Objectives: To characterize the ultrasonographic appearance of laryngeal papillomatosis and to compare ultrasound with direct laryngoscopy and bronchoscopy, the criterion standard, for airway evaluation.

Design: Prospective, nonrandomized analysis of preoperative and postoperative airway ultrasound images.

Setting: Tertiary, university-based medical center.

Participants: Eight patients (4 females and 4 males) with recurrent respiratory papillomatosis, with a mean age of 10.25 years and a mean of 14 surgical papilloma resections (range, 3-35).

Intervention: The patients underwent planned papilloma resections with ultrasound evaluation before formal endoscopic resection. Preresection ultrasound images of respiratory papillomas were evaluated.

Main Outcome Measures: The ultrasonographic appearance of respiratory papillomas and pediatric airway anatomy.

Results: Respiratory papillomas appeared as discrete, hyperechoic lesions on the relatively hypoechoic background of the true vocal folds.

Conclusions: Recurrent respiratory papillomas have a characteristic ultrasonographic appearance that seems to correlate with endoscopic findings. It seems that this modality holds promise for identifying pedunculated papillomas. Although direct laryngoscopy and bronchoscopy are the criterion standard, airway ultrasound may have a role in the early diagnosis of, surveillance of, and operative planning for recurrent respiratory papillomatosis. To our knowledge, this is the first study to describe the ultrasonographic appearance of papillomas and the first comparison of ultrasonographic and endoscopic airway images. This modality merits further study, and further investigation is ongoing.


RECURRENT RESPIRATORY PAPILLOMATOSIS (RRP) is the most common benign neoplasm of the pediatric larynx and trachea. Although histologically benign, RRP is a substantial source of morbidity because patients often require multiple endoscopic resections under general anesthesia. Preliminary diagnosis and postoperative surveillance are difficult in children, who are not consistently compliant during flexible laryngoscopy. Recently, ultrasonography has been used to evaluate vocal fold function in infants and children. In her study, Friedman1 defined the ultrasonographic anatomy of the larynx and found that this technology was capable of evaluating vocal fold motion in infants and children. Vats et al2 reported similar findings.

Ultrasonography is noninvasive, nonirradiating, and safe. It is well tolerated by patients and quickly performed, and it allows for photodocumentation. In this study, we characterize the ultrasonographic appearance of laryngeal papillomatosis and use direct laryngoscopy and bronchoscopy, the criterion standard for airway evaluation, as a reference standard. This is the first study, to our knowledge, to describe the ultrasonographic appearance of papillomas.

METHODS

The study protocol was approved by the institutional review board of The University of North Carolina at Chapel Hill Office of Human Subjects Research. Eight patients with known RRP who underwent planned papilloma resections were recruited and underwent intraoperative ultrasound evaluation before formal endoscopic resection. Preresection ultrasound images were then compared with endoscopic images. Two patients without respiratory papillomas who were undergoing direct laryngoscopy and bronchoscopy for other reasons were included as control subjects.

RESULTS

Of the 8 patients with known RRP, 4 were females and 4 were males. The mean age of the patients was 10.25 years, and the
The mean number of surgical procedures to remove papillomas was 14 (range, 3-35). Three patients were chosen to illustrate the correlation between endoscopic and ultrasonographic imaging of respiratory papillomas. **Figure 1** A is an endoscopic view of the larynx of a 2-year-old without RRP, and **Figure 1B** illustrates, via ultrasound, the anatomy of the larynx. The anterioposterior borders of the thyroid cartilage are seen, as are the relatively hyperechoic false vocal folds and the hypoechoic true vocal folds. The cricoarytenoid joints can also be appreciated. **Figure 2** illustrates the endoscopic and ultrasonographic appearance of a ball-valving papilloma in the airway of an 18-year-old patient. **Figure 3** demonstrates the endoscopic appearance of an anterior commissure papilloma. The lesion is hyperechoic via ultrasound (Figure 3B). **Figure 4** shows the pedunculated papilloma arising from the anterior aspect of the left true vocal fold of a 6-year-old patient. In general, respiratory papillomas appeared as hyperechoic lesions with a background of hypoechoic true vocal folds. In some cases, sessile lesions with less-developed vascular cores were not as obvious via ultrasound. There was a trend for this result to be present in children who have had more than 5 procedures. The dynamic nature of pedunculated lesions was readily visualized. The other 5 patients in the study had less bulky disease lesions, and these lesions were less discretely apparent on still ultrasonographic images.

**Comment**

Ultrasound has been used to evaluate various organ systems for many years; however, broader application involving the airway and larynx is relatively new. Friedman and Vats et al successfully used ultrasound to evaluate vocal fold motility in children with high reliability and concordance with endoscopy. This study on the use of high-resolution ultrasonography is the first in a larger effort to characterize the anatomy and to evaluate the utility of this technology in the pediatric airway. High-resolution ultrasound has several advantages over current methods, including its noninvasive nature, its absence of ionizing radiation, and its ease of use in the ambulatory setting. In addition, the examiner can appreciate the dynamic nature of some airway lesions, such as a ball-valving papilloma as seen and described in **Figure 2**.

Recurrent respiratory papillomatosis is caused by human papillomavirus and exerts a large financial toll on health care resources. On average, children with RRP have 4.4 surgeries per year and more than 20 procedures in their lifetime. Because direct laryngoscopy and bronchoscopy are the criterion standard for diagnosis, there is often a delay in diagnosis as other causes of hoarseness are ruled out. Another obstacle to diagnosis is that office-based flexible laryngoscopy is not available to non-otolaryngologists and is not easily tolerated by pediatric and adolescent patients and their caregivers. Furthermore, once a patient has been diagnosed as having RRP, there are few methods for nonoperatively imaging the airway.

Eight pediatric and adolescent patients with RRP underwent high-definition ultrasonography in the operating room to describe the appearance of respiratory papillomas. Papillomas appear as hyperechoic lesions on the hypoechoic background of the true vocal folds. The procedure was easy to perform, took less than 10 minutes in most cases, and allowed for easy photo-documentation.

Weaknesses of this study include the absence of independent raters, a validated rating system, and a formal control group. In addition, patients were under general anesthesia; thus, conclusions cannot necessarily be applied to the office setting, and we cannot offer any observations as to the effect of vocal cord mobility on the visualization of papillomatous lesions.
Figure 2. A ball-valving papilloma in the airway of an 18-year-old patient. A, Endoscopic appearance of the papilloma in the glottic position. B, Ultrasonographic appearance of the papilloma in the glottic position. C, Endoscopic appearance of the papilloma in the supraglottic position. D, Ultrasonographic appearance of the papilloma in the supraglottic position.

Figure 3. Endoscopic (A) and ultrasonographic (B) appearance of an anterior commissure papilloma.
Strengths of this study include that it is the first to characterize the ultrasonographic appearance of respiratory papillomas. It also further confirms the ease of use and photodocumentation capabilities of ultrasound. In addition, it sets the stage for further controlled studies in the office and operative settings.

In conclusion, there seems to be a characteristic ultrasonographic appearance of papillomatous lesions. Although endoscopy remains the criterion standard, the ease of use and noninvasive nature of ultrasound may make it a useful tool for office-based surveillance and diagnosis of RRP. In addition, ultrasound evaluation of a child or adolescent with hoarseness, as with an upper respiratory tract infection, is distinctly less traumatic than is flexible fiberoptic laryngoscopy. Use of this modality in a patient with known respiratory papillomas might save him or her from unneeded operative procedures.

Submitted for Publication: March 23, 2007; final revision received January 8, 2008; accepted February 19, 2008.

Correspondence: Austin S. Rose, MD, The University of North Carolina at Chapel Hill, Campus Box 7070, Chapel Hill, NC 27599-7070 (austin_rose@med.unc.edu).

Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Bryson, Leight, Zdanski, Drake, and Rose. Acquisition of data: Bryson, Leight, Zdanski, Drake, and Rose. Analysis and interpretation of data: Bryson, Leight, Zdanski, Drake, and Rose. Drafting of the manuscript: Bryson and Leight. Critical revision of the manuscript for important intellectual content: Bryson, Leight, Zdanski, Drake, and Rose. Administrative, technical, and material support: Bryson, Leight, Zdanski, Drake, and Rose. Study supervision: Bryson, Zdanski, Drake, and Rose.

Financial Disclosure: None reported.

Previous Presentation: This study was presented as a poster at the American Society of Pediatric Otolaryngology; May 26, 2006; Chicago, Illinois.

REFERENCES


Figure 4. Endoscopic (A) and ultrasonographic (B) appearance of a pedunculated papilloma in a 6-year-old patient.