Pitfalls in the Use of the Flexible Bronchoscope in Pediatric Patients*

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Flexible bronchoscopy is an important diagnostic (and sometimes therapeutic) tool that is underutilized in infants and children in many centers today. It is a relatively simple technique, but the unwary or inexperienced bronchoscopist can readily get into trouble, as there are many potential pitfalls. This article will review some of these pitfalls from the perspective of my own experience with more than 2,500 pediatric procedures over the past 16 years.1,2

Indications for Endoscopy

Flexible bronchoscopy should not be performed unless there are valid indications for the procedure and unless the information or potential therapeutic result to be gained outweighs the potential risk. Although the absolute magnitude of risk is low, consideration should always be given to alternative methods for obtaining the same information. If bronchoscopy is the best way to obtain the necessary diagnostic information or to accomplish the necessary therapeutic goal, however, bronchoscopy is always indicated.

There are many indications for flexible bronchoscopy in children. Marginal indications for flexible endoscopy include the examination of the larynx in cases of uncomplicated, clinically typical croup, and bronchoscopy in cases of simple, uncomplicated pneumonia (especially in patients capable of producing sputum). When the information to be gained will not likely alter the patient’s management or be of substantial benefit to the patient or family, flexible endoscopy is probably not indicated. For example, patients known to have aspirated a foreign body will need to undergo rigid bronchoscopy, and evaluation with a flexible instrument prior to rigid bronchoscopy should not be routinely performed.

On the other hand, the definitive diagnosis of a condition (eg, laryngomalacia) that, while benign, causes substantial anxiety on the part of the family, may be beneficial and reduce subsequent unnecessary utilization of medical services. Likewise, diagnostic flexible bronchoscopy may be of great utility in the evaluation of children suspected of harboring a foreign body but in whom there is either no history of aspiration or no physical or radiographic findings which lead to a very high index of suspicion. Many of the children in whom I have found a foreign body had undergone flexible diagnostic bronchoscopy because of unexplained atelectasis or persistent wheezing, with no history of aspiration.3

Instrumentation for Endoscopy

The use of inappropriate instruments for bronchoscopy is a major potential pitfall. Flexible bronchoscopes at least partially obstruct the airway, and the instrument used should be small enough to allow adequate ventilation if possible. On the other hand, it is also possible to employ an instrument which is inappropriately small for the task at hand. The “ultra-thin” flexible bronchoscopes4 do not have suction channels, and it may therefore be very difficult to adequately visualize the airways with such an instrument if there are excessive secretions. The bronchoscopist must be certain that the appropriate structures have been adequately visualized.

A more insidious problem is the use of a flexible bronchoscope when a rigid instrument should be used instead. While in general I believe that the flexible
instruments are superior for diagnostic purposes, there are several distinct situations in which use of the rigid bronchoscope may be essential to reach an accurate diagnosis. The rigid instrument approaches the glottis from the anterior aspect, and it is often difficult to adequately evaluate the anterior aspect of the glottis with a rigid instrument. On the other hand, the flexible instrument approaches the glottis (via the transnasal route) from the posterior aspect, and must be flexed anteriorly to view the glottis. Thus, it may be difficult to adequately evaluate the posterior aspect of the glottis with a flexible instrument. Therefore, the examination of a patient with suspected H-type tracheoesophageal fistula or a suspected laryngeal cleft is probably best performed with a rigid bronchoscope. The lens of the flexible bronchoscope is at the extreme distal end of the instrument; this makes it very difficult to manipulate the tissues under direct vision, as can be done with a rigid bronchoscope or laryngoscope. Vocal cord movement is most appropriately evaluated under topical anesthesia (and sedation) rather than general anesthesia, and the flexible instruments are usually adequate. However, if the vocal cords do not abduct, the problem may be either paralysis or interarytenoid fixation. These possibilities can best be distinguished with a rigid instrument, since the cords can be separated by the tip of the bronchoscope while their movement is observed through the telescope.

Another inappropriate use of the flexible bronchoscope is the attempted removal of foreign bodies. Although some small forceps and baskets are available which will pass through the pediatric (or adult) flexible scope, foreign body extraction is sufficiently difficult and risky that it should rarely, if ever, be attempted with a flexible bronchoscope unless attempts with a rigid instrument have failed and the flexible instrument offers some distinct advantage in the specific situation.

Flexible bronoscopes are expensive (>8,000 at current prices) and there is great temptation to utilize less expensive instruments, such as a nasopharyngoscope. The nasopharyngoscope has many legitimate uses but can lead to problems in routine use in pediatric patients. It has no suction channel, so that it may be more difficult to achieve adequate laryngeal anesthesia, thus tempting the operator either to not examine the larynx or to examine it from some distance. I have seen several infants with large subglottic masses who, prior to referral to my institution, had been examined by competent otolaryngologists with a nasopharyngoscope without making the correct diagnosis. The lack of a suction channel also may cause great problems in the presence of excess secretions. Another inexpensive instrument is the semidisposable "optical catheter." These instruments do provide a reasonable image, but since they lack effective distal angulation, can only be passed through an endotracheal or tracheostomy tube. Once the tip of the instrument reaches the end of the artificial airway, it is very difficult to manipulate it to visualize the anatomic structures. All flexible instruments have a wide-angle lens, which produces substantial optical distortion, with poor perception of depth and relative size. Therefore, if a nonsteerable instrument is passed through an endotracheal tube which is positioned in the right main bronchus, it is very easy to mistake the right middle lobe bronchus for the left main bronchus. Only if one can manipulate the tip of the instrument so that all the major anatomic landmarks can be unequivocally identified can one be certain of the location of the tip of the instrument.

Flexible bronoscopes are expensive and fragile, and there are many potential pitfalls which lead to their damage or destruction. Untrained assistants may easily break the image or light bundles, while exposure to high temperatures (inadvertent autoclaving or gas sterilization at too high a temperature) may destroy the bronchoscope. Newer models are immersible and do not require gas sterilization. However, they must be fitted with an exhaust valve to prevent damage from increased pressures within the instrument during sterilization. Another major risk is associated with oral passage of the instrument; bite blocks are essential, even in intubated patients who appear to be unconscious.

Nosocomial infection is a constant risk if the bronchoscope is not adequately cleaned and disinfected prior to use. Even with immersion in sterilizing solutions, microbial agents may survive beneath mucus adherent to the interior of suction valves or the suction channel. It is important to thoroughly clean and brush the entire instrument with each cleaning. Suction valves must be disassembled for cleaning. The suction side arm must also be brushed clean; contamination here may not infect the patient but it may well lead to erroneous diagnostic results.

**AIRWAY DYNAMICS**

Abnormal airway dynamics (laryngomalacia, tracheomalacia, bronchomalacia) are frequently seen during pediatric bronchoscopy. One must be careful not to overdiagnose dynamic changes in airway caliber as pathologic states. In general, one should be able to visualize change in the airway size sufficient to cause symptoms before making a diagnosis of tracheomalacia or bronchomalacia. In other words, one should see the opposite walls of the airways touch or nearly touch each other, at least during coughing. The presence of the flexible bronchoscope may increase airway resistance to the point that normal dynamics are exaggerated. Therefore, the diagnosis should also be consis-
tent with the clinical history of the patient or radiographic findings. A patient suspected of having tracheomalacia or bronchomalacia must also be examined under conditions which will produce sufficient changes in intrathoracic pressure to demonstrate the abnormal airway dynamics. I have seen a number of children who had very significant airway collapse during flexible bronchoscopy but in whom rigid bronchoscopy under general anesthesia failed to demonstrate any abnormality. Likewise, children with stridor should usually be examined while they are stridulous—the vibrating structures should then always be visible.

Occasionally, dynamic changes occur so rapidly that it may be difficult to comprehend the nature of the event unless it occurs repeatedly. The use of an endoscopic video camera and a tape recorder will allow replay of the procedure in slow motion and facilitate the understanding of such events. Use of videotape may also prevent the unnecessary repetition of procedures. Videotape is a very useful tool for communicating findings to colleagues and families.

Evaluation of Infection/Inflammation

Bronchoscopy may be very helpful in the evaluation of a patient with lower airway infection, especially if there are unusual features of the clinical picture or if the patient cannot produce sputum. However, just as expectorated material may not be representative of the lower airways, or may be contaminated with upper airway or oral secretions, specimens obtained with a bronchoscope must be subjected to serious scrutiny. Pediatric flexible bronoscopes are too small to use currently available protected microbiology specimen brushes, so bacteriologic specimens must be obtained by aspiration, with or without saline solution lavage. Great care must be taken to avoid contamination of the instrument with nasal or oral secretions; this is not always possible. Excessive use of topical lidocaine solution can wash oral secretions into the lower airways, and lidocaine can be bacteriostatic itself. It is useful to compare a specimen obtained from the oropharynx with bronchial washings (nonbacteriostatic saline solution must be used for washings), and also to use quantitative cultures. The cytology of the washings should be studied; a polymicrobial specimen containing few polymorphonuclear leukocytes does not likely indicate lower airway infection.

When larger bronoscopes are used, with protected microbiology brushes, there is still great potential for diagnostic error. Once the larynx has been anesthetized, patients may aspirate oral secretions, especially if they are in a Fowler’s or reverse Trendelenburg’s position. Thus, it is quite possible to obtain a specimen which is contaminated with oral secretions which have been aspirated during the procedure or in preparation for the procedure. Specimens obtained by brushing should be cultured quantitatively and should be transported to the microbiology laboratory in nonnutritive media.

Anesthesia, Sedation, and Monitoring

Inadequate or inappropriate monitoring of the patient during the procedure is another major potential pitfall. Bronchoscopy is fun and interesting. Often everyone in the bronchoscopy suite becomes so engrossed in the endoscopic findings that it is easy to forget about the patient and his physiologic status. Bronchoscopist’s hypnosis is a real phenomenon! Even with otherwise appropriate electronic monitoring, the patient must be continuously observed by someone other than the bronchoscopist.

Flexible bronchoscopy is usually performed in children with sedation and topical anesthesia rather than with general anesthesia. In my practice, sedative agents are almost always given by the IV route. Unfortunately, sedation of children is fraught with many potential pitfalls. Some of the most common problems include starting the procedure before the child is sufficiently sedated and not using enough sedation to begin with, then trying to achieve sedation after the child has become agitated and excited. Another common pitfall is waiting an insufficient time following the administration of a fractional dose of sedative agent before repeating the dose, thus producing oversedation. Particularly anxious children may require presedation, and it may be very helpful to have IV access established prior to bringing the child to the procedure suite. On the other hand, presedation (with agents such as chloral hydrate or “cardiac cocktail”) may make it difficult to determine how much additional sedative agent may be safely given once the child is in the procedure room.

Children are very susceptible to suggestion, and attention to hypnotic principles can be very beneficial. Many procedures are much more difficult than they should be, for both the patient and the medical staff, because of inappropriate information which has been given to the patient before or during the procedure. All conversation in the procedure room should be made with an acute awareness of its potential effect on the patient. Such expressions as “hurt,” “pain,” or “oops!” have no place in the bronchoscopy room.

Following bronchoscopy, the patient must be adequately monitored until he is sufficiently awake and stable before discharge.

The Problem of Concurrent Lesions

Bronchoscopists, especially pediatric bronchoscopists, cannot be medical unitarians. Children frequently have multiple abnormalities in their airways.17 Even when a finding explains the child’s symptoms,
other abnormalities may lurk around the corner. For example, in 15 percent of children whom I have examined for stridor and in whom a plausible explanation for the stridor was found at the subglottis or above, there was in addition a significant lesion in the trachea or bronchi. Unless there are good reasons not to do so, a thorough examination should be made of the entire airway during each examination.

When multiple lesions are found, it can sometimes be difficult to determine which lesion is most important or contributes most to the patient's problem. This may usually be resolved by careful observation under conditions which most nearly mimic those under which the symptoms occur and by paying careful attention to physiologic principles.

**Technical Problems**

Finally, there are a number of technical problems which merit mention in the context of pitfalls.

*The Difficult Nasal Passage*

Almost everyone's nasal airways are somewhat asymmetric. While the amount of pressure which can safely and reasonably be used to insert a flexible bronchoscope is a matter of some experience and learning, one should not hesitate to attempt to pass through the opposite nostril if difficulty is encountered initially. The nostril should be gently but thoroughly aspirated of secretions prior to attempted insertion of the bronchoscope, and the use of a topical vasoconstrictor may be of benefit. In general, the middle meatus, between the middle and lower turbinate, usually affords the easiest passage for the bronchoscope. The bronchoscope should be inserted parallel to the floor of the nose, and not directed upwards toward the glabella. If the light from the tip of the bronchoscope can be seen near the glabella, it is likely that the instrument is directed in the wrong direction. I have encountered only three patients in whom transnasal passage of the flexible bronchoscope was not possible. Even infants as small as 700 g easily admit the 3.5-mm pediatric flexible bronchoscope through their noses.

*Pharyngeal Hypotonia*

Patients with tracheostomies or who have decreased muscle tone because of muscle or CNS disease often have pharyngeal hypotonia. This may make it very difficult to find the larynx. Obstruction of the tracheostomy tube for several breaths will force the patient to make increased inspiratory effort, recruiting the hypopharyngeal musculature, and often dramatically opening the supraglottic airway. Alternatively, oxygen can be insufflated through the suction channel of the bronchoscope (at a rate of 1 to 3 L/min in infants) to distend the hypopharynx. If one is using an ultrathin instrument without a suction channel, a suction catheter can be inserted through the opposite nostril and oxygen passed through the catheter to achieve the same result. Care must be taken not to pass the catheter down the esophagus, distending the stomach and abdomen, and thus embarrassing ventilation. Yet another technique is to ventilate the patient through a nasopharyngeal tube while passing the bronchoscope through the other nostril. An orogastric tube may be used to relieve gastric distention in this technique. In extremis, one may expose the larynx with a rigid laryngoscope while passing the flexible bronchoscope through the nostril.

*Nasotracheal Intubation*

In my personal experience, it has rarely required more than 30 s to accomplish nasotracheal intubation with a flexible bronchoscope. The smallest of the ultrathin instruments with distal angulation (2.2 mm, Olympus PF22) will pass through a 2.5-mm endotracheal tube, so this technique is at least in theory available to everyone. A common pitfall in this technique is to pass the endotracheal tube into the posterior nasopharynx prior to passage of the bronchoscope into the tube. This severely restricts the mobility of the tip of the bronchoscope and the ability to identify the laryngeal structures. Instead, the endotracheal tube should be placed over the bronchoscope and positioned as far proximally on the shaft of the instrument as possible. The tip of the bronchoscope should first be passed to the carina and then the endotracheal tube passed through the nostril and glottis into the trachea. Unless the operator keeps the carina in view during the entire procedure, the tip of the bronchoscope may inadvertently slip into the esophagus as the endotracheal tube is positioned. A rotating motion should be used as the tube traverses the nose and larynx; this reduces friction against the bronchoscope and facilitates safe and effective passage through the nose and especially the glottis. If an endotracheal tube is used which is relatively large in relation to the bronchoscope, it may be difficult to cannulate the glottis, since the tip of the tube may hang up on the vocal cords or arytenoids. Furthermore, small flexible bronchoscopes may be damaged if they are used with larger endotracheal tubes. The 3.5-mm flexible bronchoscope should be used with tubes ranging in size from 4.5 to 6 mm in diameter, the 4.9-mm flexible bronchoscope (standard adult size) with tubes larger than 6 mm, and ultrathin instruments for tubes 4.0 mm or smaller.

*Thick Secretions*

The suction channel of the 3.5-mm pediatric flexible bronchoscope (Olympus BF3C4/10/20) is only 1.2 mm in diameter, and thick secretions may obstruct the
channel. Direct suctioning of the nose and pharynx with a catheter prior to insertion of the bronchoscope is helpful. Once in the lower airways, thick secretions must be manipulated with the bronchoscope. Small volume saline solution lavage (3 to 5 ml) may loosen secretions and facilitate their removal. However, mucous plugs may have the consistency of dry rubber cement; on rare occasions I have had to resort to a rigid bronchoscope for removal of extremely tenacious central mucus plugs. If the tip of the bronchoscope is placed onto the mucus plug and suction applied continuously, then the bronchoscope is slowly withdrawn, and the mucus plug may be removed from the airway along with the bronchoscope. I have often retrieved mucus plugs much larger in diameter than the bronchoscope itself in this fashion. If the patient is very small and is not ventilating well, this procedure must be completed within 30 s or so. Frequently, the mucus plug will dislodge itself from the suction channel, and another attempt must be made. As long as nothing is visible through the lens of the bronchoscope as it is being continuously withdrawn, there is mucus on the end of the instrument.

Mucolytic agents (eg, N-acetylcysteine) can be instilled through the bronchoscope to facilitate bronchial toilet. However, solutions more concentrated than 1 percent are hypertonic and very irritating; large volumes should not be used.

Bronchoalveolar Lavage

Bronchoalveolar lavage is often used in adult patients for a variety of diagnostic purposes. In children, standards for technique, as well as normal values, have yet to be defined. There are several potential pitfalls. If the tip of the bronchoscope is not wedged into an airway, much of the saline solution instilled through the suction channel may be distributed into adjacent or proximal airways, leading to coughing, aspiration of fluid into other areas of the lungs, and loss of specimen volume. The suction channel (in Olympus bronchoscopes) is located at 2 o’clock from the marker on the circumference of the bronchoscope image which identifies the plane of flexion. The lumen of the airway into which the tip of the instrument is wedged should be positioned to the upper right of the image. Total lavage volumes must be sufficient to permit the necessary diagnostic studies, but should not be excessive, as this may lead to respiratory compromise.

**Summary**

Flexible bronchoscopy is an important diagnostic technique for study of pediatric patients with pulmonary problems. Many pitfalls await the unwary, but with experience and care, most can be overcome or circumvented.

**References**