ULTRASOUND ASSESSMENT OF VOCAL FOLD PARESIS: A CORRELATION CASE SERIES WITH FLEXIBLE FIBEROPTIC LARYNGOSCOPY AND ADDING THE THIRD DIMENSION (3-D) TO VOCAL FOLD MOBILITY ASSESSMENT

Randall J. Amis*, Deepak Gupta*, Jayme R. Dowdall**, Arvind Srirajakalindini* and Adam Folbe**

Abstract

Background: Perioperative examination of the vocal folds with flexible fiberoptic laryngoscopy is not always feasible. Prior studies suggest vocal fold ultrasound may provide a useful screening tool, however, correlation to laryngoscopic findings is necessary. The purpose of the case series was to validate vocal fold ultrasound in the adult population and to correlate the ultrasound findings to the assessment provided by flexible fiberoptic laryngoscopy.

Materials and Methods: This IRB approved study accrued sixteen patients. Vocal fold ultrasound performed by the anesthesiologist was correlated with the laryngoscopy performed by the otolaryngologist.

Results: Assessment of vocal fold motion was congruent in thirteen patients with normal vocal fold mobility; however, there was discordance between the findings in three patients.

Conclusion: Vocal fold ultrasound may be useful to screen for vocal fold motion abnormalities in the adult population. Abnormal findings on vocal fold ultrasound should be confirmed with subsequent laryngoscopy.

Introduction

Studies trying to ultrasonically assess the vocal folds has been published in the past[1-2]. Per earlier results, ultrasound supplemented the diagnostic modality of flexible fiberoptic laryngoscopy in assessing pediatric benign vocal fold pathologies[3-4]. Additionally, the ultrasound was deemed highly accurate, reliable, radiation-free and improved patient tolerance for vocal fold mobility assessment[5]. Despite the ossified thyroid cartilage interfering vocal folds assessment in 16% cases, ultrasound depiction of laryngeal anatomy is still adequate[6]. Vats et al[7] reported 81% concordance between ultrasonic and endoscopic findings in vocal folds of young patients. The rates were higher in infants. However, there has been some conflicting report in animal studies recently

* Department of Anesthesiology, Wayne State University, UHC 4J, Room 30, 4201 St. Antoine, Detroit, MI 48201.
** Department of Otolaryngology-Head and Neck Surgery, Wayne State University, 5E UHC, 4201 St. Antoine, Detroit, MI 48201.
Corresponding author: Randall J. Amis, Staff Anesthesiologist, Box No. 162, 3990 John R, Detroit, Michigan 48201, United States, Ph: 1-313-745-7233, Fax: 1-313-993-3889. E-mail: ydnar6@yahoo.com

that ultrasound may not be as effective as the direct laryngeal visualization[8].

The purpose of the study was to correlate the ultrasound assessment and the laryngoscopy view to assess vocal fold motion in adults.

Methods

After institutional review board approval for the study protocol, the patients were enrolled in the study after obtaining the written informed consent. Adults aged 18-80 years of age with known vocal fold motion abnormalities or perioperative patients undergoing surgery presenting risk to the recurrent laryngeal nerve were recruited for this prospective, double-blind correlational study. Patients with head and neck anatomical pathologies that may have unpredictable effect on the ultrasound assessment of the vocal folds were excluded.

Ultrasound: The ultrasonic view of the airway was assessed with high frequency linear probe by the anesthesiologist. The patients were asked to engage in active maximal head tilt-chin lift position. The probe was placed in the midline of the submandibular region. Without changing the position of the probe, the linear array of the ultrasound probe was rotated in the transverse planes from cephalad to caudal or plane "A" (a coronal plane to see the mouth opening) to plane "G" (an oblique transverse plane that bisects the epiglottis and posterior most part of vocal folds with arytenoids in one 2-dimensional view) (Fig. 1). The further rotation of the ultrasound array was ceased at the first simultaneous visualization (in the same ultrasonic frame) of the epiglottis and posterior most part of vocal folds with arytenoids (Fig. 2). The patient was then asked to phonate to assess vocal fold motion in two directions: latero-medial and supero-inferior. Following data was assessed from the ultrasonic image:

1. The alignment of non-phonating folds in relation to the midpoint between them to assess any supero-inferior pre-existing misalignment

2. The latero-medial and/or supero-inferior movements of the vocal folds during phonation in relation to the midpoint between them to appreciate the discordance in the vocal fold mobility secondary to impending paresis and/or established paresis. If we noted a supero-medial pull on the vocal folds, we described it as "tenting" to describe that the examination is abnormal as it was difficult to use familiar descriptors due to the unfamiliar angle.

Laryngoscopy: Flexible fiberoptic laryngoscopy was performed. Patients were assessed for vocal fold motion.

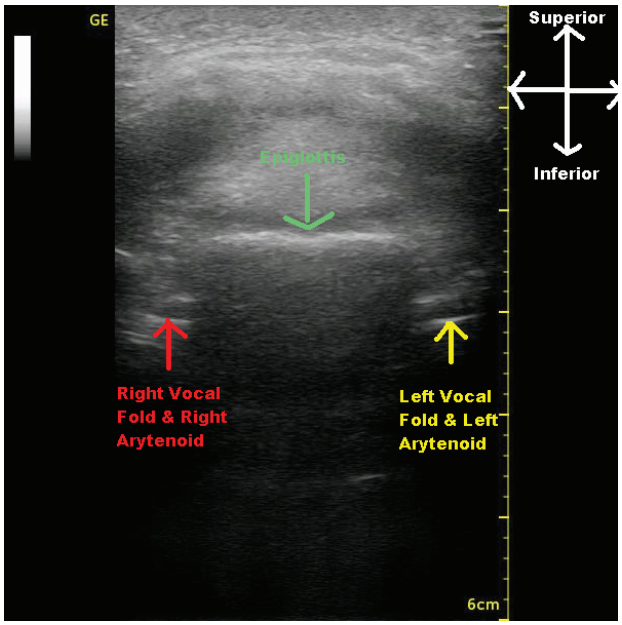
Results

On comparing the ultrasound and fiberoptic laryngoscopy assessment of vocal fold motion, congruent findings were obtained in thirteen of the sixteen study patients.

In three patients there was discordance between the findings (Table 1). Overall the sensitivity of the

Fig. 1
Ultrasonic Planes (Planes A-G) for the Ultrasound Assessment of the Vocal Folds

Fig. 2
Ultrasonic View in the Plane G for assessment of the Vocal Folds Mobility



ultrasound assessment to detect vocal fold motion abnormality was 71%; however the specificity of the ultrasound assessment to detect normal vocal fold motion was 89% (Table 2). The positive predictive value of the ultrasound assessment of the vocal folds was 83% and the negative predictive value was 80%.

Discussion

Thirteen of sixteen patients had congruent examinations in the prospective double blind correlational study. Three patients did not have congruent examinations: two of these three patients had undergone thyroidectomy and the third patient was status-post injection laryngoplasty for idiopathic paresis (Injection laryngoplasty may have contributed to unclear results). The anesthesiologist (ultrasonographer) when noted a supero-medial difference in vocal fold level described the phenomenon as "vocal fold tenting". While the ultrasonographer was able to describe the vocal fold examination as abnormal, it was difficult to use familiar descriptors for this as "vocal fold tenting" due to the unfamiliar supero-medial angle.

Flexible fiberoptic laryngoscopy is a useful pre-operative assessment, especially in patients undergoing

Table 1
Patient Findings of Ultrasound Assessment of Vocal Folds compared with Fiberoptic Laryngoscope Assessment of Vocal Folds

Table 1	Patient Care Setting	Reason for Laryngoscopy	Ultrasonographic Vocal Folds Findings	Fiberoptic Laryngoscopic Vocal Folds Findings
Patient 1	Clinic	Odynophagia	Equal Mobility	Equal Mobility
Patient 2	Clinic	s/p Thyroidectomy	Left Cord Paresis	Left Cord Paresis
Patient 3	Floor	s/p Thyroidectomy	Left Cord Tenting	Equal Mobility
Patient 4	Floor	s/p Thyroidectomy	Equal Mobility	Right Cord Paresis
Patient 5	Floor	s/p Thyroidectomy	Equal Mobility	Equal Mobility
Patient 6	Operating Room	s/p Esophagectomy	Equal Mobility	Equal Mobility
Patient 7	Operating Room	s/p Thoracotomy	Equal Mobility	Equal Mobility
Patient 8	Operating Room	s/p Thoracotomy	Equal Mobility	Equal Mobility
Patient 9	Floor	s/p Thyroidectomy	Left Cord Tenting	Left Cord Paresis
Patient 10	Operating Room	s/p Anterior Cervical Dissectomy and Fusion	Cranial Tilting of Left Vocal Cord	Cranial Tilting of Left Vocal Cord
Patient 11	Floor	s/p Anterior Cervical Dissectomy and Fusion	Left Cord Paresis	Left Cord Paresis
Patient 12	Floor	s/p Thoracotomy	Left Cord Paresis	Left Cord Paresis
Patient 13	Clinic	Vocal Cord Paresis	Equal Mobility	Right Cord Paresis
Patient 14	Clinic	Gastroesophageal Reflux Disease	Equal Mobility	Equal Mobility
Patient 15	Clinic	s/p Anterior Cervical Dissectomy and Fusion	Equal Mobility	Equal Mobility
Patient 16	Clinic	s/p Anterior Cervical Dissectomy and Fusion	Equal Mobility	Equal Mobility

Table 2
Statistical Measures of the Comparative Ultrasound Assessment and Fiberoptic Laryngoscope Assessment of Vocal Folds

Table 2	Ultrasound Assessment: Impaired Vocal Folds Mobility	Ultrasound Assessment: Normal Vocal Folds Mobility	Total	
Fiberoptic Laryngoscopy Assessment: Impaired Vocal Folds Mobility	5	2	7	Sensitivity: 5/7*100 = 71%
Fiberoptic Laryngoscopy Assessment: Normal Vocal Folds Mobility	1	8	9	Specificity: 8/9*100 = 89%
Total	6	10	16	
	Positive Predictive Value: 5/6*100 = 83%	Negative Predictive Value: 8/10*100 = 80%		

procedures which may place patients at risk of recurrent laryngeal nerve injury and subsequent vocal fold paresis. Common procedures including thyroidectomy, carotid endarterectomy, anterior approach to cervical spine surgery and thoracic procedures have been known to result in vocal fold paralysis. In addition, intubation trauma and the use of laryngeal mask airway has also been associated with vocal fold paralysis[9]. The gold standard examination for vocal fold assessment is flexible fiberoptic laryngoscopy. However, it is not always feasible to examine patients pre-operatively in the office for an otolaryngology assessment.

The majority of the literature has focused on the use of ultrasound in children because the prior researchers found it difficult to see through the calcified thyroid cartilage in the adults; however with the ultrasound view that we have found in the oblique G plane (Fig. 1), we have been able to bypass the thyroid cartilage altogether from the ultrasound view in the adult population that we investigated. Additionally our limited evidence directs to the possible future role of the ultrasound in oblique G plane as adding the third dimension (3-D) as Supero-Inferior Dimension (Cranio-Caudal) to the vocal fold mobility assessment by the 2-D flexible fiberoptic laryngoscopy (Latero-Medial Dimension and Anterio-Posterior Dimension). This addition of the third dimension by ultrasound was based on the observation in the peri-operative patients during our investigation wherein we found that in immediate post-operative period, the impending vocal fold paresis was observed by the ultrasonographer as the supero-medial vocal fold tenting and in delayed post-operative period, the established vocal fold paresis was observed by the ultrasonographer as the infero-medial lax paretic vocal fold.

We acknowledge limitations to the study. The linear transducers or even convex curved transducers does not conform to the neck anatomy and this may contribute to limiting views. The answer to this technical issues may be resolved by the development of concave curve high frequency transducer for adequately maintained contact between the probe and skin surface; this concave curve ultrasound probe may be essential to establish the ultrasound assessment of the airway and airway-related anatomical structures as standard of care. Additional limitation of the ultrasound examination is that the air-mucosa interface is noted as having a hyperechoic linear appearance which is sometimes difficult to appreciate and differentiate. Moreover, sensitivity-specificity ranging from 71-89% may underline the fact that ultrasound assessment for vocal folds may be a better modality for ruling out the vocal fold paresis (specificity 89%) than for screening vocal fold paresis (sensitivity 71%) that will require confirmation with flexible fiberoptic laryngoscopy. Finally, the results are preliminary due to the small sample size of the case series.

Conclusion

Ultrasound imaging is a safe modality wherein soft tissues can be visualized and identified. The external technique is non-invasive and minimally uncomfortable for the patient with no major sterilization concerns. The major drawback of the external technique is the difficulty in maintaining good probe-skin contact over an uneven and curved surface. However, the images of the larynx can be optimized by placing the probe under-the-chin on-the-skin (external suprathyroid ultrasonic view) and gradually tilting the probe upwards with ultrasound array pointing caudally. The vocal folds are readily visualized with this external suprathyroid ultrasonic view (Plane G) for obtaining ultrasound plane of the posterior most part of vocal folds with arytenoids. Vocal fold mobility is readily visualized with appreciable correlation between ultrasound and flexible fiberoptic laryngoscopy assessment of vocal folds.

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