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Flexible Bronchoscopy

Lael M. Yonker[a] · M. Shannon Fracchia[a,b]

[a]Pediatric Pulmonary Department, Massachusetts General Hospital, and [b]Massachusetts Eye and Ear Infirmary, Pediatric Airway Clinic, Boston, Mass., USA

Abstract

Flexible bronchoscopy is an important procedure for evaluating the pediatric airway, allowing a dynamic view from the trachea through the lower bronchi. The flexible bronchoscope offers greater maneuverability than the rigid bronchoscope and may be done in conjunction with other procedures, such as bronchoalveolar lavage, transbronchial biopsy, endobronchial ultrasound, electrocautery or laser treatments. Common indications for flexible bronchoscopy include recurrent croup or pneumonia, aspiration, foreign body and chronic cough. Although bronchospasm, transient fever, infection and pneumothorax are rare complications of flexible bronchoscopy, these risks are minimized with careful technique and an ongoing dialogue with the anesthesiologist. Flexible bronchoscopy is an important tool in the diagnosis, monitoring and therapy of certain pulmonary diseases and should be considered in the management of carefully selected pediatric patients.

Flexible bronchoscopy is an important modality used to examine the airway, offering diagnostic information regarding the upper and lower airway structures, in addition to providing means for obtaining samples of airway tissue and bronchoalveolar fluid. Made of fiber-optic rods or a distal imaging device with digital transmission, a bronchoscope comes in a variety of sizes for a wide age range, and is generally equipped with a separate suction/instrument channel. Flexible bronchoscopy can be performed independently or in conjunction with rigid bronchoscopy, and is often useful in evaluation of recurrent croup, atypical cough, hemoptysis or wheeze.

One of the greatest benefits of flexible bronchoscopy is that it offers a dynamic view of the airway, which is essential to diagnose tracheo- or bronchomalacia or compression of the airway. The smaller size of the flexible bronchoscope permits a view of the lower airways, which would not be possible with the larger rigid bronchoscope. This maneuverability allows for assessment of suspected foreign body or lower airway obstruction.

Additionally, there are several procedures done through flexible bronchoscopy which often aid in diagnosis or monitoring of an illness. The most commonly performed procedure done in conjunction with flexible bronchoscopy is bronchoalveolar lavage which not only allows removal of mucous plugs or debris but also provides sampling from the lower airways which may be sent for microbacterial and cytological analysis. Transbronchial or endobronchial biopsies may also be performed and are less invasive alternatives to an open lung biopsy. Endobronchial ultrasound, electrocautery and laser treatments may also be performed via flexible bronchoscope,

and as technology grows, flexible bronchoscopy will continue to offer invaluable assistance in the evaluation and management of airway lesions.

Indications

- Recurrent croup
- Recurrent pneumonia
- Aspiration
- Foreign body
- Cough
- Suspected airway compression
- Wheezing
- Hemoptysis
- Pulmonary alveolar proteinosis (rare condition)

Contraindications

- Cardiovascular instability
- Bleeding diathesis
- Severe bronchospasm
- Hypoxemia

Complications

- Bronchospasm
- Transient fever
- Infection
- Pneumothorax

Anesthesia Considerations

When performing a bronchoscopy on a pediatric patient, it is extremely important to have an ongoing dialogue with the anesthesiologist regarding the patient's respiratory status. Since instrumenting the airway can be irritating to the tracheobronchial tree and pediatric patients have lower pulmonary reserve than adult patients, the pulmonologist may have to remove the bronchoscope from the airway intermittently to allow the anesthesiologist to recover adequate ventilation. The size of the bronchoscope may also have implications on the respiratory status of the pediatric patient: even when an age-appropriate-sized bronchoscope is used, it may still occlude the upper airway, particularly if the airway is maintained with an endotracheal tube. For this reason, using an laryngeal mask airway (LMA) when performing a bronchoscopy, if possible, may offer better ventilatory control. Vocal cord spasm and bronchospasm are often triggered by contact with the bronchoscope and are minimized by instillation of local anesthetic (0.5–1 ml of 2% lidocaine) at the level of the vocal cords and the carina.

Bronchoscopy Set-Up

The set-up is as depicted in figures 1 and 2:

- Bronchoscope
  - Bronchofiberscope, hybrid bronchofibervideoscope or bronchovideoscopes of age-/size-appropriate diameter
- Tower: light source, video system center/monitor (recording, keyboard, printer)
- Lubricant jelly
- Sterile gauze 4 × 4s
- Swivel adaptor for LMA/endotracheal tube
- 2% lidocaine without preservative
- 5-ml syringe for inserting lidocaine
- Sterile 0.9% normal saline for lavage
- 10- or 20-ml syringes for instillation of 0.5–1cc/kg normal saline for bronchoalveolar lavage
- Sputum traps
- Suction
- Gloves

Additional Equipment

- Endobronchial forceps
- Cytology brushes
- Transbronchial biopsy forceps and C-arm X-ray machine for guidance radiographic imaging
- Sterile container for brushings/biopsies

Fig. 1. Bronchoscopy set up. A: Suction trap attached to bronchoscopy and suction. Care must be taken to hold the suction trap vertically during the procedure as not to lose the content to the wall suction. Having extension tubing as shown allows the suction trap to hang in a more vertical position. B: Gloves. C: Lubricating jelly. D: Sterile gauze 4 × 4s with some dispensed lubricating jelly. E: 2% lidocaine, draw up into a 3-ml syringe with tubing and male adaptor to allow instillation into the bronchoscope. F: 20-ml syringe with normal saline. After the lidocaine has been dispensed, the adaptor may be transferred to the saline for dispense. G: Bronchoscope. H: Sterile bowl filled with normal saline which may be used judiciously to help clear the bronchoscope of plugs once the bronchoscope is removed from the airway. Oversuctioning of saline will dilute the sample. I: Swivel adaptor for LMA/endotracheal tube.

- Aspiration needles
- Grasping forceps
- Balloon catheters
- Ultrasonic probes
- Laser and electrosurgical attachments

Procedures

- Bronchoalveolar lavage:
  - Cell count
  - Microbiology/culture
  - Lipid-laden macrophages
  - Hemosiderin-laden macrophages
  - Cytology
  - Flow cytometry
- Brush biopsy
- Endobronchial biopsy
- Transbronchial biopsy
- Endobronchial ultrasound
- Segmental bronchography, brochoscopic treatment of airway and pulmonary bleeding, endoscopy-assisted tracheal intubation, bronchial dilation, stent placement

Fig. 2. Bronchoscope tower. The bronchoscope tower is comprised of video monitor, keyboard and mouse, light source, video processor, recording equipment and printer.

Common Findings

- Normal anatomy (online suppl. video 1)
  - Video 1: Overview of flexible bronchoscopy: bronchomalacia of left main bronchus, otherwise normal anatomy. This video describes the procedure of flexible bronchoscopy while progressing through normal anatomic landmarks: trachea, carina, right upper lobe, right middle lobe, right basal segments of the right lower lobe, left upper lobe , lingula and the left basal segments of the left lower lobe in addition to visualizing each lobe's segmental branches. Bronchoalveolar lavage is also demonstrated. This patient's anatomy is notable for bronchomalacia, or collapse, of the left main bronchus.
- Tracheomalacia: weakness or floppiness of the tracheal wall causing the trachea to be more

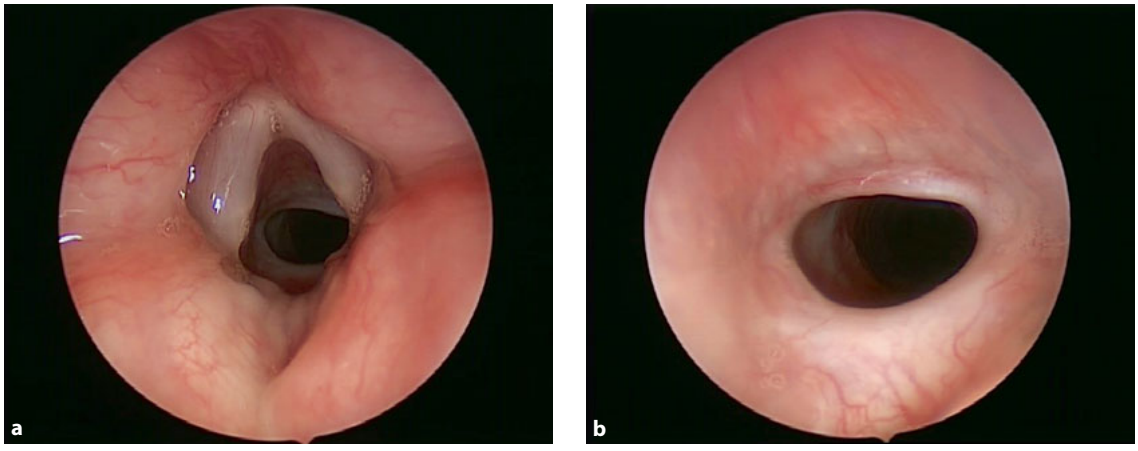

Fig. 3. Tracheal stenosis. Circumferential narrowing of the tracheal lumen is viewed from above the vocal cords (**a**) and a close-up picture (**b**).

susceptible to collapse, which is not as easily appreciated with a rigid bronchoscope (online suppl. video 2)

– Video 2: tracheomalacia and tracheo-esophageal fistula (TEF). As the bronchoscope is passed through the trachea, severe inward collapse of the tracheal wall is present. This case was severe enough to warrant tracheostomy tube placement, visible through the anterior wall of the mid-/upper trachea. As the bronchoscope is passed more distally through the trachea, a small defect is seen in the posterior tracheal wall, just above the level of the carina, representing a previously closed H-type TEF. Of note, although tracheomalacia is a relatively common finding in children with persistent cough or noisy breathing, TEF/esophageal atresia is a rare finding, reported as occurring in 1 in every 5,000 births. An H-type TEF accounts for 4–5% of these cases [1]. In cases of TEF, however, 75% of patients will have some degree of tracheomalacia [2].

- Bronchomalacia: weakness of a segment of bronchus causing collapse or compression and interferes with bronchociliary clearance (online suppl. video 1)
- Stenosis: fixed reduction in airway lumen due to abnormal development or secondary to endobronchial injury and inflammation (fig. 3)
- Compression: fixed narrowing of the trachea or bronchus, which may be pulsatile indicating arterial compression
- Bronchus suis (translated as pig bronchus, also known as tracheal bronchus): normal anatomic variant defined as having the right upper lobe bronchus diverge off the trachea, above the level of the carina, rather than from the right main bronchus (online suppl. video 3; fig. 4)

– Video 3: bronchus suis and tracheal hemangioma. Passing through the trachea, an outpouching is seen off the right side of the tracheal wall which is consistent with a bronchus suis. Adjacent to the bronchus suis is a raised vascular lesion representing an airway hemangioma. There is no association with airway hemangiomas and a bronchus suis.

- Hemangiomas: a vascular lesion which may compress or obstruct the airway, usually growing in size over the first year of life then receding. Multiple facial hemangiomas, particularly over the beard region, is a risk factor for having a hemangioma within the airway (online suppl. video 3).

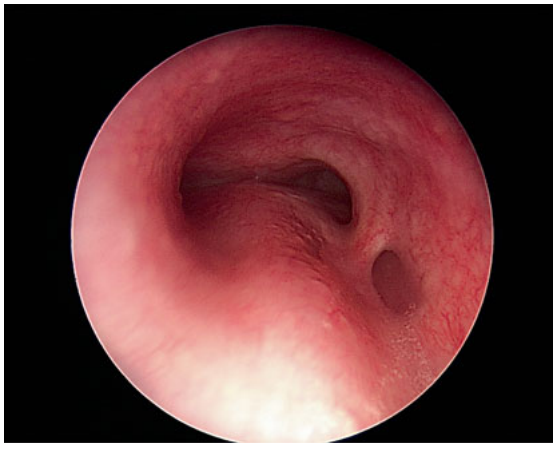

Fig. 4. Bronchus suis (pig bronchus, also referred to as tracheal bronchus). A normal anatomic variant in 0.1% of the population. Of note, there is also increased nodularity of the tracheal mucosa suggesting inflammation.

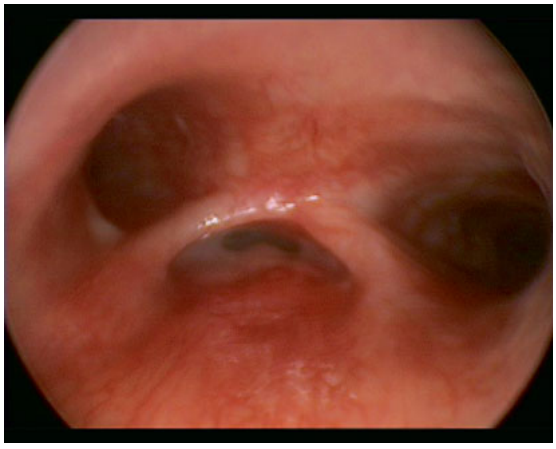

Fig. 5. H-type TEF. Although most TEFs are diagnosed in the newborn period as a result of esophageal atresia, the H-type TEF, shown here as an out-pouching in the distal posterior segment of the posterior tracheal wall connecting the trachea to the esophagus is the most common cause of TEF diagnosed in older children. This TEF is status post repair 3 years ago, but the residual defect in the tracheal wall remains, although now closed off to the esophagus.

- TEF: although there are several types of TEFs typically diagnosed in the newborn period due to esophageal atresia, the one that is most often diagnosed in older children is the H-type TEF. In the case of the H-type TEF, a small airway defect is seen typically along the base of the posterior wall of the trachea, connecting the airway with the patent esophagus (online suppl. video 2; fig. 5).
- Abnormal mucosa: the mucosa may be inflamed, edematous with loss of clarity of cartilaginous rings or nodular
- Secretions: secretions may be seen in any part of the airway and may be thin and clear or frothy, or thick, purulent and tenacious, usually making them more difficult to extract through the channels of the bronchoscope
- Foreign bodies

Pearls

- Benefits of flexible bronchoscopy compared to rigid bronchoscopy include its smaller size, dynamic view, increased maneuverability, and ability to visualize lower airways
- Certain procedures such as bronchoalveolar lavage and transbronchial biopsy may be performed in conjuction with flexible bronchoscopy
- Common indications include recurrent croup, pneumonia, aspiration, suspicion of foreign body, chronic cough or wheeze
- Common findings include tracheomalacia, bronchomalacia, stenosis, edematous or nodular mucosa
- Risks of flexible bronchoscopy include bronchospasm, transient fever, infection, pneumothorax
- An ongoing dialogue with the anesthesiologist is important to minimize bronchospasm and avoid complications

For similar information on pediatric flexible bronchoscopy we recommend the book 'Paediatric Bronchoscopy', Eds. Prifits et al. [4].

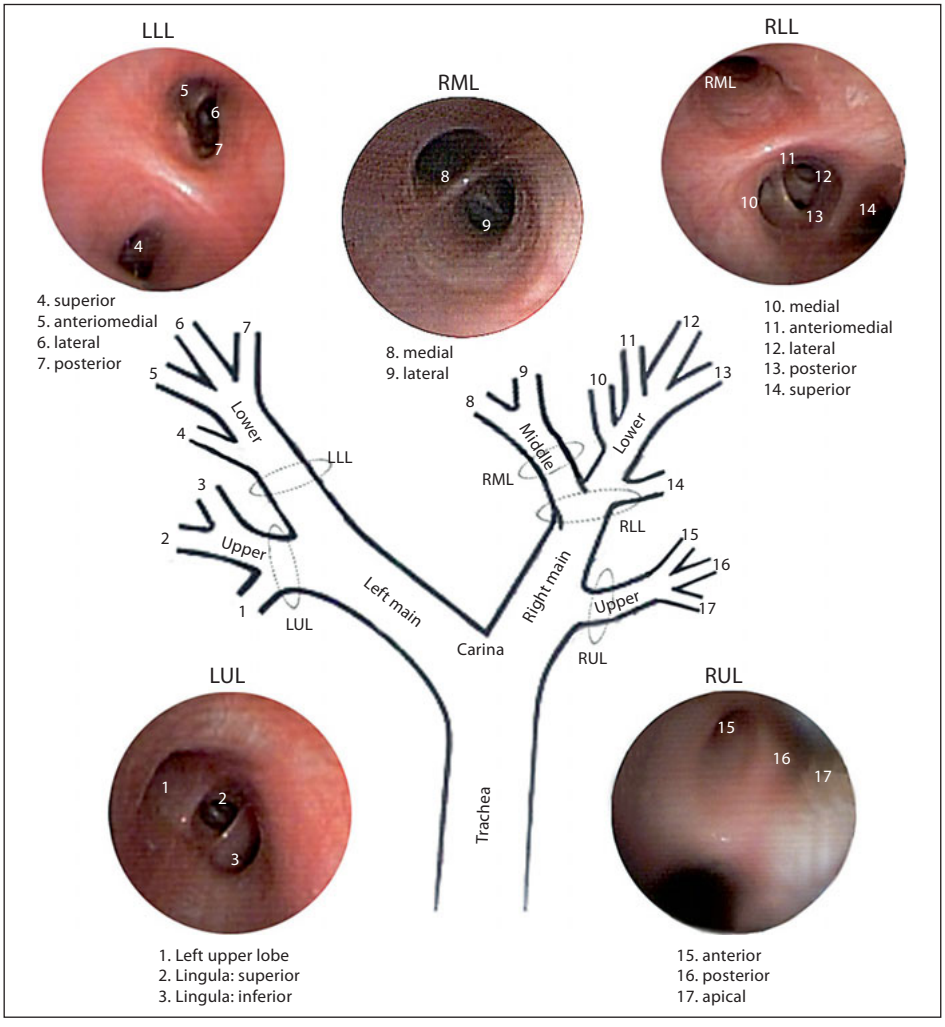

Fig. 6. Normal pulmonary anatomy with bronchoscopic views of lower airways. LUL = Left upper lobe; LLL = left lower lobe; RML = right middle lobe; RLL = right lower lobe; RUL = Right upper lobe. Created by Alexis Cook and Matthew Brudner.

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Lael M. Yonker, MD
Massachusetts General Hospital
Pediatric Pulmonary Department
275 Cambridge Street
Boston, MA 02114 (USA)
E-Mail lyonker@partners.org