Interventional Pulmonary Procedures: Guidelines from the American College of Chest Physicians

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Interventional Pulmonary Procedures*
Guidelines from the American College of Chest Physicians

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Abbreviations: ACCP = American College of Chest Physicians; APC = argon plasma coagulation; EBUS = endobronchial ultrasound; PDT = percutaneous dilational tracheostomy; RN = registered nurse; TBNA = transbronchial needle aspiration; TPNA = thoracic percutaneous needle aspiration; TTOT = transtracheal oxygen therapy; WLB = white light bronchoscopy

The ability to perform procedures is one of the defining characteristics that attracted so many of us to fellowships in pulmonary medicine, critical care medicine, and thoracic surgery. In fact, nearly 500,000 bronchoscopies are done each year in the United States. Additionally, approximately 15,000 airway stents are placed yearly worldwide. The number and complexity of procedures that can be performed in the bronchoscopy unit is increasing. For example, endobronchial electrocautery for tumor ablation and the treatment of hemoptysis can be performed under local anesthesia during a “routine” outpatient bronchoscopy.

Unfortunately, our training and expertise is not uniform. An American College of Chest Physicians (ACCP) survey revealed that > 50% of respondents believed that their training in advanced diagnostic techniques such as transbronchial needle aspiration (TBNA) was inadequate. In another query of senior pulmonary fellows, Haponik et al found that while most fellows reported “adequate” training in bronchoscopy, only 72% had any instruction in TBNA and 27% in stent placement.

Despite the proliferation in the number and type of chest procedures currently performed, there are presently no guidelines that ensure that the basic skills and competency needed to provide these services have been acquired by the pulmonologist, critical care physician, or thoracic surgeon (dedicated operators). To address this void, the development of guidelines for chest procedures was initiated through the Interventional Chest/Diagnostic Procedures Network of the ACCP (the “Network”). There were several compelling reasons to do so. First, these procedures carry inherent risks, and patient safety is of paramount concern. Second, defining the equipment and personnel required, indications, contraindications, risks, and training requirements of each of the procedures may facilitate uniform practice within fellowship training programs. In addition, these guidelines could be used as a guide to hospital nursing, respiratory therapy and administrative departments who wish to develop these services. Finally, dedicated operators who display competency in these individual procedures should have less difficulty overcoming the barriers that sometimes exist within local hospital credentialing committees.

The guidelines themselves were developed by a group of physicians representing a wide range of interests within the college. The group was comprised of pulmonologists and thoracic surgeons, academics, and private practitioners who reside in the United States and abroad. Despite the diversity of practice views, consensus was reached on all of the parameters put forth in this document.

For physicians wishing to learn how to perform one of these advanced procedures, there are several different educational approaches. There are intense short training programs (1 to 3 days). These are available throughout the United States and abroad. More formal mini-sabbaticals (1 to 6 months) are available as well. Several fellowship training programs have developed an additional year of fellowship training in advanced interventional techniques similar to other procedure-intensive internal medi-
Flexible Bronchoscopy

Definition

Flexible bronchoscopy is an invasive procedure that is utilized to visualize the nasal passages, pharynx, larynx, vocal cords, and tracheal bronchial tree. It is utilized for both the diagnosis and treatment of lung disorders. The procedure may be performed in an endoscopy suite, the operating room, the emergency department, a radiology suite, or at the bedside in the ICU.

Equipment

At minimum, the equipment needed is a bronchoscope, light source, cytology brushes, biopsy forceps, needle aspiration catheters, suction apparatus, supplemental oxygen, fluoroscopy (C-arm), pulse oximetry, sphygmomanometer, and equipment for resuscitation including an endotracheal tube. A video monitor is a useful accessory, but not required. Fluoroscopy may be needed to facilitate certain transbronchial biopsy procedures.

Personnel

A dedicated operator performs the procedure. Personnel required for this procedure include a registered nurse (RN) or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator with the procedure. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of the specimens. This will maximize patient comfort, safety, and yield.

Anesthesia and Monitoring

Flexible bronchoscopy may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

Technique

The patient should be placed in either a semi-recumbent or supine position after IV access has been obtained. The patient should fast for at least 4 h prior to the procedure. If the dedicated operator chooses to use the nose as the orifice of entry, the patient should have a topical anesthetic applied to the pharynx and nasal passages. After the topical anesthetic has taken effect, the bronchoscope is introduced either through the nose or mouth with a bite block in place. The oropharynx is examined. After a thorough examination is performed and on reaching the vocal cords, the patient is usually again anesthetized topically. The vocal cords are exam-
ined for abduction and adduction. The bronchoscope is passed through the vocal cords, and a complete airway inspection is performed.

Both therapeutic and diagnostic procedures can be performed during flexible bronchoscopy. Depending on the indication, the following diagnostic procedures can be performed: BAL, endobronchial or transbronchial biopsies, cytologic wash or brush, and TBNA, endobronchial ultrasound (EBUS), and autofluorescence bronchoscopy. Therapeutic procedures such as balloon dilatation, endobronchial laser ablation, electrocautery, photodynamic therapy, brachytherapy, and selected stent placement can all be accomplished through flexible bronchoscopy.

Indications

Indications include, but are not limited to, undiagnosed pulmonary infiltrates, lung masses, mediastinal lymphadenopathy, hemoptysis, airway disorders, endobronchial lesions, therapeutic suctioning, and pediatric bronchoscopy.

Contraindications

Most contraindications to flexible bronchoscopy are relative rather than absolute. Special attention must be paid to respiratory and bleeding status. In unstable patients or prolonged procedures, rigid bronchoscopy may be preferred.

Risks

Diagnostic flexible bronchoscopy is usually an extraordinarily safe procedure. Major complications such as bleeding, respiratory depression, cardiorespiratory arrest, arrhythmia, and pneumothorax occur in < 1% of cases. Mortality is rare, with a reported death rate of 0 to 0.04% in > 68,000 procedures.

Training Requirements

Expertise in flexible bronchoscopy for the diagnosis of lung diseases is absolutely necessary for the pulmonary physician trained in pulmonary and critical care medicine. Trainees should perform at least 100 procedures in a supervised setting to establish basic competency. To maintain competency, dedicated operators should perform at least 25 procedures per year. In addition to the number of procedures, the competency of each trainee should be certified by the program director or the director of the bronchoscopy unit. Finally, it is important that training include competency in assisting a dedicated operator in the performance of the procedure.

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Rigid Bronchoscopy

Definition

Rigid bronchoscopy is an invasive procedure that is utilized to visualize the oropharynx, larynx, vocal cords, and tracheal bronchial tree. It is performed for both the diagnosis and treatment of lung disorders. The procedure may be performed in an endoscopy suite with available anesthesia, but more appropriately in the operating room, and rarely in the ICU. It is frequently combined with flexible bronchoscopy to acquire and maintain better distal airway visualization and suctioning.

Equipment

A set of ventilating bronchoscopes should be available in different sizes. A halogenated light provides illumination; 0°, 30°, and 90° telescopes can be placed down the rigid barrel to improve visualization. An array of instruments such as graspers, biopsy forceps, and suction devices should also be readily available. Video capability is desirable but not necessary. Other miscellaneous materials that should be available include normal saline solution, lubricant jelly, syringes, and suction tubing.

Personnel

A dedicated operator performs the procedure. Personnel required for this procedure include a nurse or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator with the procedure. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of the specimens. This will maximize patient comfort, safety, and yield.
Additional personnel may be utilized, depending on where the procedure is performed (operating room vs bronchoscopy suite). An anesthesiologist, circulating nurse, and operating room technician are frequently utilized during this procedure.

Anesthesia and Monitoring

This procedure is usually performed under general anesthesia with adequate sedation and muscle relaxants. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

Technique

The patient is placed in the supine position. The head should be on a small pillow or foam rest, and positioned on the portion of the table that can be flexed or extended as needed. After introducing the instrument, the epiglottis is gently lifted with the end of the bronchoscope, after which the larynx and vocal cords can be seen. Once the vocal cords have been visualized, the bronchoscope is turned 90° vertically in order to pass through the vocal cords. This offers the least resistance and avoids damage to the vocal cords. After entering the upper trachea, the bronchoscope is turned back to its original neutral position.

Ventilation is initiated via the side port. The bronchoscope is gently advanced toward the carina, and systematically inserted into each mainstem bronchus. Anatomic, airway, and mucosal abnormalities are noted. Telescopes may be inserted into the rigid bronchoscope to visualize the distal segments, requiring the angled 30° and 90° scopes to see particularly the right upper lobe orifice. The head is usually turned to the left to enter into the right mainstem bronchus, and turned to the right to enter into the left mainstem bronchus.

Once the preliminary examination is completed, the purpose for which the procedure was performed should be addressed (eg, dilation, stent insertion, laser ablation, extraction of foreign bodies). Cautery, forceps, and suction should be readily available. If a more detailed examination, washings, laser/photodynamic ablation, or stent insertion is required, a flexible bronchoscope can be inserted through the rigid bronchoscope.

Indications

There are many indications for rigid bronchoscopy, including bleeding or hemorrhage, foreign body extraction, deeper biopsy specimen when fiberoptic specimen is inadequate, dilation of tracheal or bronchial strictures, relief of airway obstruction, insertion of stents, and pediatric bronchoscopy. It is also used for tracheobronchial laser therapy or other mechanical tumor ablation.

Contraindications

Relative contraindications include uncontrolled coagulopathy, extreme ventilatory and oxygenation demands, and tracheal obstruction to the novice operator.

Risks

Most potential complications of rigid bronchoscopy can be avoided. These include injury to the teeth or gums, tracheal or bronchial tears, or severe bleeding. Complication rates should be < 0.1%. Procedure-related mortality is rare.

Training Requirements

Trainees should perform at least 20 procedures in a supervised setting to establish basic competency in patients with normal airways, and to become comfortable with the set-up and intricacies of the procedure. Dedicated operators should perform at least 10 procedures per year to maintain competency. Individual institutional program directors in bronchoscopy and surgery should ultimately decide on the competency of each candidate, and they should also determine where best these procedures should be performed, either in the bronchoscopy or operating suite.

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Pediatric Section

Overview

Bronchoscopy has been performed in infants, children, and adolescents by pediatric surgeons and specialists for > 50 years. Until the 1980s, the approach was almost exclusively via the rigid bronchoscope and the operators, at least in the United States, were almost exclusively surgeons. Today, however, pediatric pulmonologists perform flexible bronchoscopy more often on children than rigid bronchoscopy. Due to this preference, this section focuses on flexible bronchoscopy. The equipment, techniques, and indications are quite different than those applied in adult populations. Proficiency in flexible bronchoscopy is a recommended element in pediatric pulmonology fellowship training, but no specific number or type of procedures has been required of trainees.

Equipment

The standard pediatric bronchoscope has an outer diameter of 3.4 to 3.6 mm (depending on the manufacturer) with a suction channel of 1.2 mm. Specific information about the bronchoscopes used in pediatric patients is provided in Appendix 2. The standard pediatric bronchoscope can usually be safely used in healthy infants with mild respiratory difficulties receiving oxygen supplementation. The 2.2-mm, ultrathin, flexible bronchoscope has no suction channel. It has its greatest use in premature and newborn infants who may or may not be intubated. The recently introduced 2.8-mm bronchoscope with a 1.2-suction channel is very fragile and can be used in older infants or newborn infants who are not intubated. In older children, this bronchoscope can be passed through several generations of bronchi and thereby identify abnormalities previously beyond the reach of the bronchoscope. The smallest adult bronchoscopes can be safely used in older children and adolescents, and are particularly useful when purulent secretions are present or transbronchial biopsy specimens are to be obtained.

Standard biopsy forceps cannot be passed through the 1.2-mm suction channel of the 3.4- to 3.6-mm or 2.8-mm bronchoscopes. Olympus Healthcare (Olympus America; Melville, NY) introduced a mini-forceps in the mid-1990s. As expected, the mouth of the forceps is quite small, as are the samples obtained. In order to obtain adequate specimens, multiple passages of the forceps are usually required. Cytology brushes are available that can be passed through the 1.2-suction channel. Recently, the use of urologic baskets and forceps passed through the suction channel has been described to retrieve foreign bodies with the standard pediatric bronchoscope.

Personnel

A dedicated operator must always be present, and is the overseer and supervisor over all aspects of the procedure. A second physician is often present, especially in training contexts, but is not usually required. Two other trained persons are usually present and, in the absence of a second physician, should be present. A nurse provides care and monitoring of the patient and keeps a chronologic record of medications administered and the condition of the patient. A second person, often a respiratory therapist, oversees the bronchoscope, light source, and suction equipment, and manages medications administered through the bronchoscope and collects any specimens obtained during the procedure. All personnel should be trained and skilled in cardiopulmonary resuscitation.

Anesthesia and Monitoring

As a rule, pediatric flexible bronchoscopy is performed with IV sedation due to the lower predictability of cooperation from children during bronchoscopy when compared to adults. Most practitioners use a short-acting benzodiazepine and either a short-acting opiate or ketamine. Continuous monitoring of heart rate, arterial oxymeshoglobin saturation by pulse oximetry, and BP is standard care. The 3.4- to 3.6-mm bronchoscope occupies a greater proportion of the cross-sectional area of the trachea and glottis than does standard adult bronchoscopes within the mature airway, leading to the potential for greater interference with gas exchange in infants and young children. Thus, efficiency during the procedure, minimizing the duration of inspection and instrumentation and an acute and dynamic awareness of the patient’s condition and vital signs, are critical to successful and safe pediatric flexible bronchoscopy. In addition, the potential for hypoventilation due to the use of IV sedating agents adds to the potential for respiratory compromise during pediatric flexible bronchoscopy. Similarly, the use of smaller adult scopes in the 4.8- to 5.2-mm size for school-aged children and younger adolescents will predispose to more gas exchange abnormalities than in most adult procedures.

The pioneers of pediatric flexible fiberoptic bronchoscopy stressed the importance of carefully titrated IV sedation providing conscious to deep levels of sedation depending on the needs of each individual patient and procedure. In recent years, many pediatric dedicated operators have opted for the
operating room setting with or without general anesthesia more routinely. This change appears to be related to at least four different developments. First, pediatric anesthesiologists have established themselves as the experts in pediatric sedation. Since the level of sedation often needed for successful pediatric bronchoscopy goes beyond conscious sedation, many institutions have questioned the safety of the procedure without the presence of the anesthesiologist. Second, more pediatric anesthesiologists have come to understand the need and ability for flexible bronchoscopy to be performed safely and effectively in spontaneously breathing patients, and have become interested in participating in these procedures. In the United States, IV propofol, an ideal sedative for flexible bronchoscopy when spontaneous breathing is necessary, is restricted in most institutions in North America for use by anesthesiologists. Third, the development and utilization of the laryngeal mask with appropriate pediatric sizes has permitted the safe use of the standard pediatric bronchoscope in infants with more significant degrees of respiratory insufficiency, or who require temporary elective extubation to facilitate the bronchoscopic procedure. In older patients, the laryngeal mask permits the safe use of the smaller adult bronchoscopes with the ability to assist ventilation as needed if transbronchial biopsies are required. Fourth, the involvement of the anesthesiologist and operating room provides access to a staffed recovery room with continuous monitoring after the bronchoscopy, which may not be readily available to the pulmonologist who performs the procedure outside the operating room under IV sedation. The excellent safety record documented over many years with IV sedation should ensure that this option remains available to those practitioners in those institutions who prefer that approach.

**Technique**

The patient is usually brought into the procedure room in the company of a parent to provide reassurance. Infants are laid in supine position. Children may sit while being hooked up to the monitor. IV access is obtained, and the patient is attached to the appropriate monitors. An aerosol of nebulized lidocaine or the application of lidocaine to the posterior oropharynx via atomizer is often used. Initial IV sedation is often administered before topical anesthetic is applied by cotton tip applicator to the naris. Some endoscopists prefer to add topical nasal decongestants routinely.

The patient is then placed in the supine position, and IV sedation is titrated to desired effect. Oxygen supplementation delivered via nasal cannula is virtually always used. The transnasal approach is used in the majority of circumstances. The patency of the naris is noted, and the size and position of adenoidal and tonsillar tissue is noted. The bronchoscope is advanced to a position just above the larynx, and further topical lidocaine is sprayed onto the vocal cords and adjacent structures to effect. Supraglottic anatomy in static and dynamic conditions is noted. The bronchoscope is then passed through the vocal cords, and further topical anesthesia is administered via the suction channel into the tracheobronchial tree. The bronchoscopist then carries out a thorough lower airway inspection.

**Indications**

There are many and diverse clinical indications for flexible bronchoscopy in the pediatric age group. Most common, perhaps, are those related to either upper or lower airway obstruction: stridor, noisy breathing, snoring of uncertain anatomic origin, or atypical wheeze. Evaluation of the artificial airway or as an aid to the intubation of the difficult upper airway is another reasonably common indication. Vocal cord dysfunction can often be diagnosed on clinical grounds or via spirometry, but in some individuals, the visual identification of vocal cord adduction with the patient conscious and viewing the video screen can be helpful, both from diagnostic and therapeutic points of view. Suspected aspiration of gastric contents or feedings due to swallowing dysfunction appears to be reasonably common in the population seen by most pediatric pulmonologists. Flexible bronchoscopy is commonly performed as part of the evaluation to inspect the airway and perform BAL to evaluate for lipid-laden macrophages. Complicated, severe, or persistent pneumonias and pneumonias in immunocompromised patients are other common indications for pediatric flexible bronchoscopy. Hemoptysis, undifferentiated lesions in the lung on chest radiograph, and noninfectious parenchymal lung diseases are all less common in children but still lead to elective fiberoptic bronchoscopy at times.

When transbronchial biopsy is added to flexible bronchoscopy, the most common indications are those conditions in which histopathology is important in therapeutic decision making, such as lung transplantation and rare or unusual parenchymal lung diseases. Endobronchial masses are very rare in children except for foreign bodies. Foreign bodies are virtually always indications for rigid bronchoscopy in most institutions, although a recent publication showed an excellent safety and efficacy record utilizing flexible bronchoscopy with urologic baskets and forceps.
Contraindications

The contraindication to flexible bronchoscopy occurs when the risk of the procedure outweighs the potential benefits, or when respiratory failure in a small infant will not permit the passage of a flexible bronchoscope while gas exchange is maintained. The actual determination of the strength of contraindication will vary depending on the skill and experience of the dedicated operator and clinical practice and guidelines of the specific institution in which the patient is hospitalized. With the introduction of laryngeal mask anesthesia, more young patients may safely undergo bronchoscopy with ventilation than in the past. Coagulopathy is a relatively strong contraindication to transbronchial biopsy.

Risks

The most common complications of flexible bronchoscopy are patient discomfort and transient hypoxemia. With the addition of BAL, fever 4 to 12 h after the procedure is also common. More serious complications—pneumonia, respiratory failure, life-threatening hemoptysis, pneumothorax, and death—are rare.

Training Requirements

There is no formal quantitative training requirement for bronchoscopic procedures established by the American Board of Pediatrics Sub-board for Pulmonology. Two formal courses in pediatric flexible bronchoscopy are held annually, one in the United States and the other in Europe. Pulmonary fellows should perform at least 50 pediatric bronoscopies in a supervised setting to establish basic competency. To maintain competency, dedicated operators should perform at least 25 procedures per year. When fellows do not achieve this volume of bronchoscopic procedures, they should be overseen by more senior members of the faculty or practice where they work until such time that they show proficiency in pediatric bronchoscopy.

Ancillary Procedures Applicable to Pediatric Patients

Ancillary procedures applicable to pediatric patients include the following: BAL (common); transbronchial biopsy and cytology brushing (uncommon); laser therapy (rare); airway dilation via balloon insufflation (rare); airway stenting (rare); bronchography (rare); segmental instillation of medication (rare); and assessment of lower airways inflammation (research only).

References


TBNA

Definition

TBNA is a minimally invasive procedure that provides a nonsurgical means to diagnose and stage bronchogenic carcinoma by sampling the mediastinal lymph nodes. Applications of bronchoscopic needle aspiration have expanded to include not only sampling of paratracheal or mediastinal lymph nodes, but peripheral, submucosal, and endobronchial lesions. The procedure allows for sampling tissue through the trachea or bronchial wall, and sampling of tissue beyond the vision of the dedicated operator.

Equipment

In addition to the equipment needed for bronchoscopy, the equipment needed specifically for TBNA include TBNA needles, which are designed to pass through a bronchoscope without causing damage and to be flexible enough to facilitate the positioning of the bronchoscope, yet rigid enough to penetrate the airway wall. Two types of TBNA needles, cytology needles and histology needles, should be available for the procedure.
Personnel

A dedicated operator performs the procedure. Personnel required for this procedure include an RN or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of specimens. This will maximize patient comfort, safety, and yield.

Anesthesia and Monitoring

This procedure may be performed under local anesthesia, with or without conscious sedation, or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

Technique

TBNA usually begins with review of the chest radiograph and, in most instances, is greatly facilitated by a CT scan. Knowledge of the anatomy is critical for selecting the proper anatomic location for the needle aspiration or biopsy. This is true for selecting the location of the paratracheal or subcarinal lymph nodes, or for proper location of a peripheral lesion that is to be sampled.

Generally, when performing mediastinal lymph node aspiration for staging bronchogenic carcinoma (either known or suspected), it is critical to perform the needle aspiration prior to general inspection. This will reduce the likelihood of entraining airway secretions in the sample and avoid a false-positive result. A TBNA needle should be selected according to the size and location of the lesion.

Different techniques can be used singularly or in combination to ensure complete penetration of the needle through the tracheobronchial wall. While suction is applied, the catheter (and consequently the needle tip) is agitated back and forth to shear off cells from the node or mass with care not to disengage the tip of the needle from the tracheobronchial wall. This agitation is performed for a few seconds. Once the catheter is removed from the bronchoscope, the smears are prepared.

For submucosal lesions, a similar technique is applied; however, since the goal is to obtain a specimen from the mucosa, the needle and catheter are kept in a position of slight angulation rather than the 90° angle used to obtain lymph node aspirate. For endobronchial lesions that are either necrotic in appearance or highly vascular, TBNA may be used to obtain a sample by altering the technique in order to directly place the needle into the endobronchial lesion.

For peripheral lesions, fluoroscopy is used to localize the lesion. Once the lesion is localized, the needle is locked into position, and the needle is used to shear off cells from the peripheral lesion while suction is applied.

Specimen preparation is the same for the submucosal, endobronchial, or peripheral lesions as it is for the nodal aspirations. Multiple nodal aspirations can be obtained to increase yield.

Indications

Diagnostic and staging information in the presence of malignancy in mediastinal lymph nodes, submucosal, endobronchial, and parenchymal masses are indications for TBNA. Diagnostic information may also be obtained in the same locations for many benign conditions, including sarcoidosis and fungal disease.

Contraindications

Most contraindications to TBNA are relative rather than absolute. Special attention must be paid to respiratory and bleeding status.

Risks

TBNA is extremely safe and has a very low incidence of complications. The most common potential complications are bleeding, pneumothorax, or pneumomediastinum. Significant bleeding rarely occurs even after a major vessel puncture. Fever and bacteremia have been reported following TBNA, although this may be related to the bronchoscopic procedure itself rather than this specific technique.

Training Requirements

In order to protect the bronchoscopy, the needle must be properly and carefully used. In addition, improper technique will result in an inadequate needle aspirate. Trainees should perform at least 25 needle aspirates in a supervised setting to establish basic competency. Trainees should also gain experience in the acquisition of needle aspirates from lymph nodes in mostly paratracheal as well as subcarinal regions. To maintain competency, dedicated operators should perform at least 10 procedures per year.

References

AUTOFLUORESCENCE BRONCHOSCOPY

Definition

Autofluorescence bronchoscopy is a bronchoscopic procedure in which a blue light rather than a white light is employed for illumination, and premalignant or malignant tissue is distinguished by a change in color from normal tissue without the need for fluorescence-enhancing drugs. Fluorescence techniques used with bronchoscopy have demonstrated detection of dysplasia, carcinoma in situ, and early invasive cancers not visible by standard white light bronchoscopy (WLB) through a specialized bronchoscope.

Equipment

In addition to the equipment needed for bronchoscopy, a dedicated endoscopic system allowing for blue light imaging is required. Several different systems for autofluorescence bronchoscopy have been developed. Two images of different wavelengths (red and green) are captured. Images are processed such that the image on the video monitor allows for normal tissue to be visualized as green and abnormal tissue to be visualized as reddish-brown in color. Inspection is then performed using a standard bronchoscopic technique.

Personnel

A dedicated operator performs the procedure. Personnel required for this procedure include an RN or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of specimens. This will maximize patient comfort, safety, and yield.

Anesthesia and Monitoring

This procedure may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

Technique

Initial bronchoscopic examination is performed using conventional WLB. Trauma to the mucosa, either by the bronchoscope tip or by suctioning, needs to be avoided, as this can obscure imaging under the autofluorescence system. For this reason, biopsy specimens are not obtained from abnormalities until after (or during) autofluorescence inspection. Following white light inspection, a detailed autofluorescence examination is performed and all abnormalities are graded. Biopsies are then performed either under white light settings of the areas determined to be abnormal, or after (or during) autofluorescence bronchoscopic inspection of the areas determined to be abnormal.

Indications

Indications include known or suspected lung cancer by abnormal sputum cytology findings, inspection for synchronous tumors, surveillance following cancer resection, and primary screening among high-risk patients.

Contraindications

Most contraindications to autofluorescence bronchoscopy are relative rather than absolute and do not differ from routine bronchoscopy.

Risks

There have been no untoward risks reported in the series utilizing autofluorescence bronchoscopy. Considering that fluorescence inspection simply uses light of a different wavelength and that bronchial biopsy attainment is the same as in conventional bronchoscopy, there is no increase in risk to the patient over a standard WLB flexible bronchoscopy technique. Autofluorescence inspection following WLB generally adds 5 to 10 min to the overall bronchoscopic procedure.
Training Requirements

Trainees should perform at least 20 autofluorescence bronchoscopies in a supervised setting to establish basic competency. To maintain competency, dedicated operators should perform at least 10 procedures per year.

REFERENCES


EBUS

Definition

EBUS is an invasive procedure in which physicians use ultrasound devices inside the airways and the lung for exploration of the structures of airway walls, the surrounding mediastinum, and the lungs.

Equipment

In addition to the equipment needed for flexible bronchoscopy, the most widely applied device currently used is a miniaturized catheter probe bearing a mechanical transducer at its tip that rotates 360°. For complete contact with the tracheobronchial wall, the catheter is inserted with a balloon at the tip that, after being filled with water, provides complete circular contact. Another device that is used when performing EBUS is a dedicated ultrasonic endoscope with an electronic curvilinear scanner at its tip, which provides a sectorial view into the bronchial wall and the mediastinal structures. Prototypes of this system are still under investigation and are not yet commercially available.

Personnel

A dedicated operator performs the procedure. Personnel required for this procedure include a RN or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of specimens. This will maximize patient comfort, safety, and yield.

Anesthesia and Monitoring

This procedure may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

Technique

Techniques using both devices can be applied during routine bronchoscopy under general and local anesthesia. The miniaturized probe is inserted through a regular flexible bronchoscope with a biopsy channel of at least 2.8 mm. Inside the airways, the balloon is inflated until complete circular contact is achieved and the structures of the wall and the surrounding mediastinum become visible. In order to add the longitudinal dimension to the cross-sectional image, the probe has to be moved along the axis of the airways.

When using a dedicated ultrasonic endoscope, it should be placed with its tip against the tracheobronchial wall. In order to add the circular and the longitudinal dimension to the sectorial view, the instrument has to be rotated and moved along the axis of the airways.

Indications

These two techniques are indicated for visualization, tumor invasion, TBNA guidance, and differentiating of vascular from nonvascular structures. EBUS may be helpful in guiding therapeutic procedures such as curative photodynamic and brachytherapy by assessing tumor volume and other interventions such as airway recanalization.

Contraindications

Most contraindications to EBUS are relative rather than absolute and do not differ from standard bronchoscopy. Special attention must be paid to respiratory and bleeding status.

Risks

EBUS is usually an extraordinarily safe procedure. It adds 5 to 10 min to a standard procedure.
Training Requirements

EBUS requires intensified training and practical experience in interpreting sonographic images, since the anatomic structures of the mediastinum are comparatively complex, and the planes of EBUS images may be oblique and very different from the usual images by conventional radiology. Accordingly, trainees should perform at least 50 procedures in a supervised setting to establish basic competency in analyzing anatomic structures and handling the instrument. To maintain competency, dedicated operators should perform at least 20 examinations per year.

REFERENCES

LASER THERAPY

Definition

The word laser is an acronym for light amplification of stimulated emission of radiation. The wavelength of the laser determines the characteristics of each type. Tissues absorb the intense light of the laser, and energy is dissipated, mainly in the form of heat. This tissue/light interaction is used for tissue destruction and coagulation.

Equipment

Laser therapy may be performed with either flexible or rigid bronchoscopic instruments. In addition to the equipment needed for bronchoscopy, there are four major medical lasers currently being used for bronchoscopic resection (laser therapy). Each has specific characteristics that provide advantages for certain situations. The Nd-YAG laser is the most commonly used laser. The wavelength is 1064 nm, yielding invisible light in the infrared range. Other lasers include the potassium titanyl phosphate laser, the carbon dioxide laser, and diode lasers. The specific laser fibers are usually accompanied with the appropriate power generator and specific protective eyewear.

Personnel

A dedicated operator performs the procedure. Personnel required for this procedure include an RN or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of the specimens. This will maximize patient comfort, safety, and yield. If the procedure is performed under general anesthetic, an anesthesiologist should also be present.

Anesthesia and Monitoring

Laser therapy may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment; however, it is recommended to keep the percentage concentration of oxygen within the airways as low as possible (≤ 40%) in order to prevent airway fires. The patient and personnel must be protected from the laser light by standard laser precautions.

Technique

Laser therapy can be used alone or in association with other ablative techniques or stenting. Laser firing can result in the photocoagulation of superficial and deep blood vessels, thermal necrosis, and scatter to adjacent tissues. Excessive laser application can, however, result in substantial tissue damage, necrosis, and airway wall penetration.

Rigid bronchoscopy is usually preferred over the flexible technique as a delivery mechanism for laser therapy. This provides easy access for suction and grasping of large debris. The rigid scope can be used to tamponade bleeding. Airway strictures can be dilated using rigid bronchoscopes of increasing diameter. All personnel in the operating room should wear protective eyewear. Flammable material should be kept away from the operating field. After intubation, a suction catheter and the laser fiber are inserted. While the laser is fired, the fraction of inspired oxygen should be kept at < 40% to avoid combustion. Whether performed via rigid or flexible bronchoscopy, continuous suction should be applied. This is more important if gaseous anesthesia is being delivered. Once a certain amount of charring has occurred and tissues become softer, direct mechanical debulking should be done to expedite the procedure.

Following completion of the operation, the patient should be observed for bronchospasm or laryngospasm. The recovery room staff should be closely
monitoring the patient and should be adept in the management of acute airway obstruction.

**Indications**

The primary indication for bronchoscopic laser resection is the relief of central airway obstruction usually from benign or malignant tissue. There are many potential dangers involved with the use of this technique; therefore, the indications must be weighed carefully, even in patients with terminal cancer. Note that laser therapy cannot be utilized for treatment of extrabronchial disease. The specific indications include relief of obstruction by tumor or benign exophytic lesion, and intraluminal disease involving the central airways. Central or segmental airway strictures or scarring from tuberculosis, prior lung resection, trauma, radiation therapy, tracheostomy, tracheostomy, inhalation injury, endotracheal intubation, previous laser surgery, or foreign body obstruction causing intractable cough, hemoptysis, severe dyspnea, or postobstruction pneumonia are also indications. Additionally, treatment of in situ bronchogenic carcinoma or in conjunction with photodynamic therapy is an indication.

**Contraindications**

Potential contraindications include, but are not limited to the following: tracheoesophageal fistula, uncorrected coagulopathy, total airway obstruction with little if any functional distal airway open, and little or no exophytic lesion visible. Laser firing can result in the photocoagulation of superficial and deep blood vessels, thermal necrosis, and scatter to adjacent tissues. Excessive laser application can, however, result in substantial tissue damage, necrosis, and airway wall penetration.

**Risks**

In experienced hands, laser therapy is safe and effective and rarely associated with morbidity and mortality. Hypoxemia can occur both intraoperatively and postoperatively. Hemorrhage can occur immediately after laser ablation. Other complications include perforation and fistulae formation, fire in the airway, and pneumothorax.

**Training Requirement**

Safe laser resection requires training, thorough knowledge of laser/tissue interactions, and an experienced team consisting of a dedicated operator, nurses, respiratory therapists and anesthesiologists. Most institutions require that potential dedicated operators fulfill both an outside and hospital-based laser therapy course before privileges are permitted. Dedicated operators performing laser therapy should have extensive experience in flexible bronchoscopy, management of central airway lesions, and endotracheal intubation. Dedicated operators should also have a comfortable familiarity with rigid bronchoscopy. Trainees should perform at least 15 procedures in a supervised setting to establish competency. To maintain competency, dedicated operators should perform at least 10 procedures annually.

**References**


**Electrocautery and Argon Plasma Coagulation**

**Definition**

Endobronchial electrocautery and argon plasma coagulation (APC) are modes of thermal tissue destruction that may be used via the flexible or rigid bronchoscope. Similar to laser tissue destruction, the effect of both endobronchial electrocautery and APC is determined by heat and tissue interaction, and is fairly rapid. Heat is created through the application of high-frequency electric currents to coagulate or vaporize tissue. The difference between the two procedures centers on the fact that APC is a non-contact mode of tissue coagulation. Dedicated operators use argon plasma as the medium to conduct the electric current in APC rather than using the contact probe as a medium to conduct the electric current as electrocautery does.

**Equipment**

In addition to the equipment needed for the flexible or rigid bronchoscopy, a dedicated operator needs a high-frequency electrical generator in com-
bination with insulated probes. Different types of probes in terms of shape as well as polarity (monopolar vs bipolar) are available. For patient and staff protection, proper insulation precautions need to be observed. Insulated flexible equipment is also available. For APC, a dedicated operator needs a special catheter allowing for the argon gas and the electrical current flow. This catheter is not used in electrocautery where there is direct tissue contact.

**Personnel**

A dedicated operator performs the procedure. Personnel required for this procedure include an RN or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of specimens. This will maximize patient comfort, safety, and yield.

**Anesthesia and Monitoring**

This procedure may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

**Technique**

Endobronchial electrocautery and APC are thermal tissue-destructive modalities that use electricity to generate heat. They differ in the fact that APC does not make contact with the tissues it destroys and has a penetration depth of just a few millimeters. For these reasons, it is more suitable for the treatment of superficial and spreading lesions. Once gas is released through the catheter tip, it is ignited through electrical current; an arc is formed if the probe is close enough to the mucosal surface, causing heat destruction and desiccation of the tissue. The arc can be moved back and forth (painting) and can even be aimed around bends, making it very suitable for hard to reach lesions.

Endobronchial electrocautery, however, relies on direct tissue contact. The set power output determines the type of tissue destruction (coagulation vs vaporization). Different probes and sizes are available for different indications. Energy delivery in both modalities is terminated once the desired effect has been achieved.

**Indications**

Endobronchial electrocautery is frequently seen as a less expensive alternative to laser therapy with similar effects and as such similar indications. Similar to laser, electrocautery cannot be used for extrabronchial disease. APC and electrocautery are indicated for any benign or malignant tissue destruction responsive to heat delivery. These indications include endobronchial malignancy, benign tumors, and relief of postintubation stenosis, and, in the case of APC, treatment of stent-induced granuloma.

**Contraindications**

In addition to the contraindications for rigid or flexible bronchoscopy, the only absolute contraindication is the presence of a pacemaker susceptible to electrical interference.

**Risks**

In addition to the risks associated with the rigid or flexible bronchoscopy, potential complications are similar to other thermal therapies and include airway fires (need to keep oxygen levels as low as possible, preferably < 40%), hemorrhage, airway perforation, and stenosis.

**Training Requirements**

Dedicated operators performing endobronchial electrocautery and APC should have extensive experience in flexible bronchoscopy and management of central airway lesions. Trainees should perform at least 15 procedures in a supervised setting to establish basic competency in endobronchial electrocautery and APC. To maintain competency, dedicated operators should perform at least 10 procedures per year.

**References**

Homasson JP. Endobronchial electrocautery. Semin Respir Crit Care Med 1997; 18:535–543

Hooper RG, Jackson FN. Endobronchial electrocautery. Chest 1985; 87:712–714


Cryotherapy

**Definition**

Cryotherapy is a form of thermal tissue ablation. In contrast to the use of heat, it is the application of repetitive freeze/thaw cycles that cause tissue damage and destruction. Due to the particular action of cryotherapy, results are not immediate and may be delayed for several days.

**Equipment**

In addition to the equipment needed for flexible or rigid bronchoscopy, dedicated operators need different probes depending on whether the cryotherapy is delivered through the rigid or flexible bronchoscope. Generally, the area of freezing is larger and the thawing quicker with the rigid probes. The gas most commonly used in cryotherapy and the gas most commercially available is nitrous oxide.

**Personnel**

A dedicated operator performs the procedure. Personnel required for this procedure include an RN or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of specimens. This will maximize patient comfort, safety, and yield.

**Anesthesia and Monitoring**

This procedure may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthetic and monitoring guidelines in their particular practice environment.

**Technique**

Tissue destruction is achieved through repetitive freeze/thaw cycles. The cooling probe is directly attached or inserted into the lesion to be treated. The same area has to be frozen several times before treating the next part of the lesion. There should be overlap between all regions in order to not leave any area untreated. As the effects are delayed and necrotic tissue frequently cannot be expectorated, follow-up therapeutic bronchoscopy should be performed.

Indications

Cryotherapy is indicated for the treatment of intrinsic airway lesions. Due to the delayed effects, it is not the first choice in high-grade lesions needing immediate intervention. Some tissues are not responsive to cryotherapy (eg, fibrotic scarring). The use of cryotherapy may be helpful in the removal of foreign bodies.

**Contraindications**

In addition to the contraindications for rigid or flexible bronchoscopy, cryotherapy is contraindicated in patients with life-threatening airway obstruction.

**Risks**

Besides the risks associated with the rigid or flexible bronchoscopy, complications are rare, especially since cartilage is resistant to cryotherapy. Most side effects are associated with the use of bronchoscopy itself. There is no risk of airway fire.

**Training Requirements**

Dedicated operators performing cryotherapy should have extensive experience in flexible bronchoscopy and management of central airway lesions. Trainees should perform at least 10 procedures in a supervised setting to establish competency. To maintain competency, dedicated operators should perform at least five procedures per year.

References


Brachytherapy

**Definition**

Brachytherapy is a minimally invasive procedure that allows localized delivery of radiation therapy within the body. Methods of brachytherapy delivery...
include direct implantation of radioactive seeds into the tumor area; image-guided implantation of radioactive sources; transbronchial source implantation with a bronchoscope; and, most commonly, delivery of a radioactive source through a transnasal catheter placed via the lumen of a bronchoscope. This section applies only to the last, most commonly utilized method of delivery.

**Equipment**

Placement of the delivery catheter requires personnel and equipment for flexible bronchoscopy, including a flexible bronchoscope with adequate channel size for the delivery catheter. Afterloading catheters and radioactive sources are required. Fluoroscopy is needed to confirm correct catheter placement. A treatment room must have appropriate shielding and, for high-dose-rate treatment, a remote afterloading device. $^{192}\text{Ir}$ is the preferred radiation source at this time.

**Personnel**

A dedicated operator performs the procedure. Personnel required for this procedure include an RN or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of specimens. This will maximize patient comfort, safety, and yield. A radiation oncologist and the appropriate support staff are responsible for the delivery of the therapeutic radiation.

**Anesthesia and Monitoring**

This procedure may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

**Technique**

After establishing satisfactory topical analgesia and appropriate monitoring, flexible bronchoscopy is performed. The involved portion of the airway should have a visible lumen through which to pass the catheter. If the bronchus is occluded, a passage must be established with a variety of means, including mechanical debridement or laser ablation. This is usually done in a separate setting and may require rigid bronchoscopy. The afterloading catheter is advanced distal to the tumor area. If additional catheters are needed, the procedure is repeated. Catheter position is confirmed radiographically. The radioactive source is then afterloaded in a shielded room using a remote device in the case of high-dose-rate treatment. Dwell stations and times are determined by radiation oncology and radiation physics personnel. Several treatments at weekly intervals are usually required for maximal response, but there is no consensus on optimal dose or frequency.

**Indications**

Brachytherapy is mainly used for palliation of symptomatic malignant airway obstruction, but may also be a curative modality in some patients with carcinoma in situ or very limited early stage lung cancer within the central airways. Improvement in postobstructive symptoms and hemoptysis is achieved in most patients.

**Contraindications**

In addition to the contraindications for rigid or flexible bronchoscopy, brachytherapy is contraindicated as primary treatment for malignant tracheoesophageal fistula, and for patients who have had prior brachytherapy in the same area.

**Risks**

In addition to the risks associated with rigid or flexible bronchoscopy, complications related to the risks of the procedure itself are rare and are most commonly related to the risks of the bronchoscopy itself. The catheter may get displaced and even penetrate the airway wall and cause pneumomediastinum and pneumothorax. Complications due to the actual radiation effects include fatal hemoptysis, bronchial necrosis, airway fistulas to neighboring structures, fibrotic stenosis, and radiation bronchitis.

**Training Requirements**

Dedicated operators performing brachytherapy catheter insertion should have extensive experience in flexible bronchoscopy and management of central airway lesions. Trainees should perform at least five procedures in a supervised setting to establish basic competency in brachytherapy. To maintain competency, dedicated operators should perform at least five procedures per year.

**References**

Chella A, Ambrogji MC, Ribechini A, et al. Combined Nd-YAG laser/HDR brachytherapy versus Nd-YAG laser only in malignant...
PHOTODYNAMIC THERAPY

Definition

Photodynamic therapy is a minimally invasive procedure that is done using a bronchoscope and targets tissue destruction using a selectively retained photosensitizer, which, when exposed to the proper amount and wavelength of light, produces an activated oxygen species that oxidizes critical parts of neoplastic cells. The photosensitizer is administered IV, and the light source, in the case of endobronchial treatment, is delivered endoscopically via a quartz fiber. Direct interstitial delivery of light energy is also possible. Repeated injections and treatments can be performed.

Equipment

In addition to the equipment needed for flexible and rigid bronchoscopy, a dedicated operator should have available a photosensitizer, facilities for IV administration, a laser light source (630 nm with current agents), and an optical fiber. Laser safety equipment and precautions are also necessary, such as appropriate eye protection and signage.

Personnel

A dedicated operator performs the procedure and must be experienced in the use of medical lasers and photosensitizers. Personnel required for this procedure include an RN or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator with the procedure. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of specimens. This will maximize patient comfort, safety, and yield.

Anesthesia and Monitoring

This procedure may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

Technique

The photosensitizer is administered IV at a dose recommended for the specific agent. After an appropriate interval (usually 1 to 2 days, but within 7 days), a flexible or rigid bronchoscopy is performed, and the area of abnormality is illuminated with light of the proper wavelength and dose.

The light is delivered in a superficial or interstitial manner as required for uniform delivery to the target tissue. Penetration is limited to 5 to 10 mm from the tissue surface.

Immediate effects are not seen, but within 48 h, necrosis becomes apparent. Necrotic tissue must be debrided with repeat bronchoscopy 1 to 2 days after treatment. Any residual tumor can be immediately retreated.

Indications

Photodynamic therapy has been approved in the United States, Japan, and Europe to treat superficial cancers in patients ineligible for surgery or external beam radiation. It is also approved for palliation of malignant endobronchial obstruction. Photodynamic therapy response is not dependent on the tumor cell type. It can be applied in patients who have already undergone surgery, radiation, or chemotherapy. Photodynamic therapy produces complete response rates in 60 to 80% of early stage mucosal carcinomas, and has been shown to palliate airway obstruction in 80% of patients.

Contraindications

In addition to the contraindications for rigid or flexible bronchoscopy, photodynamic therapy is contraindicated for patients with critical central airway obstruction (because of the delay in improvement), for tumors invading the esophagus or major vessels, and for patients with porphyria or an allergy to components of the photosensitizer.

Risks

In addition to the risks associated with rigid or flexible bronchoscopy, the most common complica-
tion of photodynamic therapy is skin photosensitivity. This may last for up to 8 weeks after injection of the photosensitizer. All patients receiving these agents must take careful precautions to avoid significant light exposure during the period of sensitivity.

Local complications from the treatment include airway edema, necrosis, and stricture. Tumor lysis can result in bronchovascular fistula or tracheoesophageal fistula. Fatal hemoptysis has been reported, but its relationship to photodynamic therapy, as opposed to progression of disease alone, is not known.

Training Requirements

Dedicated operators performing photodynamic therapy should have extensive experience in flexible bronchoscopy, management of central airway lesions, and endotracheal intubation. Familiarity with rigid bronchoscopy is recommended. Trainees should perform at least 10 procedures in a supervised setting to establish basic competency. To maintain competency, dedicated operators should perform at least five procedures per year.

REFERENCES


AIRWAY STENTS

Definition

Airway stents, similar to vascular stents, are devices designed to keep tubular structures open and stable. Airway stents are intended for placement in the central tracheobronchial tree. Depending on the design, they may be placed with either flexible or rigid bronchoscopes.

Equipment

Numerous different stent designs have been developed to allow for adaptation to the individual anatomic requirements and operator preference. Depending on the manufacturing material (silicone, metal, or hybrid design), flexible or rigid endoscopic equipment is required. Delivery devices specific for the individual stent are necessary and frequently accompany the actual device (such as delivery catheters). Some operators may want fluoroscopic capability to be available.

Personnel

A dedicated operator performs the procedure. Personnel required for this procedure include an RN or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator with the procedure. All supporting personnel should be familiar with the procedure, as well as the appropriate handling of the specimens. This will maximize patient comfort, safety, and yield.

Anesthesia and Monitoring

This procedure may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

Technique

In case of airway obstruction, an appropriate lumen needs to be reestablished before placing a stent. This can be achieved by a variety of methods depending on the type of obstruction. The choice of stent depends on the underlying lesion to be treated, dedicated operator preference and resource availability. Proper stent sizing is critical and can be achieved by reviewing CT images, balloon catheter sizing and other methods, including relying on the experience of the dedicated operator. The stent length should exceed the length of the lesion to some degree to ensure patency. If stents are chosen too small, they may migrate; if they are chosen too large, they may not open or may cause stress on the airway wall.

Indications

Indications for stents in the central airways are expanding. Conditions responsive to stenting under the appropriate circumstances are intrinsic airway obstruction from benign or malignant diseases, extrinsic airway compression such as tumors or other structures within the chest, sealing of airway fistulas and, in selected cases, tracheobronchomalacia.
**Contraindications**

In addition to the contraindications for flexible or rigid bronchoscopy, stent placement, like other endobronchial therapeutic interventions, should be avoided if nonviable lung is present beyond the obstruction. As long-term experience with metallic stents is limited compared to silicone prosthesis, many authorities prefer the primary consideration of removable stents in benign disorders.

**Risks**

In addition to the risks associated with rigid or flexible bronchoscopy, stents may migrate and cause infection. Granuloma formation, breakage of metal fibers, hemoptysis, and airway obstruction due to impaction or granulomas and pain are potential results. Mortality due to stent placement is rare.

**Training Requirements**

Dedicated operators performing airway stenting should have extensive experience in flexible and rigid bronchoscopy and management of central airway lesions. Trainees should perform at least 20 supervised procedures in a supervised setting to establish basic competency. To maintain competency, dedicated operators should perform at least 10 procedures per year. In order to make the best choice for the individual patient, the dedicated operator should be proficient in the placement of both flexible and silicone stents.

**REFERENCES**

Bolliger CT. Airway stents. Semin Respir Crit Care Med 1997; 18:563–570
Dumon JF. A dedicated tracheobronchial stent. Chest 1990; 97:328–332

**THORACIC PERCUTANEOUS NEEDLE ASPIRATION/ CORE BIOPSY**

**Definition**

Thoracic percutaneous needle aspiration (TPNA) and core biopsy are both minimally invasive proce-

**Equipment**

Biopsy needles are typically 15 cm in length and 18- to 25-gauge in diameter. They may be aspirating or core biopsy needles. In addition, “automatic firing” biopsy guns are available. Ultrasound, fluoroscopy, or CT for localizing nonpalpable lesions and confirming accurate placement of the biopsy needle are also needed. Cytology slides and fixatives along with specimen containers for core biopsies and culture samples are needed, as are small-bore (SF to 12F) catheters or chest tubes to treat large or symptomatic pneumothoraces.

**Personnel**

A dedicated operator performs the procedure. Personnel required for this procedure include an RN or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of specimens. This will maximize patient comfort, safety, and yield. An on-site cytopathologist and/or technician should confirm adequate tissue samples.

**Anesthesia and Monitoring**

This procedure may be performed under local anesthesia with or without conscious sedation. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

**Technique**

After positioning the patient to provide suitable exposure and reviewing the imaging studies, the appropriate site, angle, and approximate depth of needle penetration are determined. Before inserting the biopsy needle, sufficient local anesthesia should be given. In case of a lesion that cannot be palpated, the needle path is guided through the use of ultrasound, fluoroscopy, or CT. Cell aspirate or core biopsy as previously determined is obtained and transferred to slides or appropriate media. Repeat biopsy in a separate area, if insufficient or inade-
quate material was obtained, may be performed. A chest radiograph should be obtained to check for pneumothorax.

**Indications**

Indications are an undiagnosed chest wall lesion, as well as undiagnosed pleural masses. An undiagnosed lung lesion may be an indication for TPNA; however, most central lung lesions will be approached with a bronchoscopy as the first attempt at a diagnosis. Patients eligible for surgical therapy with significant risk for lung cancer and peripheral lung lesions often proceed directly to appropriate surgical therapy. Presumed metastatic mediastinal masses are appropriate for TPNA. The diagnostic accuracy of cytology for thymoma, lymphoma, and germ-cell tumors is low. Some authors report good diagnostic success using 16- to 20-gauge core biopsy needles to obtain adequate tissue from nonmetastatic mediastinal masses.

**Contraindications**

Contraindications for TPNA and core biopsy include uncontrolled bleeding disorders and coagulopathies, as well as the inability to tolerate a pneumothorax.

**Risks**

Most series report a 20 to 25% incidence of pneumothorax after TPNA of the lung, with higher rates when patients have moderate-to-severe emphysema or with core biopsy. A minority of patients, 2 to 5%, will require a chest tube or catheter for drainage of the pneumothorax. Hemoptysis is reported in 5 to 15% of cases, with most patients having minimal hemoptysis. Fewer than 1% of patients experience significant (30 to 50 mL) hemoptysis. Pleuritic chest pain without a pneumothorax is also seen 2 to 5% of patients. Fewer than 1% of patients will experience a vasovagal reaction. Tension pneumothorax and death are rare complications of TPNA.

**Training Requirements**

Trainees should perform at least 10 TPNA procedures and 10 core biopsies in a supervised setting to establish basic competency. To maintain competency, dedicated operators should perform at least 10 procedures per year.

**References**


**Tube Thoracostomy**

**Definition**

Tube thoracostomy is a minimally invasive procedure in which a drainage catheter is placed percutaneously into the pleural space.

**Equipment**

Equipment consists of a sterile set of instruments, local anesthetic, suture material to fix the tube, a chest tube or catheter, a collection device, which includes a water seal (or dry equivalent), and dressings. No monitoring, oxygen, specialized personnel, or dedicated space is necessary, unless required for other aspects of the patient’s condition.

**Personnel**

The only required personnel is the dedicated operator placing the tube. An RN or nurse assistant may be useful to set up the sterile field, position the patient, and prepare the collection device.

**Anesthesia and Monitoring**

This procedure may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

**Technique**

The desired entry position of the tube is determined from radiology studies and physical examina-
tion. The patient is positioned to provide suitable exposure. After sterile preparation, local anesthetic is administered from the skin to the pleura. The dedicated operator then aspirates the pleural contents to verify the presence of fluid or air. A small skin incision is made. Blunt dissection is carried through the inferior portion of the selected interspace (to avoid injury to intercostal vessels) into the pleural space. The chest tube is passed into the pleural space and secured with all drainage holes within the pleural space. A collection device with water seal is connected. Wall suction may be applied to the collection device if desired. A chest radiograph is obtained to verify correct tube position and resolution of the intrapleural process.

**Indications**

Tube thoracostomy is indicated for pneumothorax, hemothorax, pleural effusion, empyema, and chylothorax. Timing, position, and relative indications will vary with each patient and must be individualized.

**Contraindications**

Tube thoracostomy is contraindicated in the absence of a pleural space (pleural symphysis). Coagulopathy is a relative contraindication in elective settings.

**Risks**

Complications of tube thoracostomy include hemorrhage, pulmonary laceration, air leak, and pain. Tube thoracostomy is usually a safe, relatively painless, and reliable bedside procedure. Complications, as outlined above, should be uncommon (approximately < 10%).

**Training Requirements**

Dedicated operators performing this procedure should have ample experience, excellent knowledge of pleural and thoracic anatomy, mature judgment in interpreting radiographic images related to pleural disease, and sufficient surgical skill. In this setting, complications should be minor and uncommon. Trainees should perform at least 10 procedures in a supervised setting to establish basic competency. To maintain competency, dedicated operators should perform at least five procedures per year.

**References**


**Medical Thoracoscopy/Pleuroscopy**

**Definition**

Medical thoracoscopy/pleuroscopy is a minimally invasive procedure that allows access to the pleural space using a combination of viewing and working instruments. It also allows for basic diagnostic (undiagnosed pleural fluid or pleural thickening) and therapeutic procedures (pleurodesis) to be performed safely. This procedure is distinct from video-assisted thoracoscopic surgery, an invasive procedure that uses sophisticated access platform and multiple ports for separate viewing and working instruments to access pleural space. It requires one-lung ventilation for adequate creation of a working space in the hemithorax. Complete visualization of the entire hemithorax, multiple angles of attack to pleural, pulmonary (parenchymal), and mediastinal pathology with the ability to introduce multiple instruments into the operative field allows for both basic and advanced procedures to be performed safely.

**Equipment**

Sterile equipment for visualization, exposure, manipulation, and biopsy is required. A high-resolution video imaging system, which includes the pleuroscope, that allows all members of the team to view and participate in the procedure is beneficial to facilitate maximum assistance to the dedicated operator and safety for the patient. The procedure can be either performed in the operating room or in a dedicated environment for invasive procedures.

**Personnel**

A dedicated operator performs the procedure. Personnel required for this procedure include an RN or a respiratory therapist to administer and monitor conscious sedation, as well as a separate RN or a respiratory therapist to assist the dedicated operator. All supporting personnel should be familiar with the procedure being performed, as well as the appropriate handling of specimens. This will maximize patient comfort, safety, and yield.

**Anesthesia and Monitoring**

This procedure may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hos-
pital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthetic and monitoring guidelines in their particular practice environment.

**Technique**

After adequate sedation is achieved, the patient is positioned in the full lateral decubitus with the hemithorax up, padded comfortably, and secured to the table. The site for pleuroscope entry into the pleural space is determined by surface anatomy landmarks, preoperative imaging studies, and physical examination to maximize visualization of the expected pathology. Standard sterile skin preparation and draping to create an adequate field are performed while the skin is anesthetized with local infiltration anesthesia. After ensuring adequate sedation, the hemithorax is entered bluntly with a clamp passed over the rib and through the pleura (see chest tube insertion technique). With an adequate access space created, the pleural space immediately subjacent to the entry site is digitally inspected to ensure an adequate pleural space (freedom from pleural adhesions) to safely insert the pleuroscope. The pleuroscope is inserted under direct vision into the pleural space. Once the surveillance panoramic examination is completed, the specific purpose of the procedure (eg, evacuation of pleural fluid, pleural biopsy, or pleurodesis) is addressed. Fluid is evacuated using suction catheters passed through the working channel under direct vision. Parietal pleural biopsy is performed with biopsy forceps passed through the working channel under direct vision. Once the examination and procedure are completed, the pleuroscope is withdrawn, a chest drain is placed, and the pneumothorax is evacuated.

**Indications**

Indications for medical thoracoscopy/pleuroscopy include indeterminate pleural fluid, abnormal pleura, and need for pleurodesis.

**Contraindications**

Lack of a pleural space, uncorrected coagulopathy, and hemodynamic instability are contraindications to the procedure.

**Risks**

Complications of medical thoracoscopy/pleuroscopy are uncommon. They include bleeding, infection of the pleural space, and injury to intrathoracic organs, atelectasis, and respiratory failure.

**Training Requirements**

Physicians performing this procedure should have ample experience, excellent knowledge of pleural and thoracic anatomy, mature judgment in interpreting radiographic images related to pleural disease, and sufficient surgical skill. Trainees should perform at least 20 procedures in a supervised setting to establish basic competency. To maintain competency, dedicated operators should perform at least 10 procedures per year.

**References**

Danby CA, Adebontojo SA, Moritz DM. Video-assisted talc pleurodesis for malignant pleural effusions utilizing local anesthetics and IV sedation. Chest 1998; 113:739–742  

**Percutaneous Pleural Biopsy**

**Definition**

Percutaneous pleural biopsy is a minimally invasive procedure performed to obtain pleural tissue using a pleural biopsy needle. This may be performed for targeted for pleural effusions, or using image guidance for pleural masses.

**Equipment**

The equipment needed for percutaneous pleural biopsy include pleural biopsy needles and a facility to perform an aseptic procedure under local anesthetic.

**Personnel**

The personnel required are the dedicated operator performing the pleural biopsy, and usually an RN or a physician’s assistant to monitor the patient, help with positioning, provide sterile supplies as needed, and process the specimen(s).

**Anesthesia and Monitoring**

Local anesthetic is sufficient for performing a percutaneous pleural biopsy and does not differ from
that provided for a standard thoracentesis. Initial vital signs are obtained, but continuous monitoring is not required.

**Technique**

In most patients, no focal pleural abnormality is present; in those with a focal abnormality, that location should be marked using CT or ultrasound (preferably in the same position as will be used for the biopsy). After selecting the site for biopsy, using aseptic technique, local anesthetic is administered to the pleural level. A small incision is made to accommodate the biopsy needle, which is then inserted into the pleural space at the lower side of the selected interspace (to minimize risk of intercostal neurovascular injury). The cutting edge of the needle is seated in the pleura and the biopsy taken.

Diagnostic yield is increased with multiple passes. Pleural brushings can also be obtained through the pleural needle.

**Indications**

Indications for percutaneous pleural biopsy include undiagnosed pleural effusions and pleural thickening or pleural masses. Diagnostic thoracentesis should precede pleural biopsy for pleural effusions. The role and relative yield of diagnostic thoracoscopy should also be considered when selecting closed pleural biopsy.

**Contraindications**

An uncorrectable coagulopathy is a contraindication. The risk of pneumothorax may be increased if no free-flowing pleural fluid is present.

**Risks**

Complications occur in < 1% of pleural biopsies, and include pneumothorax, hemotorax, and laceration of diaphragm, lung, liver, and spleen. Tumor seeding along the needle tract has rarely been reported.

**Training Requirements**

Physicians performing percutaneous pleural biopsy should be competent in thoracentesis, familiar with the mechanism and technique of the biopsy needle being used, and competent to recognize and treat the common complications. Trainees should perform at least five procedures in a supervised setting to establish basic competency. To maintain competency, dedicated operators should perform at least five procedures per year.

**Percutaneous Dilatational Tracheostomy**

**Definition**

Percutaneous dilatational tracheostomy (PDT) is an invasive procedure in which the placement of a tracheostomy tube is achieved after establishing a tracheal stoma through dilation, rather than surgical creation of a stoma.

**Equipment**

The procedure may be performed in the operating room or at the bedside. Dedicated procedure kits including needles, guidewire, and dilators are available. Easy access to bronchoscopy and airway management equipment is necessary.

**Personnel**

Two dedicated operators need to be present for this procedure; one dedicated operator performs the procedure, and the other manages the airway and endotracheal tube. This second dedicated operator should be prepared to perform bronchoscopy if necessary. Additional personnel required for this procedure include a nurse with the ability to administer and monitor conscious sedation.

**Anesthesia and Monitoring**

The procedure may be performed under local anesthesia, conscious sedation, or general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

**Technique**

Several techniques with slight variations from one another are described herein. Generally, the patient

**References**

is in supine position with the neck slightly extended. Ventilation should be controlled and the fraction of inspired oxygen changed to 1.0. Landmarks such as the tracheal cartilages are identified, and the area is then prepared and draped. A 1.0- to 1.5-cm superficial incision is made over the intended entry site, which usually is below the first and above the third tracheal ring. Depending on the neck anatomy, higher or lower entry points may need to be chosen. The endotracheal tube may be pulled back at this time, but the cuff should stay below the vocal cords. Alternatively, the endotracheal tube may stay in place during the procedure. A needle is introduced into the chosen interspace in the midline and a guidewire inserted. Once the needle is removed, the space is sequentially dilated to a size appropriate for the desired tracheostomy tube. The tracheostomy tube is then placed over the guidewire on an obturator. Once placement is confirmed, the endotracheal tube is removed. Bronchoscopic guidance may be beneficial for the novice and in complicated cases, and therefore should be readily available. It is not required for routine use.

**Indications**

Indications for PDT do not differ from accepted indications for placement of a surgical tracheostomy. The main indications are a need for a long-term artificial airway for prolonged ventilator dependence or management of secretions.

**Contraindications**

Absolute contraindications are uncontrollable coagulopathy, infection over the site, extreme ventilatory and oxygenation demands, and tracheal obstruction. Relative contraindications pertain to unfavorable neck anatomy and emergency airway management.

**Risks**

The complication rate is low. Airway injury, respiratory depression, pneumothorax, bleeding, cardiorespiratory arrest, arrhythmia, infection, and death are potential complications. Several studies have shown comparable outcomes between conventional and dilatational tracheostomy. An advantage of PDT seems to be a lesser incidence of bleeding and infection. If performed as a bedside procedure, the risk of patient transportation and operating room costs are foregone.

**Training Requirements**

Dedicated operators need to be experienced in emergent airway management before performing PDT. Trainees should perform at least 20 procedures in a supervised setting to establish basic competency. To maintain competency, dedicated operators should perform at least 10 procedures per year. Surgeons competent in conventional tracheostomy still need to acquire the necessary expertise with this procedure, but the required number of procedures could be less for such dedicated operators.

**REFERENCES**


**TRANSTRACHEAL OXYGEN THERAPY**

**Definition**

Transtracheal oxygen therapy (TTOT) is a minimally invasive procedure that is achieved through percutaneously placed devices that allow for long-term oxygen use. This procedure only deals with methods not employing surgically created stomas, and is usually a multistep procedure.

**Equipment**

The procedure is usually performed on an outpatient basis. Dedicated procedure kits including needles, guidewire, dilators, stents, and oxygen delivery catheters are available.

**Personnel**

A dedicated operator performs the procedure. Personnel required for this procedure include an RN or a respiratory therapist to administer and monitor conscious sedation if required, as well as a separate RN or a respiratory therapist to assist the dedicated operator. All supporting personnel should be familiar with the procedure being performed. This will maximize patient comfort and safety. As the long-term success of a TTOT procedure depends on careful teaching and follow-up and instructions on self-care, it is highly recommended to have a process in place dedicated to providing adequate patient education on the care of the device.
Anesthesia and Monitoring

This procedure may be performed under local anesthesia with or without conscious sedation or under general anesthesia. Specific monitoring and documentation guidelines vary from hospital to hospital and from state to state. We recommend that the dedicated operator inquire about the applicable anesthesia and monitoring guidelines in their particular practice environment.

Technique

Before establishing TTOT, patients and their caregivers need to undergo appropriate teaching and preparation and demonstrate motivation to return for multiple postprocedure visits. The first step for the procedure is placement of the percutaneous stent. A small, 1.0- to 1.5-cm vertical incision is made over the insertion site and a guidewire introduced via Seldinger technique. The opening is then dilated and a stent is placed. After 1 week of tract maturation, the stent is removed and the oxygen delivery catheter placed. Until the tract is completely mature, all exchanges have to occur over the wire. Regular frequent follow-up is needed for several weeks postprocedure to allow for patient teaching and early recognition of complications.

Indications

Long-term oxygen has been shown to be beneficial in a variety of disorders. TTOT provides an additional means of delivering oxygen. Advantages are longer life of oxygen sources and cosmetic issues. Additionally, there is some evidence that patients experience improvement of dyspnea and exercise tolerance. TTOT can be considered for any patient receiving long-term oxygen. It is a good option in the patient intolerant of nasal cannula oxygen delivery, refractory hypoxemia, and limited mobility due to high oxygen demands.

Contraindications

Contraindications are uncorrectable coagulopathy, terminal illnesses, lack of motivation or support, inability to return for follow-up, pleural herniation over the trachea, and upper airway obstruction.

Risks

Complications of TTOT placement are very uncommon and include mucous ball formation, pneumothorax, and subcutaneous emphysema. Mortality is exceedingly low, and the most common morbidity is catheter-induced coughing.

Training Requirements

Trainees should perform at least 10 procedures in a supervised setting to establish basic competency. To maintain competency, dedicated operators should perform at least five procedures per year.

References


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APPENDIX 1

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APPENDIX 2: Bronchoscopes Used in Pediatric Patients

<table>
<thead>
<tr>
<th>Scope Designation</th>
<th>Outer Diameter, cm</th>
<th>Working Length, cm</th>
<th>Suction Channel, mm</th>
<th>Smallest Endotracheal Tube Size*</th>
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</thead>
<tbody>
<tr>
<td>Olympus pediatric fiberoptic and video bronchoscopes†</td>
<td>BF-N20 2.2</td>
<td>55</td>
<td>None</td>
<td>3.0</td>
</tr>
<tr>
<td>BF-XP40 2.8</td>
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<td></td>
<td>3.5</td>
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<tr>
<td>BF-3G40 3.6</td>
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<td></td>
<td>4.5</td>
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<tr>
<td>BF-3C160 (video) 3.8</td>
<td></td>
<td></td>
<td></td>
<td>5.0</td>
</tr>
</tbody>
</table>

†The Olympus pediatric fiberoptic bronchoscope is a preferable size for pediatric bronchoscopy. It is smaller and has a design that minimizes irritation to the pediatric airway.

*Tube sizes are the smallest possible with each instrument. Utilizing these bronchoscopes with these sizes often leads to limited ability to ventilate, and the distinct possibility of the scope meeting significant frictional resistance as it is passed through the tube. It will always be safer and preferable to use 0.5 size larger than those listed or a laryngeal mask of larger caliber, especially in patients with significant intrinsic lung disease.

†Olympus; Tokyo, Japan.

‡Pentax; Asahi Optical; Tokyo, Japan.