography in early postoperative diagnosis of vocal cord palsy after total thyroidectomy. World J. Surg., 40 (3): 665-671, 2016.

الدور التشخيصى للموجات فوق الصوتية فى تقييم حركة الأحبال الصوتية قبل جراحة الرقبة

الخلفية: أن تقييم حركة الأحبال الصوتية للمريض المقرر له إجراء جراحة فى الرقبة هو شىء إلزامى. يختلف النهج التشخيصى لذلك أما الطرق التقليدية مثل منظار الحنجرة المرن والمنظار الغير مباشر أو الطرق الأحدث مثل التصوير بالأشعة المقطعية والرنين المغناطيسى. أما الموجات فوق الصوتية فلها مزايا كثيرة منها كونها آمنة، قابلة للتكرار، بجانب السرير لا يتم التعرض فيها للأشعاعة الأيونى مع التقدم التكنولوجيا تتوفر صور عالية الدقة وأشرطة فيديو قصيرة. هذا جنباً إلى جنب مع إمتثالا لمريض الجيد لهذه التقنية.

الهدف: معرفة القيمة التشخيصية للموجات فوق الصوتية فى تقييم حركة الأحبال الصوتية قبل جراحات الرقبة.

الطرق: أجريت هذه الدراسة المقطعية بين أكتوبر ٢٠١٦ ونوفمبر ٢٠١٨ على ٦٠ مريضاً فى مستشفيات جامعة عين شمس. تم تحديد موعد لهم جميعاً لإجراء جراحات الرقبة لأسباب مختلفة. بعد معرفة التاريخ المرضى بالكامل، فحص الرأس والعنق الكامل، فحص الحنجرة بالمنظار المرن / أو غير المباشر، خضع المرضى لفحص بالموجات فوق الصوتية. تم تقسيم المرضى إلى مجموعتين. المجموعة الأولى مع عدم وجود أعراض أو علامات سريرية توحى بشلل بالحبل الصوتى. المجموعة الثانية يوجد علامات لوجود شلل بالحبل الصوتى من جانب واحد. تم فحص الصور الثابتة المكتسبة ومقاطع الفيديو السينمائية الديناميكية بدقة لتحديد الهياكل الغضروفية للحنجرة وتقييم مسافات ما بين الغضروف الطرجهالى بالجهتين وحركة الثنايا الصوتية أثناء النفس والكلام.

النتائج: بعد تحديد ووصف غضاريف الحنجرة، وجدنا أن النسبة المئوية للتغير فى المسافات ما بين الغضروف الطرجهالى بالجهتين كانت أقل بكثير فى المجموعة الثانية من المجموعة الأولى. ولوحظ وجود إكتشاف مهم اخر فى مقاطع الفيديو السينمائية المسجلة التى تظهر غضروف الطرجهالى غير متحرك على الجانب المشلول أثناء كل من النفس والكلام.

الاستنتاجات: أثبت الفحص بالموجات فوق الصوتية قبل الجراحة لحركة الحبل الصوتى أنه صالح لتعريف مختلف الهياكل الغضروفية للحنجرة مع فعالية عالية فى الحكم على تحرك الحبل الصوتى إما عن طريق مقاطع فيديو سينمائية قصيرة فى الوقت الحقيقى أو قياس المسافات ما بين الغضروف الطرجهالى بالجهتين. نوصى أن نعتبر الموجات فوق الصوتية الحنجرية كطريقة تصوير موثوقة فى التقييم لحركة الحبل الصوتى قبل جراحة الرقبة.