*The Laryngoscope*


# Laryngeal Ultrasound and Pediatric Vocal Fold Nodules

Julina Ongkasuwan, MD; Danielle Devore, CCC-SLP; Sarah Hollas, CCC-SLP;
Jeremy Jones, MD; Brandon Tran, MD

**Objectives/Hypothesis:** The term vocal fold nodules refers to bilateral thickening of the membranous folds with minimal impairment of the vibratory properties of the mucosa. Nodules are thought to be related to repetitive mechanical stress, associated with voice use patterns. Diagnosis is typically made in the office via either rigid or flexible laryngeal stroboscopy. Depending on the individual child, obtaining an optimal view of the larynx can be difficult if not impossible. Recent advances in high-frequency ultrasonography allows for transcervical examination of laryngeal structures. The goal of this project was to determine if laryngeal ultrasound (LUS) can be used to identify vocal fold nodules in dysphonic children.

**Study Design:** Prospective case-control study in which the patient acted as his or her own control.

**Methods:** Forty-six pediatric patients were recruited for participation in this study; the mean age was 4.8 years. Twenty-three did not have any vocal fold lesions and 23 had a diagnosis of vocal fold nodules on laryngeal stroboscopy. Recorded LUSs were reviewed by two pediatric radiologists who were blinded to the nodule status.

**Results:** There was substantial inter-rater agreement ($\kappa$ = 0.70, 95% confidence interval [CI]: 0.50-0.89) between the two radiologists regarding the presence of nodules. There was also substantial agreement ($\kappa$ = 0.87, 95% CI: 0.72-1) between LUS and laryngeal stroboscopy. Sensitivity of LUS was 100% (95% CI: 85%-100%) and specificity was 87% (95% CI: 66%-97%).

**Conclusions:** LUS can be used to identify vocal fold nodules in children with substantial agreement with laryngeal stroboscopy.

**Key Words:** Pediatric airway, voice, dysphonia, vocal fold nodules, laryngeal ultrasound.

**Level of Evidence:** 3b

***Laryngoscope*, 00:000–000, 2016**

## INTRODUCTION

The term vocal fold nodules refers to bilateral thickening of the membranous folds with minimal impairment of the vibratory properties of the mucosa.[1] Diagnosis is typically made in the office via either rigid or flexible laryngeal stroboscopy. Depending on the individual child, obtaining an optimal view of the larynx can be difficult if not impossible. The reported incidence of vocal fold nodules in school age children is 17% to 30%, with reported resolution in most cases by puberty.[2] Although the probability of spontaneous resolution is reassuring, in the interim, children with voice disorders can suffer from repeated voice loss, are often seen as more aggressive, and are viewed more negatively than their peers.[3] Traditionally, conservative management has been recommended for these lesions, although voice hygiene approaches, voice therapy techniques, and surgery have also been advocated.[4]

In both adults and infants, flexible nasolaryngoscopy (FNL), with or without strobe, can be uncomfortable and cause statistically significant changes in heart rate, blood pressure, and oxygen saturation.[5,6] In addition, 25% of adults undergoing FNL have reported gagging, and 10% have dyspnea with the procedure.[7] For young children, FNL often requires two or more adults to restrain the child. In some cooperative children, rigid transoral 70° stroboscopy may be an option.[8–12] However, there remains a group of children whose larynges cannot be examined in the office.

Laryngeal ultrasound (LUS) has been used to identify vocal fold mobility in neonates and children with much less physiologic impact compared to FNL.[6] A few small studies in both adults and children have attempted to use LUS for the identification of a variety of vocal fold lesions with limited success.[13–17] The difficulty appears to be resolving superficial lesions at the air–soft tissue interface. Both Rubin et al. (5–10 MHz probes, 29 patients) and Sirikci et al. (5 MHz probe, 14 patients) examined a heterogeneous group of adult patients and found LUS helpful in identifying lesions greater than 2 mm in size that project into the lumen.[13,14] In the case of sessile lesions, they could only

From the Department of Otolaryngology–Head and Neck Surgery (J.O.), Baylor College of Medicine/Texas Children's Hospital, Houston, Texas; Department of Speech Pathology (D.D., S.H.), Texas Children's Hospital, Houston, Texas; Department of Pediatric Radiology (J.J., B.T.), Baylor College of Medicine/Texas Children's Hospital, Houston, Texas, U.S.A.

Editor's Note: This Manuscript was accepted for publication June 27, 2016.

This work was conducted at Texas Children's Hospital.

Poster presentation at the American Laryngological Association Annual Meeting, Chicago, Illinois, U.S.A., May 18–19, 2016.

This work was funded by a Texas Children's Hospital Department of Surgery seed grant.

The authors have no other funding, financial relationships, or conflicts of interest to disclose.

Send correspondence to Julina Ongkasuwan, MD, 6701 Fannin, Suite 640, Houston, TX 77030. E-mail: julinao@bcm.edu

**DOI: 10.1002/lary.26209**

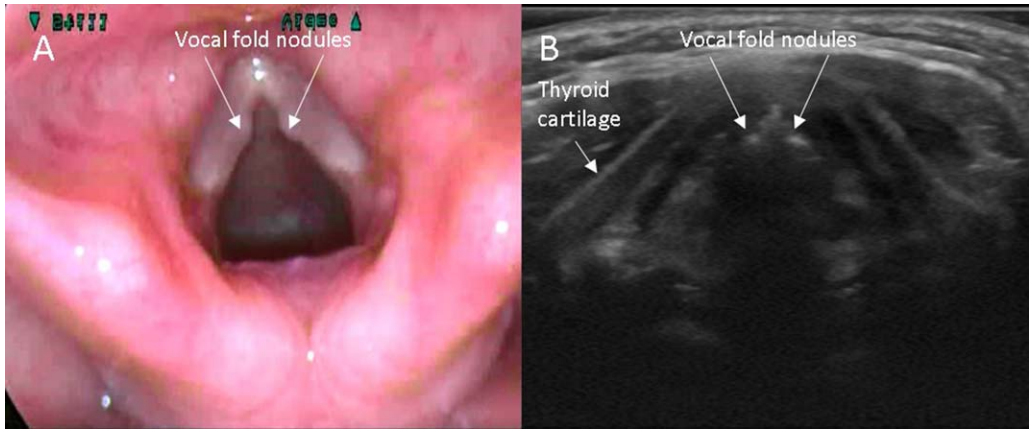


Fig. 1. (A) Vocal fold nodules on laryngoscopy. (B) Vocal fold nodules on ultrasound. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

be identified if the echogenicity differed from the surrounding vocal fold.

Regarding LUS and pediatric lesions, in 2009, Bisetti et al. published a series of 16 children, mean age of 7.5 years, with nodules, cysts, and papilloma diagnosed on FNL.[16] They reported that all the lesions could be seen on LUS, but did not specify if they could be specifically identified. Bryson et al. used ultrasound to evaluate eight patients, mean age 10.25 years, with recurrent respiratory papillomatosis and described discrete, hyperechoic lesions that could be easily seen.[18] They did not, however, determine if papilloma could be distinguished from other vocal fold lesions. None of these previous studies had a comparison control group without vocal fold lesions. The primary goal of this project was to replicate the finding that vocal fold nodules can be identified on LUS with a control group without vocal fold lesions. The secondary goal of this project was to determine if reliable size measurements of the lesions could be obtained using LUS.

## MATERIALS AND METHODS

This was a case-control study in which the patient acted as his or her own control. With institutional board review approval, 23 consecutive patients with a diagnosis of vocal fold nodules, as seen on laryngeal stroboscopy in the pediatric otolaryngology voice clinic, were recruited for participation. Stroboscopy was performed with either a 70° transoral rigid Hopkins rod or a Storz flexible distal chip nasolaryngoscope (KARL STORZ, Tuttlingen, Germany) depending on patient tolerance and cooperation. The control group was 23 patients without vocal fold lesions who underwent laryngoscopy and LUS for the evaluation of vocal fold mobility and who had normal mobility. LUS was performed using a GE Logic E9 ultrasound machine (GE Healthcare, Milwaukee, WI) with a 51-mm long, 15 MHz linear probe. Two pediatric radiologists, who were blinded to the vocal fold nodule status and were not involved in performing the ultrasounds, interpreted the LUS (Fig. 1). The radiologists were trained using an example of an ultrasound from a normal larynx and another with known nodules. These training ultrasounds were not used as part of the study. Using an image that they felt best represented the size of the nodules, the radiologists measured the nodules in the anterior-posterior and lateral dimensions using the measurement tools available on the GE ultrasound machine. For comparison to stroboscopy, there had to be agreement between the reviewers on the presence of nodules. If there was a discrepancy between the two raters, a third reviewer, also blinded to the nodule status, was used as a tie breaker. Level of agreement between laryngeal stroboscopy and LUS to correctly identify vocal fold nodules was determined using Cohen's $\kappa$. Pearson correlation coefficient was used to assess the consistency of the raters' size measurements.

## RESULTS

The demographics of the subjects are listed in Table I. There was substantial inter-rater agreement ($\kappa$ = 0.70, 95% confidence interval [CI]: 0.50-0.89) between the two radiologists regarding the presence of nodules. With a third reviewer as a tie breaker for discrepancies between the reviewers, there was substantial agreement ($\kappa$ = 0.87, 95% CI: 0.72-1) between LUS and laryngeal

TABLE I.
Demographics.

| | Nodules (N = 23) | Normal (N = 23) | *P* Value |
|---|---|---|---|
| Age, yr, mean ± SD | 6.22 ± 3.45 years | 97 ± 319 days | .001 |
| Gender, no (%) | | | .77 |
| Female | 12 (54.6) | 10 (45.5) | |
| Male | 11 (45.8) | 13 (54.2) | |

SD = standard deviation.

TABLE II.
Sensitivity and Specificity.

| | Sensitivity (95% CI) | Specificity (95% CI) |
|---|---|---|
| LUS vs. strobe* | 100 (85-100) | 87 (66-97) |
| Radiologist 1 | 100 (82-100) | 74 (51-89) |
| Radiologist 2 | 96 (76-99) | 100 (82-100) |

*For the purposes of comparison between LUS and strobe, if there were discrepancies between the reviews, a third reviewer was used as a tie breaker.

CI = confidence interval; LUS = laryngeal ultrasound.

TABLE III.
Consistency of Vocal Fold Nodules Measurements on Laryngeal Ultrasound.

| Measurement | Pearson Correlation Coefficient | *P* Value |
|---|---|---|
| Right AP | 0.075 | .75 |
| Right lateral | 0.280 | .23 |
| Left AP | −0.123 | .61 |
| Left lateral | 0.313 | .18 |

AP = anterior-posterior.

stroboscopy. The overall sensitivity of LUS as well as the individual reviewers are listed in Table II. However, the measurements of nodules size lacked consistency ($P > .05$) (Table III).

## DISCUSSION

Although vocal fold nodules are the most common laryngeal lesions seen in children, it is essential to differentiate nodules from other potentially surgically amenable lesions such as vocal fold cysts, polyps, or sulcus.[9,19] Laryngeal stroboscopy via a transnasal or transoral approach allows for high-resolution assessment of lesions and vibratory parameters. The transoral approach is not painful; however, it does require patient cooperation. The transnasal approach often entails two or more adults to restrain the child. There are some children, especially those with sensory issues or developmental delays, who are cannot be examined in the office. In this circumstance, the only other option to obtain an evaluation of the vocal folds is sedation or anesthesia. In the young larynx without calcification, laryngeal ultrasound can provide a painless window into the endolarynx.[20] Newer high-frequency probes allow for improved resolution of small laryngeal lesions. Previous work has demonstrated that laryngeal ultrasound can be used to evaluate vocal fold mobility in neonates with much less physiologic impact compared to FNL.[6] A limitation of LUS is resolution at the air–soft tissue interface.

Our data showed that two radiologists had substantial agreement with each other and with stroboscopy regarding the presence of nodules. The radiologists measurements of the nodules size, however, were very inconsistent. This may be due to the very small size of the lesions, making accurate measurement challenging.

The primary goal of this project was to determine if we could replicate the reliable identification of vocal fold nodules from normal vocal folds on LUS despite their small size and presence at the air–soft tissue interface. Because children with normal vocal folds do not often undergo laryngoscopy, the control group consisted of patients undergoing laryngoscopy and laryngeal ultrasound for the evaluation of vocal fold mobility. This resulted in a younger cohort for the normal group.

A clear limitation of this project was that we have not determined whether LUS can differentiate between different types of laryngeal lesions such as papilloma, cysts, or polyps. Additionally, LUS cannot determine vocal fold vibratory characteristics or closure patterns. Distinguishing types of laryngeal masses on LUS will have to be the subject of further investigation.

## CONCLUSION

LUS has substantial agreement with laryngeal stroboscopy for the identification of vocal fold nodules in children. With its high sensitivity, LUS may be useful as a screening tool for vocal fold nodules. It may also serve as an alternative means of visualizing the larynx in children who cannot tolerate in-office laryngoscopy.


### Acknowledgments

The authors thank Wei Zhang, PhD, at the Texas Children's Hospital Outcomes Center for her help with the statistical analysis.


## BIBLIOGRAPHY


1. Rosen CA, Gartner-Schmidt J, Hathaway B et al. A nomenclature paradigm for benign midmembranous vocal fold lesions. *Laryngoscope* 2012; 122:1335–1341.
2. Tezcaner CZ, Karatayli Ozgursoy S, Sati I, Dursun G. Changes after voice therapy in objective and subjective voice measurements of pediatric patients with vocal nodules. *Eur Arch Otorhinolaryngol* 2009;266:1923–1927.
3. Hooper CR. Treatment of voice disorders in children. *Lang Speech Hear Serv Sch* 2004;35:320–326.
4. Ongkasuwan J, Friedman EM. Is voice therapy effective in the management of vocal fold nodules in children? *Laryngoscope* 2013;123:2930–2931.
5. Ongkasuwan J, Yung KC, Courey MS. The physiologic impact of transnasal flexible endoscopy. *Laryngoscope* 2012;122:1331–1334.
6. Ongkasuwan J, Ocampo E, Tran B. Laryngeal ultrasound and vocal fold movement in the pediatric cardiovascular intensive care unit [published online April 23, 2016]. *Laryngoscope* doi: 10.1002/lary.26051.
7. Paul BC, Rafii B, Achlatis S, Amin MR, Branski RC. Morbidity and patient perception of flexible laryngoscopy. *Ann Otol Rhinol Laryngol* 2012;121:708–713.
8. Zacharias SR, Weinrich B, Brehm SB, et al. Assessment of vibratory characteristics in children following airway reconstruction using flexible and rigid endoscopy and stroboscopy. *JAMA Otolaryngol Head Neck Surg* 2015;141:882–887.
9. Mortensen M, Schaberg M, Woo P. Diagnostic contributions of videolaryngostroboscopy in the pediatric population. *Arch Otolaryngol Head Neck Surg* 2010;136:75–79.
10. Mackiewicz-Nartowicz H, Sinkiewicz A, Bielecka A. Laryngovideostroboscopy in children—diagnostic possibilities and constraints. *Int J Pediatr Otorhinolaryngol* 2011;75:1015–1017.
11. Wolf M, Primov-Fever A, Amir O, Jedwab D. The feasibility of rigid stroboscopy in children. *Int J Pediatr Otorhinolaryngol* 2005;69:1077–1079.
12. Akif Kilic M, Okur E, Yildirim I, Guzelsoy S. The prevalence of vocal fold nodules in school age children. *Int J Pediatr Otorhinolaryngol* 2004;68: 409–412.
13. Sirikci A, Karatas E, Durucu C, et al. Noninvasive assessment of benign lesions of vocal folds by means of ultrasonography. *Ann Otol Rhinol Laryngol* 2007;116:827–831.
14. Rubin JS, Lee S, McGuinness J, Hore I, Hill D, Berger L. The potential role of ultrasound in differentiating solid and cystic swellings of the true vocal fold. *J Voice* 2004;18:231–235.
15. Gomaa MA, Hammad MS, Mamdoh H, Osman N, Eissawy MG. Value of high resolution ultrasonography in assessment of laryngeal lesions. *Otolaryngol Pol* 2013;67:252–256.
16. Bisetti MS, Segala F, Zappia F, Albera R, Ottaviani F, Schindler A. Noninvasive assessment of benign vocal folds lesions in children by means of ultrasonography. *Int J Pediatr Otorhinolaryngol* 2009;73:1160–1162.
17. Tsui PH, Huang CC, Sun L, Dailey SH, Shung KK. Characterization of lamina propria and vocal muscle in human vocal fold tissue by ultrasound Nakagami imaging. *Med Phys* 2011;38:2019–2026.
18. Bryson PC, Leight WD, Zdanski CJ, Drake AF, Rose AS. High-resolution ultrasound in the evaluation of pediatric recurrent respiratory papillomatosis. *Arch Otolaryngol Head Neck Surg* 2009;135:250–253.
19. Sataloff RT, Spiegel JR, Hawkshaw MJ. Strobovideolaryngoscopy: results and clinical value. *Ann Otol Rhinol Laryngol* 1991;100:725–727.
20. Wenaas AE, Tran B, Ongkasuwan J. The progression of thyroid cartilage calcification as it relates to the utilization of laryngeal ultrasound. *Laryngoscope* 2016;126:913–917.