Understanding the basics of rigid bronchoscopy

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Abstract: In the assessment of central airway obstruction and disease, no imaging technique is an adequate substitute for bronchoscopy. The indications for rigid bronchoscopy include multiple malignant and benign disorders, with most interventions performed for treatment of complications of lung cancer. The rigid bronchoscope is a useful tool for managing most types of airway stenoses, and it facilitates other endobronchial therapies, including stent placement, argon plasma coagulation, balloon dilatation, electrocautery probes, and laser therapy. Certain patients with benign lesions or postintubation or post-tracheostomy stenosis may benefit from rigid bronchoscopic techniques instead of surgery. Although use of the rigid bronchoscope requires general anesthesia, it provides a stable airway and often results in fast removal of foreign bodies. (J Respir Dis. 2006;27(3):100-113)

For over 100 years, rigid bronchoscopy has been used to view the lower respiratory tract, and today this procedure has new applications in the emerging area of interventional bronchoscopy. Although bronchoscopes are simply designed, their use requires an experienced operator who is familiar with airway disease and the technical aspects of the procedure (Figure 1). Because rigid bronchoscopy requires the use of general anesthesia in the operating room, an experienced anesthesiologist who understands sedation and control of ventilation during airway procedures is also essential. In this setting, rigid bronchoscopy is performed safely with infrequent complications.

The rigid bronchoscope is a useful tool for treating patients with most types of airway stenoses, and it facilitates other endobronchial therapies, including stent placement, argon plasma coagulation (APC), balloon dilatation, electrocautery probes, and laser therapy. Because lung cancer remains a common problem, pulmonologists and primary care physicians will increasingly recognize treatable airway complications. In this article, we will review the indications and contraindications for rigid bronchoscopy. We will describe the procedure, associated complications, and use in central airway obstruction. Background

Rigid bronchoscopy was first performed by German otolaryngologist Gustav Killian in 1897 to remove an aspirated pork bone. Killian, who is often referred to as the "father of bronchoscopy," continued to develop new bronchoscopes and techniques. Around this time, American laryngologist Chevalier Jackson made significant advances in the field of endoscopy; these included designing new equipment, teaching bronchoesophagology, and establishing safety techniques. In the 1960s, the development of the flexible bronroscope by Shigeto Ikeda in Japan revolutionized the field of bronchoscopy and helped expand the procedure beyond the realm of the surgeon to that of the pulmonologist. Over the next 10 years, flexible bronchoscopy replaced rigid bronchoscopy as an easier procedure for the patient and the physician. As a result, few modern pulmonologists have significant training or proficiency in rigid bronchoscopy.

In 1991, an American College of Chest Physicians (ACCP) bronchoscopy survey revealed that 8% of pulmonologists in North America were performing rigid bronchoscopy. By 1999, only 5% of surveyed pulmonologists had performed this procedure in the previous year. Renewed interest in rigid bronchoscopy is largely a result of an evolving arsenal of tools to treat the airway manifestations of lung cancer. Worldwide, the mortality rate for lung cancer is higher than the combined rates for breast, colorectal, and cervical cancers. One million deaths were attributed to lung cancer in 2001, with the global incidence increasing 0.5% per year. Survival continues to be poor, and a significant percentage of cases of lung cancer involve endotracheal or endobronchial disease. Thus, we can expect to see a continued need for rigid bronchoscopic techniques for years to come. Indications

The indications for rigid bronchoscopy include multiple malignant and benign disorders, with most interventions performed for the treatment of lung cancer involving the airway. Malignant airway stenosis and obstruction

About 20% of patients with lung cancer may have central airway obstruction as the initial manifestation of disease, and most patients will have airway obstruction at some point during the
disease course. Other malignant and metastatic causes of airway obstruction include tumors of the thyroid, colon, esophagus, and breast; renal cell carcinoma; melanoma; and lymphoma (Table 1). Rigid bronchoscopy is an excellent tool for relieving large-airway obstruction. The bronchoscope itself can be used to resect lesions (by mechanically shearing off a tumor) and dilate the affected airway. The large working channel allows the use of larger forceps for removal of larger pieces of tissue than is possible with the smaller channel of the flexible bronchoscope. The rigid bronchoscope facilitates the use of many adjunctive techniques, including laser therapy, electrocautery probes, cryotherapy, and APC. These modalities may be used to debulk a tumor or achieve hemostasis before and after tumor resection. Silicone stents, which frequently help restore airway patency, require rigid bronchoscopy for placement. Dilating balloons can be placed easily through the rigid bronchoscope to help open obstructed airways.

In addition to malignant airway obstruction from endobronchial tumors and bronchogenic carcinoma, other primary or metastatic tumors can cause airway obstruction by extrinsic compression. This is especially true of bulky mediastinal tumors, such as small-cell carcinoma of the lung, lymphoma, esophageal carcinoma, germ cell tumors, and thymic or thyroid carcinomas. Significant extrinsic compression of a major airway may be dilated by the rigid bronchoscope or by a balloon. A silicone or metal stent may be placed to maintain airway patency.

Benign airway stenosis and obstruction
Many nonmalignant conditions can lead to stenosis of the trachea or large bronchi (Table 2). Tracheal stenosis can occur after endotracheal intubation or in patients with a history of tracheostomy. About 12% to 19% of patients with a history of endotracheal intubation may have some degree of tracheal narrowing, and a small percentage of these persons have symptoms. This form of tracheal stenosis has been reported following short-term intubation and many years after intubation. Tracheal stenosis has been found in about 14% of patients with long-term tracheostomy. Although resection is often preferred for benign postintubation or post-tracheostomy stenosis, many patients are not surgical candidates because of their particular airway anatomy or comorbidities. The rigid bronchoscope or one combined with a balloon dilator can be used to mechanically dilate this type of stenosis. Laser therapy can facilitate a mucosal-sparing technique of dilatation with the rigid bronchoscope.

About 58% of patients with long-term tracheostomy may have significant endotracheal granulation tissue. Many of the same techniques used in benign postintubation or post-tracheostomy stenosis may be used in the treatment of this disorder. Uncommon manifestations of infectious diseases such as tuberculosis, histoplasmosis, and coccidioidomycosis can cause airway stenosis. Inflammatory diseases, such as Wegener granulomatosis, or remote trauma can lead to benign stenosis. Idiopathic subglottic stenosis is a rare narrowing of the proximal trachea without an obvious cause; it occurs more frequently in females than in males and occurs over a wide age range. It is important to recognize that subglottic stenosis (idiopathic or from other causes) represents a special subgroup of airway stenoses that often requires different treatment. Patients who have undergone lung transplantation may have stenosis at the anastomosis site in a main-stem bronchus. Other known causes of benign stenosis include sarcoidosis, radiation therapy, inhalation injury, and congenital anomalies. Depending on the anatomic features of the airway lesions and the medical condition of the patient, many benign lesions may be treated with rigid bronchoscopic techniques instead of surgery.

Tracheal or bronchial obstruction can be caused by benign endobronchial tumors, such as papillomas, polyps, and hamartomas. Benign structures in the mediastinum—including goiter and aortic aneurysm—and lymphadenopathy can cause obstruction by extrinsic compression. Tracheobronchomalacia is a chronic airway condition that can also cause significant airway obstruction. This disorder consists of a widened, hyperdynamic posterior membranous wall; decreased anteroposterior airway diameter; and weakened surrounding tracheal cartilage. Each of these benign causes of airway stenosis or obstruction may be treated with some combination of rigid bronchoscopic dilatation, balloon dilatation, laser therapy, electrocautery probes, APC, or stent placement.

Massive hemoptysis
In cases of massive hemoptysis, initial lower respiratory tract examination is often performed using flexible fiberoptic bronchoscopy. However, rigid bronchoscopy has several advantages over flexible bronchoscopy in this setting. Most important, the size of the channel of the rigid bronchoscope allows for insertion of large or...
multiple suction catheters, which are more effective in evacuating blood and clots than are catheters used in the small channel of the flexible bronchoscope. The rigid bronchoscope can be used to tamponade bleeding lesions in the central airways and to facilitate the use of other coagulating devices, including the laser, electrocautery device, and APC. **Foreign-body removal**

Most bronchoscopists attempt retrieval with a flexible bronchoscope because of their experience with this instrument. Although use of the rigid bronchoscope requires general anesthesia, it provides a stable airway and often results in faster removal of the foreign body.

Removal of foreign bodies with a flexible bronchoscope is successful in 60% to 90% of cases, but it can be time-consuming and result in a second procedure with a rigid bronchoscope. Because multiple removal attempts are often required with flexible bronchoscopy, a foreign body is more likely to be pushed distally. A foreign body may also drop into an unaffected area of the lung as a result of inadequate grasping with flexible instruments.

Rigid bronchoscopy is better suited for large aspirated items because of the size of the working channel and the ability to use larger instruments, such as optical grasping forceps. **Tracheoesophageal fistulas**

Abnormal connections between the bronchial tree and the esophagus usually develop with a malignancy; esophageal cancer is a more common cause than bronchogenic cancer. Other conditions reported to cause tracheoesophageal fistulas are trauma, prolonged intubation, ruptured esophageal diverticulum, tuberculosis, broncholithiasis, and a congenital anomaly.

Patients who have malignancies are often too ill to undergo surgery. Despite high mortality, these patients may benefit either from the placement of a tracheobronchial silicone stent by rigid bronchoscopy to cover the fistula or from the combined use of tracheobronchial and esophageal stents. Covered, self-expandable metallic or silicone stents can be used for these purposes.

**Contraindications**

There are few contraindications to rigid bronchoscopy. Often, the most limiting factors are those related to the safety of anesthesia. Risk assessment should focus on comorbid conditions that are routinely evaluated for any patient undergoing general anesthesia.

The presence of hypoxic respiratory failure, unstable cardiac disease, or arrhythmia likely prohibits a safe procedure. Other contraindications to rigid bronchoscopy include an unstable cervical spine; laryngeal stenosis; limited ability to open the jaw; and conditions that restrict cervical range of motion, such as severe kyphoscoliosis.

It is essential that the procedure be performed by a bronchoscopist experienced in rigid bronchoscopy and an anesthesiologist trained in rigid bronchoscopic ventilation. If there is a need to visualize or work beyond the main-stem or lobar bronchus, a flexible bronchoscope may be passed through the rigid bronchoscope. **RIGID BRONCHOSCOPIC PROCEDURE**

The rigid bronchoscope has not undergone significant change over the past century. Basically, it is a hollow metal tube with a smooth beveled edge on the distal end and a series of different-sized ports on the proximal end.

The beveled edge can be used to resect tumors and to help facilitate the passage of the bronchoscope through the vocal cords and airway stenoses. The ports are used for a connection to ventilation devices and for the passage of suction catheters or other instruments. Depending on the type of ventilation used, a port may be left open to allow room air into the system.

A typical bronchoscope is about 40 cm long, with diameters ranging from 9 to 13.5 mm. The bronchoscope is distinguished from the shorter rigid tracheoscope by a series of side holes on the distal end, allowing for ventilation of the opposite lung when the bronchoscope is placed deep into the right or left main-stem bronchus.

Rigid video telescopes are placed through the large operating channel of the bronchoscope to provide magnified imaging of the airways. A flexible bronchoscope can also be used through the rigid bronchoscope to visualize and treat more distal airways. Many other devices can be placed through the rigid bronchoscope, including a variety of balloon devices, biopsy forceps, cryotherapy probes, and several types of stents and stent deployment devices. **Anesthesia and ventilatory support**

Rigid bronchoscopy is usually performed with general anesthesia and standard anesthesia monitoring. General anesthesia allows for control of patient movement and cough, creating an operative field in which there is little motion.

Anesthetics can be given by inhalation or intravenously. Intravenous medications are preferred because of the technical difficulty in using inhaled agents in a bronchoscope that is open to room air. Commonly used medications include midazolam, fentanyl, and propofol (which allows rapid
Intubation. When symptoms are present. The patient should also be asked about a history of lung cancer or other diseases known to cause airway obstruction should raise suspicion. Less obstructive tracheal lesions or main-stem bronchial lesions may cause dyspnea with exertion. Limiting dyspnea usually does not occur until about 75% or more of the tracheal lumen is obstructed. In postintubation stenosis, symptoms often occur within 3 months of extubation. Some patients may receive treatment for asthma without improvement. Others may have difficulty in expectorating pulmonary secretions. The patient is placed in the supine position with protective eye covers and a tooth guard.

The trachea is positioned anteriorly by extending and placing a rolled towel under the patient's neck. Some bronchoscopists allow the patient's head to extend over the edge of the table, forcing the trachea into an anterior position. A telescope is placed through the rigid bronchoscope but is not allowed to extend beyond the distal end during insertion. One of 4 intubation techniques can be used to introduce the rigid bronchoscope into the airway. The technique selected may depend on the patient's anatomic features or, more important, on the experience of the bronchoscopist.

In the direct technique, the operator looks either directly down the bronchoscope or at the video image on a monitor. With the beveled edge in the anterior position, the bronchoscope is placed in the mouth, perpendicular to the patient. One hand serves as a guide to simultaneously stabilize the bronchoscope and protect the teeth. Once the uvula is in view, the operator's other hand and the bronchoscope are lowered and advanced, using the beveled tip to lift the epiglottis. The bronchoscope is rotated 90 degrees as it passes through the vocal cords and then is rotated back once in the trachea, so that the beveled tip is again in an anterior position. A gentle corkscrew motion is used to advance through the trachea while avoiding excessive pressure on the posterior tracheal wall. Some bronchoscopists prefer to keep the bevel along the posterior wall, suggesting that this position reduces risk of damage to the membranous trachea.

Direct laryngoscopy can be used to intubate with a rigid bronchoscope. The bronchoscope is inserted next to a straight-blade laryngoscope, and the laryngoscope is pulled back as the bronchoscope moves under the patient's epiglottis and into the trachea. The rigid bronchoscope can also be inserted alongside an existing endotracheal tube or through a laryngectomy stoma.

Complications

Most patients can safely undergo rigid bronchoscopy. In fact, many patients with advanced malignancies tolerate the procedure well, with very few adverse events. The largest reported series evaluated nearly 12,000 rigid bronchoscopic procedures in Italy—only 2 deaths occurred. Drummond and colleagues reported their experience with 775 rigid bronchoscopic procedures. Complications occurred in 13.4% of patients, and there were 3 deaths. Patients with severe preoperative risk, including hypoxia, unstable cardiac status, and coagulopathy, and those with carinal disease had the highest risk of complications. Other adverse events were hemorrhage (6%), transient mild respiratory failure (5.3%), severe cough (0.6%), transient arrhythmia (0.3%), pneumothorax (1 patient), and a broken tooth (1 patient).

Complications may also include injury to the gums or larynx, bronchospasm, laryngospasm, rupture of the tracheal or bronchial wall, pneumothorax, fever, and pneumonia. Overall, serious complications are uncommon and can be avoided with adequate safety precautions and, most important, a team that is experienced in rigid bronchoscopy. CENTRAL AIRWAY OBSTRUCTION

The presenting signs and symptoms of large-airway obstruction can vary from an abnormality on an imaging study in an asymptomatic patient to life-threatening near-total airway obstruction. Patients with benign or malignant stenoses can present with dyspnea, hoarseness, cough, or wheezing (often monophasic). Some patients may receive treatment for asthma without improvement. Others may have difficulty in expectorating pulmonary secretions. In postintubation stenosis, symptoms often occur within 3 months of extubation. Functionally limiting dyspnea usually does not occur until about 75% or more of the tracheal lumen is obstructed. Less obstructive tracheal lesions or main-stem bronchial lesions may cause dyspnea with exertion. A history of lung cancer or other diseases known to cause airway obstruction should raise suspicion when symptoms are present. The patient should also be asked about a history of intubation. Radiographic evaluation
Plain chest radiographs are rarely diagnostic of airway obstruction and often do not have a significant impact in the planning of rigid bronchoscopic procedures. Findings may include pneumonia, mediastinal lymphadenopathy, atelectasis, and tracheal or main-stem bronchial narrowing.

Chest CT provides much greater detail of airway anatomy than plain chest radiography, and it is more sensitive in detecting tracheal lesions. In addition, CT may help measure airway size for stent placement and define the extent of malignant disease, pneumonia, or atelectasis. However, the maximum length of time that atelectasis may exist and still reexpand following the restoration of airway patency is controversial.

The limitations of CT include difficulty in predicting stenosis length and poor ability in demonstrating tracheobronchomalacia. At present, no chest imaging techniques have been proved to help either the technique or the outcomes of rigid bronchoscopic procedures. Newer imaging modalities include super-high-resolution CT and virtual bronchoscopy (CT bronchography). Finkelstein and colleagues\textsuperscript{24} compared these modalities with conventional CT and flexible bronchoscopy for the detection of tracheobronchial cancers. The overall sensitivities and specificities of super-high-resolution CT and virtual bronchoscopy in detecting these lesions were 83% and 100%, respectively. Conventional CT had an overall sensitivity of 59% and a specificity of 85%.

Although the images provided by these techniques are impressive, they have not replaced bronchoscopy as the best means of detecting tracheobronchial malignancy, and their utility in planning rigid bronchoscopic procedures is unclear. \textbf{Pulmonary function testing}

Patients with central airway obstruction frequently have abnormal pulmonary function; however, this finding often does not correlate well with symptoms. Patients who have lung cancer are likely to have spirometric findings consistent with obstructive lung disease (from underlying chronic obstructive pulmonary disease).

Spirometry and lung volume testing are not essential in the evaluation of these patients, but flow-volume loops may be more helpful in assessing both the severity of obstruction and the response to bronchoscopic therapy in those with chronic benign stenoses. Patients with fixed airway stenosis may demonstrate the classic finding of flattened inspiratory and expiratory phases on a flow-volume loop. \textbf{Flexible bronchoscopy}

No imaging technique is an adequate substitute for bronchoscopy (flexible or rigid) in the assessment of airway disease. Rigid and flexible bronchoscopes are complementary tools. Those who perform rigid bronchoscopy often prefer to do flexible bronchoscopy first to help plan the treatment. Multiple assessments must be made, including the size and shape of the lesion and its distance from other vital structures, bleeding risk, and stent size and type. Bronchoscopists with more experience may proceed directly to the rigid bronchoscopic procedure. \textbf{CASE 1}

A 72-year-old man with an 8-year history of colon cancer, including metastasis to the liver, was referred for evaluation of several months of increasing dyspnea. Physical examination revealed near-absent breath sounds in the left side of the chest. Flexible bronchoscopy and conventional CT showed a large endobronchial mass obstructing the proximal left main bronchus (Figure 2A). Results of a biopsy of the mass were consistent with metastatic colon cancer. The patient underwent rigid bronchoscopy with laser coagulation of the tumor; it was easily removed using the bronchoscope and large forceps. The remaining tumor base was coagulated with the laser to achieve hemostasis (Figure 2B). The patient tolerated the procedure without difficulty and had significant improvement in his dyspnea. \textbf{CASE 2}

A 49-year-old woman was evaluated for a 2-year history of dyspnea with exertion. She reported a brief episode of endotracheal intubation for a drug overdose about 30 years ago. A flow-volume loop was consistent with tracheal stenosis. Flexible bronchoscopy revealed a web-like stenosis in the proximal one third of the trachea (Figure 3A). The patient underwent rigid bronchoscopy and dilatation of the lesion using the bronchoscope itself. The tracheal diameter was increased, which resulted in a significant improvement in dyspnea (Figure 3B).

\textbf{CONCLUSION}

After a major decline in use over several decades, the utility of rigid bronchoscopy in treating both benign and malignant airway disease is increasingly being recognized. Pulmonologists, oncologists, and primary care physicians should be aware of the potential manifestations of these diseases. Given that about 170,000 new cases of lung cancer are diagnosed in the United States each year, central airway obstruction from these malignancies will continue to be a significant problem.\textsuperscript{25} Although some of these problems can be managed with flexible bronchoscopy, many are best
treated with rigid bronchoscopic techniques. Patient referral to centers that specialize in complicated airway procedures may be required.

The ACCP and the European Respiratory Society/American Thoracic Society have recently established 2 sets of guidelines for proficiency in rigid bronchoscopy and many other interventional pulmonary procedures to ensure that these procedures are done safely by experienced endoscopists.26,27

References: REFERENCES

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