



Forty-Nine Ways to Get the Wrong Answer from a Bronchoscopy

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Robert E. Wood

Bronchoscopy is an important aspect of the practice of pediatric pulmonology. The ability to examine and sample the airways of a child adds immeasurably to the diagnostic accuracy and appropriateness of therapeutic measures subsequently employed. Bronchoscopy is a serious procedure that should not be undertaken for trivial reasons, but on the other hand, it is very likely underutilized in contemporary pediatric pulmonary practice. Care must be taken to perform the procedure safely and properly. While every human activity entails some degree of risk, and bronchoscopy is no exception, the incidence of complications of flexible bronchoscopy in pediatric patients is gratifyingly low. However, a more subtle complication is cognitive: *Other than death of the patient, the most serious complication of a diagnostic bronchoscopy is to have done the procedure, and gotten the wrong answer.*

There are many ways to get the wrong answer from a diagnostic bronchoscopy. The following discussion is based on nearly 50 years of doing bronchoscopies and observing my colleagues doing bronchoscopies.

1. Not knowing what you are looking for: A bronchoscopy is always a search for specific information. Clearly, there must be a specific

indication for the procedure. If the physician performing the bronchoscopy is not the primary managing pulmonologist, there is a significant potential for missing things if there is no very clear and complete communication in advance of the procedure. “If you don’t know where you are going, you are very likely to wind up somewhere else...”

2. Not knowing the history of the patient may cause you to order the wrong lab studies or to overlook pathology you would otherwise have identified. We typically do not order mycobacterial studies on pediatric bronchoalveolar lavage (BAL) specimens, for example, but if we are aware of a pertinent history, this might be a crucial aspect of the bronchoscopy.
3. Not looking at relevant radiographs prior to the procedure may cause you to sample the wrong portion(s) of the bronchial tree. The right middle lobe and the lingula are often cited as the “preferred” sites for BAL, but we must not forget Sutton’s Law – “go where the money is.” Some years ago, a patient of mine, a lung transplant recipient, came in with a left lower lobe pneumonia. The transplant team decided (I was out of town) to perform a bronchoscopy to guide subsequent therapy. Assuming that the boy had uniform disease, the pulmonologist lavaged the right middle lobe only; the cultures were sterile and the BAL cytology revealed no signs of

R. E. Wood (✉)
Division of Pulmonary Medicine,
Cincinnati Children’s Hospital, Cincinnati, OH, USA
e-mail: RobertE.Wood@cchmc.org

inflammation. Several hours later, I returned from my journey, and repeated the bronchoscopy. The BAL from the left lower lobe grew $>10,000,000$ cfu/ml of *Burkholderia cepacia* and the cytology revealed a pure exudate. This bronchoscopist not only failed to look at the radiographs but also violated a number of the other points in this essay – the erroneous result could have led to the death of the patient. After all, we had “proven” that the child did not have bacterial pneumonia, by doing the most definitive test – a bronchoscopy! Therefore, the conclusion was that antibiotics were not needed.

4. Not understanding that the patient may be immunodeficient may cause you to order the wrong BAL assays. Typically, we do not order every possible assay on routine bronchoscopies, but in immunocompromised patients, special studies may be crucial.
5. Not understanding that the patient may be neutropenic may cause you to believe that pathogens identified in BAL culture are inconsequential, since there are no polymorphonuclear neutrophils (PMNs) in the BAL. I have established a new diagnosis of an immune deficiency in at least three patients who had pathogens but no neutrophils in the BAL specimen.
6. Obtaining the BAL from the wrong place: Sutton's law.
7. Not examining the entire bronchial tree: Patients often have more than one abnormality or more than one foreign body (fragments). It can be very easy to miss important abnormalities if the entire bronchial tree is not examined. When I am called to perform a bronchoscopic intubation, I always take a few seconds to examine the entire bronchial tree, and in a very substantial percentage of the patients, I find something of importance. Especially in this setting, clearing the bronchi of obstructing secretions can make the subsequent anesthetic session safer for the patient. And if you do aspirate mucus plugs, etc., in this situation, the aspirated material should, at the very least, be cultured. Give the patient the full benefit of the procedure.
8. Using sedation that is too deep may cause you to miss important dynamic abnormalities or to over-diagnose. Flexible bronchoscopy is often employed (as it should be) in the evaluation of children with stridor. Stridor is always visible; if the noise can be heard but the vibrating structures are not seen, the only possible explanation is that the wrong part of the airway is being visualized. Conversely, in a patient with a history of noisy breathing, the examination must be performed under conditions that reproduce the noise. Deep sedation, with low inspiratory flow rates, is very likely to result in a failure to understand the patient's physiology. It is often most useful, I have found, to perform the dynamic aspect of the bronchoscopy after obtaining the BAL specimen (see below for an expansion on this concept), then lighten the sedation to allow a more careful evaluation of the airway dynamics. This applies to the upper and to the lower airways. If the sedation is too deep, it is also possible to make a false-positive diagnosis – the observed dynamic abnormalities must correspond to the clinical history. It is not unusual to find what appears to be very impressive glossoptosis in a child with no history of obstructive sleep apnea (OSA). This may be a false-positive finding, induced by sedation, or it could also be that the history is incomplete (parents of teenagers often are not aware of the symptoms of OSA and wonder why the child is sleepy during the day).
9. Using sedation that is not deep enough may cause you to not see much of anything or to terminate the procedure prematurely. The advantage of having the assistance of an experienced pediatric anesthesiologist is that the level of sedation can be titrated with short-acting drugs. To terminate a procedure because of inadequate sedation is an invitation to missed diagnoses. Change the level of sedation, then complete the examination.
10. Using a laryngeal mask airway (LMA) for routine bronchoscopy will cause you to completely bypass the upper airway and miss a lot of pathology. This, unfortunately, in my

not-so-humble opinion, is the cause of many erroneous diagnoses in pediatric patients. Unless there is a valid reason otherwise (and “unstable upper airway obstruction” is not one of them, since in that case, it is mandatory to evaluate the upper airway and definitively explain the causes of the obstruction if they are not already well defined by a prior procedure), the flexible bronchoscope should be passed transnasally – the airways begin *at the nostril*.

11. Using an endotracheal tube (ETT) for routine bronchoscopy will cause you to completely bypass the upper airway and miss a lot of pathology. Ditto from the LMA (#10 above).
12. Not using an ETT when the primary indication for the procedure is to obtain BAL cultures in an immunocompromised or a patient with cystic fibrosis (CF). Passing a flexible bronchoscope through the native upper airway can lead to contamination of the subsequent BAL specimen, if suctioning is done in the process of reaching the BAL site. Most bronchoscopies performed in immunocompromised patients are done purely for the BAL data, and the anatomy and dynamics of the upper airway are not at issue. Every measure possible should be taken to obtain as clean a specimen as possible. In a supine patient, there is a 30° downhill slope from the larynx to the carina, and oral secretions can and do slide down the trachea with great alacrity. Visualize the giant ski jump at the Winter Olympics.
13. Using positive-pressure ventilation when evaluating for dynamic problems: This will mask tracheomalacia and bronchomalacia, especially if positive end-expiratory pressure (PEEP) is involved as well. A subtle variation on this is the expiratory resistance produced by the presence of the bronchoscope in an artificial airway (“inadvertent PEEP”).
14. Not observing the patient cough when evaluating for dynamic problems – may cause you to miss significant dynamic collapse. The visual evaluation of airway dynamics is imprecise at best, and the evaluation of tracheomalacia is often challenging. Many patients who have a history of symptoms such as exercise-induced asthma (EIA), recurrent croup, or a deep brassy sounding cough may demonstrate significant dynamic collapse only during vigorous expiratory effort, especially a cough. Insisting on having the patient light enough to see cough will drive anesthesiologists crazy, and is best done at the end of the procedure, lightening the sedation in preparation for awakening the patient, but before removing the bronchoscope from the airways.
15. Not clearing secretions to see the anatomy clearly enough: Your mother taught you how to vacuum clean, so do it! ☺.
16. Allowing the patient to aspirate saliva prior to obtaining BAL specimen: Take every reasonable measure to get an uncontaminated specimen; start as soon after induction of sedation as possible, and go straight to the preselected BAL target area – see #12 above. It is useful to start the procedure with a deeper level of sedation, rapidly reach the BAL target, and then examine the airway anatomy and dynamics more leisurely, when suctioning can be performed without worrying about contaminating the BAL specimen.
17. Not understanding that a “protected brush” specimen does not eliminate contamination from upper airway secretions aspirated during the procedure. These devices are rarely used in pediatric practice, but are standard procedure in adult patients. They will enable one to obtain a specimen uncontaminated by things suctioned through the bronchoscope prior to passing the brush, but all too often the specimen collected is a representative sample of what has been aspirated during the procedure.
18. Using a flexible instrument when a rigid instrument is more appropriate/effective: Flexible instruments are very limited in their ability to accurately evaluate the posterior aspects of the larynx and subglottic space. Specifically, one cannot manipulate the tissue in such a way as to definitively demonstrate minor laryngoesophageal clefts

- (a surprisingly common finding in children with a history of aspiration). I have even had difficulty finding Type II or even Type III clefts, knowing they were there, with a flexible scope. In any child suspected of aspiration, rigid laryngoscopy rather than flexible laryngoscopy is much more likely to yield an accurate anatomic diagnosis.
19. Using a rigid instrument when a flexible instrument is more appropriate/effective: This is especially true of the upper airway dynamics. It is extremely difficult, if not impossible, to evaluate glossoptosis, for example, with a rigid instrument. Most other dynamic upper airway abnormalities are much more readily evaluated with a flexible scope passed transnasally.
 20. Failing to use both rigid and flexible instruments when both are needed: Consider the entire spectrum of questions the proposed procedure is tasked to address. Analysis of a BAL specimen is often crucial to effective management (e.g., infection, inflammation, and aspiration), and it is very challenging to obtain a good BAL specimen with a rigid bronchoscope.
 21. Failing to examine peripheral bronchi: In many patients, the pathology may lie in fifth-generation bronchi or beyond. If the examination is limited to segmental bronchi, much can be missed.
 22. Contaminating the bronchoscope during passage through the upper airway: Do not attach the suction line to the bronchoscope until the tip of the instrument is near the preselected BAL site. It can also be useful to insufflate oxygen through the suction port continuously until the tip of the bronchoscope reaches the carina (2–3 lpm). Obviously, one *should not* wedge the tip of the bronchoscope in a peripheral bronchus while insufflating, as pneumothorax may occur. But the use of oxygen insufflation can be helpful also to distend soft tissue in the nasopharynx or around the larynx, and it also benefits the patient's oxygenation.
 23. Not performing the bronchoscopy when it should be done: Physicians may be reluctant to perform a procedure such as flexible bronchoscopy, perceiving the cost/risk/inconvenience to outweigh the potential benefit. In at least two-thirds of patients in whom I initially declined to do a bronchoscopy, subsequently, I discovered my mistake and found significant pathology when I finally did so.
 24. Not performing a BAL when it was needed: Just because the airways look "clean," it does not mean that a BAL will be normal. Clearly, a BAL is not needed with *every* flexible bronchoscopy, but before deciding not to do so, the bronchoscopist should think carefully about the global clinical picture of the patient, and err on the side of conservatism by obtaining and analyzing a BAL sample.
 25. Not recognizing the anatomy" *Res ipsa loquitur*.
 26. Not recognizing the pathology: Airway pathology can be subtle. I am frequently asked to help evaluate a suspected airway problem on the basis of photographic images obtained during a bronchoscopy at another institution. While sometimes I can help, I must point out that a still image of a bronchoscopic finding is vastly inferior to a video recording, which gives multiple images as well as much better perspective.
 27. Failing to take the proper specimen (biopsy, brushing) for the observed pathology: However, one must carefully assess risk/benefit in the given situation. Transbronchial biopsy in pediatric patients results in very small specimens with an associated high risk of hemorrhage – my lung transplant surgeon often claimed, "unless you get 100 ml of blood with a transbronchial biopsy, you probably don't have an adequate tissue specimen." I am sure he was exaggerating *a bit*, but if a sample of tissue is needed, carefully consider all the options and choose the most likely option to result in a diagnosis with the least risk. Endobronchial biopsies are much safer than transbronchial, and the pediatric pulmonologist should not be unwilling to do them unless there appears to be a high risk of hemorrhage. Bronchial brushings are relatively very safe, but of limited diagnostic

utility in pediatric patients (except for the evaluation of suspected primary ciliary dyskinesia). To avoid losing most of the specimen, bronchial brushings should be done with the bronchoscope passed through an endotracheal or tracheostomy tube, and the brush should not be withdrawn into the tip of the bronchoscope.

28. Assuming that the pathology is uniform throughout the lungs: You may often need to obtain BAL specimens from multiple locations. Several studies have shown markedly different bacterial flora and cytologic results on BAL specimens taken from multiple sites in the same patient on the same procedure. See also #3 above.
29. Failure to make and keep a video recording of the procedure for future reference: Video recording is crucial! See #30. I have sometimes discovered a significant anatomic abnormality upon review of the video recording (in one case, 1 year later) that I did not appreciate at the moment, during the procedure. For consultation, for teaching, and for comparing findings with those from a previous bronchoscopy on the same patient, a video recording is essential. At CCHMC, every endoscopic procedure is recorded and stored in an online accessible video database, going back to 2006. This video archive is of inestimable value in patient care. I have also testified in several medicolegal cases in which, had the bronchoscopist merely been able to present a video of the procedure, the lawsuit would have been dismissed immediately.
30. Forgetting what was seen before documenting in the patient's medical record: This is all too common! Even the most experienced bronchoscopist – and I surely include myself in this – can (and will) forget the details of the endoscopic findings if the written procedure report is not generated immediately after completion of the procedure (and sometimes even then ☹).
31. Using the wrong technique for BAL: The volume of saline used for BAL must be sufficient to ensure that at least some of the fluid recovered represents alveolar surface liquid. Clearly, too little volume can lead to erroneous results. The only problem is that it is never absolutely clear just what volume is needed. If the tip of the bronchoscope is gently wedged into the bronchus, presumably most if not all of the lung volume distal to that point will be included in the sampling. However, the bronchial generation into which the scope can be wedged is dependent on two major factors: the size of the patient and diameter of the bronchoscope. One might also add the enthusiasm with which the bronchoscopist “wedges” the scope. Problems can also arise when withdrawing the instilled fluid, especially in patients with readily collapsible bronchi (bronchomalacia). When the volume returned is small in proportion to the volume instilled, most of the fluid may represent “dead space” and the specimen may be significantly diluted, sometimes to the point of becoming uninterpretable.
32. Failure to properly interpret BAL data: The pediatric bronchoscopist must ensure that the cytopathologist studying the specimen performs the appropriate stains and interprets the data properly, in the context of the patient's history and the endoscopic findings. In a hospital with a small pediatric presence, the cytopathologist may only be accustomed to dealing with specimens from adults, and may review the slides and report “no malignant cells identified” – full stop. The bronchoscopist should make friends with the cytopathologist and review slides together, at least until there is mutual confidence in the validity and consistency of the interpretations. The bronchoscopist and pathologist can educate each other in the process.
33. Failure to interpret BAL data in the context of the patient's history and the procedural details: The absence of lipid laden macrophages does not mean the patient is not aspirating, especially if the patient is being fed via gastro-jejunal (GJ) tube, for example. If a patient has been given antibiotics just prior to the procedure, there may be detectable levels of the antibiotic in the BAL specimen.

34. Failure to process the BAL specimen promptly: Bacteria die or multiply, and cells die or adhere to the walls of the specimen container. If the specimen is delivered to the laboratory after hours, and sits on a shelf (or even in a refrigerator) overnight, the final results may be very different than that from a fresh specimen.
 35. Not getting the BAL specimen to the proper laboratory: The analysis will not get done in a timely fashion.
 36. Not getting the BAL specimen to the laboratory at all: *res ipsa loquitur*. Do not depend on the hospital courier system; if in doubt, take it to the lab yourself!
 37. Allowing a trainee to do the procedure while not paying close attention: The tip of the bronchoscope can flip from one lobe to another in the blink of an eye, and result in obtaining specimens from the wrong anatomic location, etc.
 38. Using an instrument that is damaged.
 39. Using an instrument that has not been properly cleaned: There have been mini-epidemics caused by improper cleaning of instruments. There have also been mini-pseudo-epidemics, where the specimens were contaminated, but not the patient, again, due to improper cleaning.
 40. Not completing the procedure because of perceived difficulties: You may need to stop, allow the patient to settle down, or even to intubate the patient. Unless there is a legitimate danger to the life of the patient, it should always be the rule that the goals of the procedure are accomplished before terminating.
 41. Failure to alter the conditions of the procedure if the dynamic observations are inconsistent with the patient's history (i.e. history of stridor, but no audible stridor during the procedure).
 42. Evaluating the upper airway dynamics with the head/neck in the wrong position: Even a very small change in the angle of the neck or elevation of the mandible can have dramatic effects on the airway dynamics.
 43. Evaluating the upper airway dynamics with the wrong level of inspiratory effort: Often, impressive laryngomalacia is not seen until the patient is breathing much more vigorously.
 44. Applying excessive topical anesthesia to the larynx, thereby causing aspiration of oral secretions: This is one of the reasons why, when doing multidisciplinary procedures (i.e., both rigid and flexible bronchoscopy), the flexible bronchoscopy should be done first. The laryngotracheal anesthesia (LTA) typically employed by the rigid bronchoscopists usually involves instilling 4–5 ml of lidocaine into the trachea and hypopharynx; this is guaranteed to wash a considerable amount of oral secretions into the trachea and bronchi.
 45. Performing the flexible bronchoscopy after rigid endoscopy (the delay and manipulation allow aspiration of oral secretions – See #44).
 46. Using a bronchoscope of the wrong size: Larger scopes obstruct more of the airway and limit correct interpretation of dynamics and reduce the potential to visualize more peripheral bronchi. Larger bronchoscopes, with larger suction channels, may result in more mucosal trauma, with bleeding, and also may confuse the interpretation of airway dynamics.
 47. Doing the bronchoscopy at the wrong time: Sometimes, it may be most informative to do the bronchoscopy when the patient is ill, rather than wait until recovery.
 48. Doing the bronchoscopy after the patient has been given antibiotics: False-negative cultures.
 49. Failure to obtain ancillary data (i.e., to do a bronchogram, or a simultaneous esophagoscopy).
- I am certain that there are many other ways to get the wrong result from a diagnostic bronchoscopy, but these points are offered to lead the reader to perform the most important aspect of bronchoscopy – THINK!