

Accuracy and Safety of Tracheoscopy for Infants in a Tertiary Care Clinic

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Objective: To assess the diagnostic accuracy and safety of office-based tracheoscopy when combined with flexible fiberoptic laryngoscopy (FFLT). Flexible laryngoscopy on infants is routinely performed by otolaryngologists in the clinic. The addition of tracheoscopy may improve overall airway assessment but is rarely performed due to the suspected risk of airway compromise.

Design: A 6-year retrospective medical record review.

Setting: Tertiary care hospital.

Patients: Thirty-one infants younger than 1 year with complete data from preoperative FFLT and microlaryngoscopy and bronchoscopy (MLB) were examined.

Main Outcome Measures: Results from 241 MLB procedures were reviewed.

Results: Laryngomalacia (LM) and tracheomalacia (TM) were identified more often by FFLT than by MLB. In particular, the detection rate for LM and TM by MLB, as seen preoperatively by FFLT, was 79% and 61%, respectively. Compared with FFLT, MLB accurately diagnosed the severity of LM and TM only 55% and 65%, respectively, of the time. Fiberoptic laryngoscopy revealed synchronous airway lesions in 62% of infants with LM, while MLB discovered synchronous airway lesions in 54%. Static airway lesions were more frequently diagnosed with MLB. No respiratory events occurred during FFLT.

Conclusions: In an appropriate patient, FFLT is a safe and effective diagnostic tool for common infant tracheal and laryngeal abnormalities. Detection and characterization of dynamic airway lesions is better achieved by FFLT than by MLB.

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FLEXIBLE FIBEROPTIC LARYNGOSCOPY is an essential tool in the evaluation of upper airway anomalies in the awake child. The procedure is routinely performed using topical nasal anesthesia and is reasonably safe and well tolerated by children of all ages. This allows an otolaryngologist to examine the upper airway in its dynamic state.¹ Site-specific airway compromise can thereby be quickly assessed in the office to determine the next best step in management.

Historically, flexible laryngoscopy has not been used to assess regions below the true vocal cords owing to the suspected risk of laryngospasm and airway compromise. Therefore, its utility in diagnosing both fixed and dynamic lesions below the vocal folds has not been established. This has traditionally been achieved through rigid microlaryngoscopy and bronchoscopy (MLB) during general intravenous and/or inhalational anesthesia.²

At Arkansas Children's Hospital, Little Rock, awake flexible fiberoptic laryngoscopy with tracheoscopy (FFLT) has been

used as a routine diagnostic tool of the upper airway and trachea. This is based on the hypothesis that FFLT accurately and safely assesses airway lesions. Therefore, this study evaluates the role and accuracy of FFLT relative to MLB in infants by comparing FFLT with MLB results.

METHODS

After institutional review board approval, a retrospective medical record review was performed for all patients younger than 1 year, who underwent rigid MLB at Arkansas Children's Hospital from January 2003 to September 2008.

A total of 241 sequential MLBs were identified. These medical records were reviewed for patient name, age, sex, presenting symptoms, findings on in-office FFLT if performed, findings on MLB, and complications. Thirty-one unique infants met this criteria (17 male and 14 female) and had complete data on both FFLT and MLB. A complete FFLT and MLB examination described all key structures from the supraglottis to the distal trachea. All procedures were performed or directly supervised by the senior author (C.M.B.).

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Table 1. Flexible Fiberoptic Laryngoscopy With Tracheoscopy (FFLT) vs Microlaryngoscopy and Bronchoscopy (MLB) Findings^a

Procedure	Patients	LM	TM	SGS	SG Lesions
FFLT	31	29	18	4	2
MLB	31	24	12	6	4

Abbreviations: LM, laryngomalacia; SG, subglottis; SGS, subglottic stenosis; TM, tracheomalacia.
^aData are given as number.

FLEXIBLE FIBEROPTIC LARYNGOSCOPY WITH TRACHEOSCOPY

Flexible fiberoptic laryngoscopy with tracheoscopy was performed in the clinic setting with a Vision Sciences ENT-1000 flexible fiberoptic scope (2.4-mm outer diameter) (Vision Sciences, South Orangeburg, New York). Less than 1 mL of a 1:1 mixture of phenylephrine hydrochloride and tetracaine was applied to both nares. The patient was then held securely by a guardian or nurse in the upright position. The flexible scope was then advanced through the nose, examining the nasopharynx, pharynx, and hypopharynx. The larynx was examined and the scope was then positioned a few millimeters above the glottis toward the anterior commissure. At the commencement of inspiration, the scope was flexed posteriorly to assist with transglottic passage and quickly advanced to the middle of the trachea and centered. The trachea was assessed as the scope was slowly retracted to the level of the subglottis. An attempt to pause in the subglottis was then made to improve diagnosis at this site. Once the examination was complete, the scope was withdrawn from the patient and the infant was then passed over to his or her guardian for consolation. The FFLT procedure was recorded for frame-by-frame playback to facilitate diagnosis and patient education. The entire technique was typically completed in less than 2 minutes. Appropriate emergency equipment and personnel were readily available for each procedure.

MICROLARYNGOSCOPY AND BRONCHOSCOPY

Microlaryngoscopy and bronchoscopy was performed with the patient under general anesthesia in the operating room. After intravenous access was obtained, the patient was induced with either intravenous sedation (typically propofol) or inhalational anesthetic (usually sevoflurane) and then maintained at a proper depth of anesthesia for spontaneous ventilation. Once appropriate depth of anesthesia was obtained, a rigid Parson laryngoscope with a ventilatory port was used to briefly visualize the supraglottis and glottis directly and administer a small amount of lidocaine hydrochloride, 4%, to the vocal cords. After waiting an additional 1 to 2 minutes for the lidocaine to take effect, the laryngoscope was replaced and a 0° Storz-Hopkins telescope (ranging from 1.7 mm to 4 mm, depending on the size of the airway) was used for microscopic evaluation. The hypopharynx and larynx were then evaluated followed systematically by the subglottis, trachea, and bronchi. Photographic documentation was typically obtained to allow for reassessment postoperatively. Surgical intervention was performed if indicated. Prior to termination of the procedure, the airway was routinely sized with an uncuffed, endotracheal tube, while noting the pressure required to obtain an air leak as well as determining the grade of stenosis, if applicable, according to the Myer-Cotton classification.³ The patient was then turned over to the anesthesiologist to emerge from anesthesia and was taken to the recovery room or other indicated location.

Table 2. Percentage of Patients for Whom Microlaryngoscopy and Bronchoscopy Correspond With Flexible Fiberoptic Laryngoscopy With Tracheoscopy for Findings of Dynamic Airway Lesions

	Patients, %	
	LM	TM
Detection	79	61
Accuracy	55	65

Abbreviations: LM, laryngomalacia; TM, tracheomalacia.

RESULTS

Among 241 consecutive MLBs performed between January 2003 and September 2008, 31 infants were identified for inclusion in the present study. The majority of FFLT procedures performed during this period did not proceed to MLB. Of those infants who underwent both procedures, 17 were male and 14 were female. The mean age at FFLT was 115 days (median, 86 days), with a range from 5 to 330 days, and the mean age at MLB was 163 days (median, 146 days). The most common presentation at the clinic was stridor or noisy breathing (71%). Less common presentations included dysphagia and failure to thrive. No adverse events (ie, hypoxia, apnea, laryngospasm) occurred during FFLT.

The incidence of synchronous airway lesions (SALS) in patients with LM detected by FFLT was 62%. Microlaryngoscopy and bronchoscopy had a rate of 54% of SALS in patients with laryngomalacia (LM).

Of 31 patients, FFLT detected LM in 29 (94%), while an LM diagnosis was made with MLB in 24 (77%) (**Table 1**). In 23 of the LM cases (79%) diagnosed with FFLT, LM was also detected by MLB (**Table 2**). There were, however, 6 of 29 LM cases (21%) diagnosed with FFLT (21%) that were not detected by MLB. In 1 patient (3%), MLB detected LM that was not identified by FFLT. Tracheomalacia (TM) was diagnosed with FFLT in 18 of the 31 patients (58%), while a TM diagnosis was made with MLB in 12 (39%) (**Table 1**). In 11 of the TM cases (61%) diagnosed with FFLT, TM was also detected by MLB. There was an isolated case in which MLB detected TM that was not identified by FFLT (6%).

Of the 31 patients evaluated for LM by FFLT and MLB, 17 (55%) were found to have the same degree of LM (from normal to severe) by both modalities (**Table 2**). Eleven of the remaining patients (35%) were found to have more severe findings of LM by FFLT. Three other patients (10%), however, had more severe findings on MLB compared with FFLT. Of the 31 patients evaluated for TM

by both procedures, 20 (65%) had the same severity reported by both techniques (Table 2). Nine cases (29%) of those remaining, however, showed worse findings of TM on FFLT than MLB. The 2 remaining cases (7%) showed more severe findings of TM by MLB compared with FFLT.

In 4 patients, FFLT detected subglottic stenosis. All 4 cases were confirmed by MLB but an additional 2 cases were also discovered with rigid endoscopy (Table 1). Of 4 subglottic lesions detected by MLB, only 2 were found during FFLT (Table 1).

COMMENT

Flexible laryngoscopy is commonly used to evaluate the upper airway in pediatric otolaryngology patients. The most common indication is to evaluate the patient with stridor. Accurate, dynamic views of the pharynx, supraglottis, glottis, and often subglottis can be obtained using flexible laryngoscopy. This helps identify the site of airway obstruction and determine the treatment plan. Many of these patients are diagnosed as having LM and are treated without proceeding to the operating room for MLB.

An appropriate algorithm for managing LM rarely requires MLB unless supraglottoplasty is intended. However, controversy exists in the literature about SALs and whether MLB is necessary in every case of LM. The reported incidence of SALs with LM ranges in the literature from 7.5% to 58%.⁴⁻¹² A reasonable solution to this dilemma would be to diagnose SAL during the awake state with flexible fiberoptic endoscopy.

In the present study, the SAL detection rate for FFLT and MLB was 62% and 54%, respectively. The addition of tracheoscopy to the routine flexible fiberoptic laryngoscopy may help determine SAL prior to operative evaluation. Our results suggest that FFLT can provide valuable information for predicting the clinical course of a patient with LM. For example, the surgeon may choose to advance to operative management of LM when SALs such as subglottic stenosis or TM are found. This may also help with preparing the patient's family because postoperative expectations for LM with SALs, treated with supraglottoplasty, more frequently have a more protracted postoperative course.¹³

Primary indications for FFLT in this study included stridor, noisy breathing, respiratory distress, failure to thrive, dysphagia, and aspiration. It should be noted, however, that severe LM or copious pooled secretions may make this technique more challenging. We have found that recording FFLT procedures for later evaluation is essential to pick up all findings and make an accurate diagnosis.

One of the reasons why awake tracheoscopy without sedation has been traditionally avoided is because of the concern for laryngospasm and respiratory distress.¹⁴ In a prospective study of 1328 flexible bronchoscopy procedures by de Blic et al¹⁵ in 2002, the frequency of transient desaturation was significantly higher in patients undergoing flexible bronchoscopy under deep sedation compared with only mild sedation. Thus, sedation appears to play a significant factor in tolerance of airway manipulation. Minor complications were reported in 5.2%

of the procedures in their series and major complications occurred in 1.7%, which predominantly occurred in patients with cardiopulmonary disease. The majority of the minor complications were transient desaturations below 90%. Interestingly, however, these occurred most frequently in the age group younger than 2 years.

Contraindications for using FFLT include significant subglottic stenosis, suspected bronchial foreign body, symptomatic bradycardia or tachycardia, and parent request. Absolute contraindications include epiglottitis, respiratory distress, or compromised ventilatory status. Conditions that should also be considered when deciding to perform FFLT are hypoxemia and congenital heart disease. Many times, however, the decision to pass through the glottis can only be determined while in the process of scoping. Also, if a lesion is identified by flexible laryngoscopy that requires surgical management (eg, high-grade subglottic stenosis, papilloma, glottic foreign body), then tracheoscopy should not be pursued in most instances.

In the cases reviewed for the present study, no significant cardiorespiratory events occurred during FFLT. The majority of the procedures were, however, performed without cardiopulmonary monitoring, although appropriate emergency equipment and personnel were readily available. Incidentally, we routinely perform FFLT in the intensive care units on children of all ages who are continuously monitored and have not experienced any untoward events. To date, no complications have occurred during FFLT at our institution. This is consistent with a previous report by Lindstrom et al,¹⁶ who reported no complications during a prospective study of 105 pediatric patients who underwent office-based lower-airway endoscopy.

We theorize that infants undergoing FFLT were able to tolerate awake, glottic manipulation owing to the immaturity of their developing nervous system, the general desensitization of the larynx,^{17,18} the high prevalence of gastroesophageal reflux, or an increased respiratory drive that allows for rapid recovery from irritating stimuli (ie, a subclinical laryngospasm). It also may be easier to anesthetize the glottis transnasally because of the smaller airway size of position of the larynx. The infant response to irritation of repetitive crying also provides an ideal opportunity for translaryngeal passage. Older children and adults tend to gag and withdraw from the scope owing to anxiety. Most infants are also given a pacifier during or immediately after the procedure is finished, which may assist with inspiratory drive, thus improving their tolerance of the procedure and prompt recovery. However, this technique has been safely applied to older individuals without complication. The article by de Blic et al¹⁵ reported that sedation appears to play a vital role in patients' tolerance of glottic manipulation, and possibly, by just having these patients fully awake helps prevent any significant events from occurring.

The present study revealed differences in the diagnosis of dynamic and fixed lesions in the airway when comparing FFLT and MLB. Flexible fiberoptic laryngoscopy with tracheoscopy was more sensitive in detecting and characterizing dynamic lesions including LM and TM. The rate of agreement between FFLT and MLB in the di-

agnosis of LM and TM was 79% and 61%, respectively (Table 2). In only 1 case was a diagnosis of LM made with MLB when FFLT did detect LM, and an additional case of TM was diagnosed only with MLB.

The accuracy of MLB for describing dynamic airway lesions when compared with FFLT was low. Including the instances when each procedure reported normal findings, the agreement between FFLT and MLB for LM and TM severity was 55% and 65%, respectively (Table 2). In 35% and 29% of cases, FFLT had more severe findings of LM and TM, respectively.

The results of this study for static airway lesions, however, have an opposing conclusion. Only 66% of cases of subglottic stenosis diagnosed with MLB were identified by FFLT preoperatively (Table 1). Subglottic lesions (such as hemangiomas or cysts) were only identified 50% of the time by FFLT. Flexible fiberoptic laryngoscopy with tracheoscopy is useful for detecting these fixed airway lesions, but the presence of a lesion cannot be ruled out if the examination finding is negative.

An article that illustrates our findings showed that the use of the rigid laryngoscope and telescope during MLB can alter the anatomic and dynamic findings.⁶ This brings up the question about which examination is truly the gold standard. Flexible fiberoptic laryngoscopy with tracheoscopy offers a dynamic, upright, anatomic picture of the airway with somewhat diminished optical quality compared with the sedated and manipulated airway encountered during MLB with better optics. As suggested by Wood,⁶ maybe the answer is the combined findings of the 2 techniques placed into the context of the specific patient. Because the rate of LM and TM was found to be much higher with FFLT than with MLB in our study, perhaps FFLT should be considered the more definitive examination for dynamic lesions of the pediatric airway. Our study also showed a trend for MLB to better diagnose static lesions of the airway and should be considered the gold standard for these cases.

Recognized limitations of the study include recall bias and reporting error. The study also included only a selected population (individuals who had a preoperative FFLT followed by an MLB) in a retrospective analysis. The senior author (C.M.B.) was also not blinded to the results of the FFLT, which may have influenced the diagnoses reported with MLB. Many of the patients who underwent FFLT were also not continuously monitored, and thus transient hypoxia and brief laryngospasm may not have been appreciated. Obvious complications, however, were not seen, and thus the technique appears to be safe and effective.

In conclusion, FFLT was able to be applied both safely and effectively in this study population in the diagnosis of both LM and TM. Detection of both LM and TM was higher with FFLT compared with MLB. The accuracy of MLB for severity of lesions found was not very high compared with FFLT. The fixed lesions such as subglottic stenosis, hemangiomas, and cysts were more reliably detected by MLB. Thus, FFLT appears to be the more reliable test for dynamic airway lesion assessment, while MLB is better for static airway lesions. The present study also presents for consideration an additional safe method to determine SALs without requiring intravenous catheters, fasting, and the risks of sedation and anesthesia.

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