REVIEW

Anesthetic considerations for interventional pulmonary procedures

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Purpose of review
To discuss the anesthetic considerations of various procedures now performed by the interventional pulmonologist. With recent technological advances, many of these procedures represent acceptable alternatives to the invasive surgical procedures. For example, the placement of endobronchial valves can substitute for lung reduction surgery and can greatly reduce the postoperative recovery period. However, many of these complex procedures require anesthesia services. The nature and indication for the procedure as well as the patient's overall health will have an impact on the anesthetic choice.

Recent findings
New studies have documented common complications from interventional pulmonology procedures and recent ways to avoid these complications have been suggested. Strategies to avoid obstruction, bleeding, pneumothorax and air embolism are discussed in this article. Potential benefits of high frequency jet ventilation in reducing airway pressures and, perhaps, barotraumas are cited. Novel interventional pulmonary procedures are described.

Summary
As the array of diagnostic and therapeutic pulmonary interventions is expanding, the types of anesthetic techniques and ventilatory modes are varying to fit the procedural requirements. Some pulmonary procedures are best accomplished in the lightly sedated patient, who is breathing spontaneously, whereas procedures that use the working channel of a rigid bronchoscope are better performed in the patient under general anesthesia and mechanical ventilation that often use jet ventilation to minimize respiratory movements.

Keywords
anesthesia, bronchoscopy, pleuroscopy, pulmonology, sedation, total intravenous

INTRODUCTION

Interventional pulmonology includes a variety of techniques to treat diseases and conditions of the chest using bronchoscopic and pleuroscopic techniques. Many of these procedures can be performed without the presence of anesthetists and with only mild or conscious sedation. Other patients, however, because of the severity of their thoracic disorder or to other co-morbidities, must undergo deep sedation or general anesthesia administered by an anesthesiologist or certified nurse anesthetist. This review will focus on the types of interventional pulmonology procedures that do require anesthesia services. In addition to a description of the individual procedures, this review will highlight the concerns to the anesthetist and the usual choice of anesthetic technique. Evidence in the literature will be presented, whenever it is available, to help support clinical decisions.

Most patients who require interventional pulmonology procedures have a form of central airways obstruction (CAO). CAO is a collection of conditions that affect the large bronchi and the trachea. The airway obstruction can result from intrinsic, extrinsic or mixed compression. The causes of CAO are summarized elsewhere [1■■,2], but consist of malignant and nonmalignant causes. The malignant causes can be primary or metastatic neoplasms. The nonmalignant causes include trauma, infection, inflammation and vascular lesions as well as

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KEY POINTS

- The anesthetic plan may vary, because of the requirements of the pulmonologist, the extent of the patient's lung disease, or the patient's comorbidities.
- The anesthetic used may be conscious sedation, deep sedation, or general anesthesia
- If general anesthesia is used, it is usually a form of total intravenous anesthetic (TIVA).
- The use of specialized breathing techniques, such as high frequency jet ventilation (HFJV), may provide better and safer conditions for the pulmonologist and for the patient.

other entities, such as tracheomalacia, relapsing polychondritis and sarcoidosis.

PROCEDURES IN INTERVENTIONAL PULMONOLOGY THAT REQUIRE ANESTHESIA

The following procedures span the usual types of interventions that require anesthesia services and that consist of either deep sedation or general anesthesia.

Rigid bronchoscopy

Rigid bronchoscopy is often used as both an instrument of diagnosis and a vehicle to administer therapy. First described by Killian in 1898 [3], the long, linear instrument was passed in awake patients using local anesthesia (cocaine). Killian described the mobility of the tracheobronchial tree and demonstrated the ability to selectively inspect both the right and left bronchi. For interventional pulmonology procedures, the beveled instrument can help pass obstructing tumors in the airway and the large working channel can allow for passage of debrider instruments, laser equipment, balloons, stents and valves. The following interventional pulmonology techniques are usually employed through the rigid bronchoscope.

(1) Stent placement in the tracheobronchial tree is used to establish or maintain the integrity of the hollow architecture of the airways. The first reliable and successful airway stent was the Montgomery T-tube of the 1960s, which held open the airways above and below a tracheostomy site [4]. The first distal airway stents were designed by Dumon [5]. The Dumon stents were made of silicone and were relatively easy to place. A generation of either silicone or plastic stents is now manufactured, that are inexpensive and easy to position and remove. The Dumon-type stents provide a barrier to tumor in-growth and cause minimal local tissue inflammation. Complications include migration, granulation formation and secretion inspissation. Bifurcated or Y-stents can be useful in tracheobronchial malacia and are much less likely to migrate.

The other major class of stents is the metallic stents. These stents are expandable and less likely to migrate than the silicone tube stents. In addition, metallic stents tend to preserve the mucociliary clearance and can be deployed using only a flexible bronchoscope. They are expensive, however, and can crack or fracture. The metal stents often require a rigid bronchoscope for removal as they often are adherent to surrounding tissues such as local granulation formation, inflammatory changes, and tumor in-growth.

Anesthetic considerations during stent placement: The underlying thoracic condition can affect the anesthetic management of the patient during the interventional pulmonology procedure as well as during the postoperative period. For example, if the patient is undergoing the stent placement for the relief of an obstructed airway, the establishment of a communication to an unventilated lung segment can release copious thick or even purulent secretions. Large mediastinal masses can become more obstructive when the patient is placed supine. Extensive tracheobronchial malacia can become more symptomatic when an irritative stent causes frequent coughing fits. Therefore, issues related to the postoperative recovery phase need to be anticipated and the appropriate respiratory support provided.

Most providers would prefer general anesthesia for the rigid bronchoscopy. Usually, a total intravenous anesthetic (TIVA) is used with propofol 100–200 μg/kg per min and remifentanil 0.1–0.3 μg/kg per min. Succinylcholine 1.5 mg/kg can be administered in order to facilitate the passage of the rigid bronchoscope. A maintenance dose of a nondepolarizing muscle relaxant, such as rocuronium 0.3 mg/kg, will help to maintain adequate levels of relaxation. Often, high frequency jet ventilation (HFJV) is used to minimize movement during the case and, perhaps to reduce airway pressures and the chance of barotraumas.

Jet ventilation offers several advantages, such as delivering small tidal volumes, often below dead space, little diaphragmatic excursion, and minimal movement of the heart. Although several forms of high frequency ventilation exist, this discussion will focus on moderate HFJV with frequencies of approximately 120 breaths per minute. Jet ventilation allows for lower mean and peak airway pressures and can result in greater hemodynamic stability, when compared with conventional positive pressure ventilation. In our center, a frequency of 120 breaths per minute, an inspiratory ratio of 0.4, a driving pressure of 20 psi, and an FiO_2 of 0.5 are used as initial settings. The jet is attached onto the side port of the rigid bronchoscope using a luer lock connection. A jet ventilator, with an added feature of a 'hard stop' that prevents ventilation if high airway pressures are detected, is used.

Jet ventilation has been used to facilitate other procedures, such as endobronchial laser surgery and interventional bronchoscopy [6,7]. In a study comparing jet ventilation with conventional ventilation performed during endobronchial laser surgery, the authors reported a shorter duration of surgery when the jet ventilation was used. However, no significant differences were seen between the hemodynamic profile of the two patient groups, the ability to extubate the patients at the end of the procedure and in the values of arterial blood gas analysis. In the jet ventilation group, flexible bronchoscopy at the end of the procedure showed no apparent trauma of the airway.

However, there are possible complications caused by jet ventilation and they include hypercapnia, hypertension, hypotension, hypoxemia and bronchospasm.

In the case of a metallic stent placement using a flexible bronchoscope, the case is done under laryngeal mask airway (LMA) general anesthesia. The TIVA consists of a single drug infusion: propofol at doses of 150–250 μg/kg per min. The patient may be able to breathe spontaneously during the procedure.

(2) Tissue resection and removal can be in the form of biopsies [including transbronchial needle aspirations (TBNA)], washings, lavage, debridement, resection, excision, and cauterization and cryoablation. All of these techniques have a common aim of the removal of tissue to relieve an obstruction or cancer or the acquisition of tissue to make a diagnosis. All of these techniques share the common complications of bleeding and perforation. Blood loss can range from inconsequential to massive. Perforation can lead to the extravasation of air locally in the form of subcutaneous emphysema, pneumothorax or pneumomediastinum. Air can also embolize into the vascular system.

The type of technology used to manipulate tissue can determine the potential complications as well. For instance, laser excision involves fire hazards and requires low (near atmospheric) oxygen tensions to prevent acceleration of combustion. Electrocautery can present an employee health risk with the vaporization of carcinogens and the aerosolization of viruses. The argon beam coagulator has been associated with venous air (or argon) emboli, some of which have been seen to reach the left heart and coronary arteries [6]. Cryoablation has affected the nerve conduction of adjacent structures such as the vagus nerve, causing bradycardia. Radiofrequency ablation also has been associated with nerve conduction interruptions as well as with local damage to instruments in adjacent structures; such as transesophageal echocardiography probes in the distal esophagus. Brachytherapy, which involves the local implantation of radioactive implants, can lead to delayed hemoptysis and fistula formation. Photodynamic therapy, which relies on the increased ability of neoplastic cells to incorporate and retain hematoporphyrin compounds, uses these compounds as photosensitizing agents. When exposed to monochromatic light via multiple bronchoscopic treatments, the neoplastic cells lyse. As such, hemoptysis can result from this extensive tumor necrosis. In addition, the patient's skin is also very sensitive even to sources of artificial light.

Anesthetic consideration for tissue resection procedures: Most cases of tissue washings and biopsies are accomplished using flexible bronchoscopic access and obviate the need for deep sedation or general anesthesia. Certain biopsies, such as fine needle aspirations that require localization using endobronchial ultrasound (EBUS), usually happen under general anesthesia, which allows for a more precise movement of the ultrasound instrument and location of the fine needle. This general anesthetic often involves an LMA with either TIVA using propofol as described above or the continuous administration of an inhalational anesthetic, such as sevoflurane in 2–3% concentrations and spontaneous respirations.

The other exception, during which time general anesthesia is used, occurs when bronchoalveolar lavage (BAL) is employed therapeutically for pulmonary alveolar proteinosis (PAP). PAP consists of the exuberant accumulation of lipoproteinaceous material in the distal airways and, in the adult, usually occurs secondary to a malignancy, infection or pneumoconiosis. Both congenital and adult forms have been associated with low levels of granulocyte macrophage colony stimulating factor (GM-CSF), suggesting an abnormality in the pulmonary macrophage as a cause for this condition. These patients are at greater risk for infection and have a higher likelihood to have connective tissue disorders. The BAL requires the administration of 10–50 liters of irrigating fluid, a procedure that takes several hours. Thus, the patient is given general anesthesia and is intubated with a double lumen tube to accomplish lung isolation. The lungs are lavaged sequentially, with the ventilating lung as the nondependent lung and with the appropriate endobronchial cuff inflated to safeguard the ventilating lung. Warmed lavaging solutions are essential to prevent hypothermia.

(3) Dilation of tracheal stenosis, while a form of tissue resection, can often manifest with severe symptoms of dyspnea and stridor and with preoperative challenges that can compound the anesthetic management. The patient with tracheal stenosis often presents with obvious dyspnea at rest, audible stridor, and reliance on accessory chest musculature to ventilate adequately. Usually, these symptoms require an obliteration of at least 70% of the cross-sectional area of the airway. Although the cause of tracheal stenosis has a long list of causes, the reasons for adults to present with tracheal stenosis usually consist of neoplasm, trauma, systemic disorder and infection. Both primary and secondary neoplasms can create a narrowing from within the airway or a tumor growth that envelops the airway. Traumatic causes include postintubation and posttracheostomy states as well as blunt and penetrating injuries. Common systemic disorders that result in tracheal stenosis include Wegener's granulomatosis and amyloidosis. Infections causing stenosis of the airway are more rare, such as diphtheria, syphilis, and typhoid.

Various surgical procedures can be used to establish an emergency airway and to perform an elective resection of tracheal stenosis. These procedures are beyond the scope of this article. Instead, the interventional pulmonology approaches to tracheal stenosis will be described. Many of the resective techniques are described above in the section on tissue resection and removal and will not be repeated here. In addition, balloon dilation is a commonly employed procedure used to expand a narrowed airway. In severe stenosis, a wire can be advanced across the narrowed area. A balloon is then advanced over the wire, using care to expand the proximal portion of the stenosis first. Depending on the cause of the stenosis, the airways can be friable, inflamed or calcified. Complications from balloon dilation include bleeding, airway perforation and fracture. Immediate balloon inflation can also result in hypoxemia.

Percutaneous tracheostomy/tracheotomy

Percutaneous approaches to the trachea provide a surgical airway that can be accomplished at the patient's bedside and that has fewer complications than conventional open tracheostomies. In addition, the stomal wound healing is much improved with these newer techniques. Several commercial devices exist that share common features. All the devices require initial passage of a flexible wire into the trachea. The tract of the wire is then systematically widened, either by the use of dilating forceps or by the sequential use of tapered dilators.

Percutaneous tracheotomy generally improves symptoms and overall allows increased daily activities. Nonetheless, certain complications do exist. Temporary hoarseness is common and approaches a prevalence of 50% [7]. Other complications are rare, such as symptomatic tracheal stenosis (with a prevalence of 1.9%). Direct injuries to the vocal cords or the recurrent laryngeal nerves are extremely uncommon. The recommended use of concomitant bronchoscopy during the procedure can help to avoid the complications of paratracheal cannula insertion and pneumothorax. Prolonged bronchoscopic examination, however, has been associated with hypercarbia during these percutaneous procedures.

Anesthetic consideration of percutaneous tracheostomy/tracheotomy

Intravenous sedation as well as intravenous general anesthesia (TIVA) is employed, depending on the clinical anesthetic requirements of the patient and conditions needed by the proceduralist. Usually, an advanced airway such as an endotracheal tube or a LMA is used to support ventilation and to facilitate instrument insertion and manipulation. Unconscious patients require little sedation but may need local anesthesia applied trans-trachealy to blunt airway responses to tracheal manipulation. Usually, the conscious sedation is accomplished using an infusion of propofol at 30–100 μg/kg per min, whereas a TIVA requires a propofol infusion of 100–200 μg/kg per min along with an infusion of remifentanil at 0.1–0.3 μg/kg per min. Spontaneous ventilation is maintained, as it allows for the continuous ventilation during maneuvering of the endotracheal tube above and below the level of the vocal cords.

For the airway portion of the procedure, which includes the initial wire passage, dilation, and passage of the tracheostomy tube, the endotracheal tube is withdrawn to ensure that the cuff is superior to the level of cannulation. Lidocaine local anesthetic is given trans-trachealy as mentioned, as well as infiltrated around the stoma site.

Once the trachea is passed and ventilation is verified, the sterile tubing is passed off the field to the anesthetic circuit. The ability to provide positive ventilation is confirmed and the tracheal cuff is adjusted to the minimal pressure that maintains a seal with ventilation to a peak of 20 mmHg.

Postsurgical care should include watching for such complications as obstruction and decannulation, which occur in as much as 3% of times and is a more common occurrence with the percutaneous procedures. This complication is often severe and frequently life-threatening. Other postoperative problems include hemorrhage, infection, and death. Death, however, is seldom related to the procedure and more likely represents the associated comorbidities with their attendant risks of most of this patient population.

Flexible fiberoptic bronchoscopy

The anesthetic technique most often used for the procedures involving the flexible fiberoptic bronchoscope has been the TIVA with a LMA. The TIVA allows for a deep level of sedation and spontaneous ventilation. Usually, 150–250 μg/kg per min of propofol is used. The LMA allows for a low resistance during spontaneous ventilation and, thus, adequate tidal volumes. In addition, the LMA affords easy access via the bronchoscope to the vocal cords and the bronchial tree. In general, a standard LMA is used, which does not have the exaggerated curve of an intubating LMA or the aperture bars of some LMA types. Topical lidocaine can be given prior to the induction of anesthesia to decrease coughing on LMA insertion. Tracheal reflexes are blunted by incorporating a 'spray-as-you-go' technique of topical lidocaine spray via the working channel of the bronchoscope. The advantage of TIVA over inhalational anesthesia is the lack of significant concentrations of halogenated compounds in the interventional pulmonology room environment.

Problems that arise during flexible bronchoscopy can be related to the anesthetic agents or to the procedure performed. Local anesthetic agents can produce toxicity such as tinnitus, confusion, and seizures as well as allergic reactions. Specific local anesthetics, such as chloroprocaine, can produce methemoglobinemia. Propofol can induce hypotension, especially in the elderly. This form of hypotension may require bolus injections of phenylephrine or ephedrine as well as continuous infusion of phenylephrine.

The procedure of flexible bronchoscopy is associated with its own complications. With multiple insertions and withdrawals of the scope, for example, the LMA can become dislodged and the patient can exhibit a large air leak. This can lead to hypoventilation and to desaturation as measured by the pulse oximetry. Flexible bronchoscopy can also result in bleeding, bronchospasm and bronchial disruption. Bleeding is more common with tissue cauterization and excision and bronchial disruption is more likely with balloon dilation.

Endobronchial volume reduction

Although the effectiveness of surgical lung volume reduction has been shown in patients with severe emphysema [8], this effectiveness has not been demonstrated in the case of endobronchial volume reduction. In surgical patients, this procedure can improve the walking distance, the quality of life as well as measured lung function (FEV_1). The endobronchial procedure is accomplished using small one-way valves that occlude distal bronchial segments and allow nonventilating or hypoventilating areas to passively collapse.

Anesthetic consideration of endobronchial volume reduction

The considerations for volume reduction procedures follow those for any flexible bronchoscopic procedure with the understanding that these patients often have severe and longstanding emphysema. The intraoperative choice of anesthetic technique is usually conscious sedation, which is accomplished using an infusion of propofol at 30–100 μg/kg per min. Spontaneous ventilation is maintained. The resultant loss of lung volume occurs in areas with decreased aerating spaces, so oxygenation and ventilation are not effected. Postoperative care may require a period of mechanical ventilation, especially if the patient has severe lung disease or if significant amounts of opioids are required to accomplish postoperative analgesia.

Pleuroscopy

The exploration of the pleural cavity can be performed for both diagnostic and therapeutic indications. Often performed in patients with loculated pleural effusions or multiple pleural masses, pleuroscopy provides means to both visualize and acquire tissue, if needed. In the cases of tuberculous and of malignant pleural effusions, the use of pleuroscopy has greater sensitivities than using percutaneous thoracocentesis alone [8]. The identification of a nonmalignant condition is also comforting, as survival in these patients is on average 9.5 years and without development of a malignancy [9]. A recent Cochrane review [10▪] suggests that surgical pleurodesis is more effective than medical pleurodesis and that talc is the preferred sclerosant agent. The major advantage to medical pleurodesis is the ability to perform the procedure with the patient breathing spontaneously and requiring minimal, if any, sedation.

A significant number of patients who undergo thoracoscopic talc pleurodesis develop major postprocedure complications [11]. Almost 10% of patients complain of worsening dyspnea and almost 3% of patients show evidence of talc-related lung injury.

Anesthetic consideration of pleuroscopy

For the patient, who is receiving anesthesia, there are several absolute contraindications to thoracoscopy. A trapped lung or lack of a pleural space would preclude the procedure. Severe pulmonary fibrosis, pulmonary hypertension or uncorrectable coagulopathy would also be reasons to avoid pleuroscopy. Relative contraindications would be hypoxemia unrelated to the pleural disease, unstable cardiovascular disease, fever or poor general health. Most of these cases can be accomplished with moderate or deep sedation while maintaining spontaneous ventilation. Often, opioid analgesia is required in the postoperative period following pleurodesis, due to an exaggerated pain from pleural inflammation. On occasion, a thoracic epidural is started in the recovery area as a rescue technique to provide satisfactory analgesia.

Bronchial thermoplasty

The medical treatment of asthma involves the modulation of bronchial constriction and the reduction of the inflammatory changes in the airways. By applying directed radiofrequency energy to the airways, bronchial thermoplasty serves to reduce the smooth muscle hypertrophy of airways and to lessen the ability of the airways to bronchoconstrict. The efficacy of this treatment has been demonstrated in animals and it includes the demonstration of prolonged reduction in the bronchoconstrictive response to a methacholine challenge for as long as 3 years [12,13]. Pathologic examination of human airways after bronchial thermoplasty treatment and prior to a scheduled resection showed temporary redness and edema, but little scarring. A significant reduction in airway smooth muscle, measured as a percentage circumference with abnormal or absent smooth muscle, has also been observed [14]. Although the mechanism for the decrease in airway responsiveness remains poorly understood [15▪], the reports of effectiveness of bronchial thermoplasty seems to be causing an increase in its popularity as a treatment of asthma.

The procedure of bronchial thermoplasty involves the radiofrequency treatment of airways of 3–10 mm in diameter, with the exception of the right middle lobe. The right middle lobe is not treated, because of a theoretical risk of inducing right middle lobe syndrome through radiofrequency-induced edema of the long and narrow right middle lobe bronchial segment. A small flexible bronchoscope is used (4.9–5.2 mm outer diameter), to assure access to smaller bronchial segments. The procedure is usually divided into three sessions: Right Lower Lobe treatment, Left Lower Lobe treatment, and Bilateral Upper Lobe treatment. During each subsequent treatment, there is assessment of the previously treated lobes to screen for persistent damage or stenosis. Usually, there is a 3-week interval between each treatment session. There is a systematic distal-to-proximal treatment of the segments in an agreed-upon order, to obviate the twice-treated segment or the untreated airway.

Anesthetic consideration of bronchial thermoplasty

Most clinicians have only included a stable cohort of asthmatics to undergo bronchial thermoplasty. These patients need to be free of any recent pulmonary infection and without any recent asthma exacerbation. They should also be without any comorbidity, which would increase their risk of perioperative respiratory problems. Patients with obstructive sleep apnea, significant cardiovascular disease, epilepsy, insulin-dependent diabetes or cancer were excluded from early clinical trials. In addition, patients with known allergies to local anesthetics, atropine, opioids, or benzodiazepines were excluded. Patients with internal pacemakers or neurostimulators were also not considered as candidates for bronchial thermoplasty. These patients were excluded from study for the theoretical possibility of thermal injury to pacemaker or stimulator leads or to the tissue surrounding these leads.

Preoperatively, the patient is given an oral corticosteroid, such as methylprednisolone and an antisialogogue, such as glycopyrrolate 30 min before the procedure. Albuterol is also given. A benzodiazepine, such as midazolam can be administered as an anxiolytic and amnestic.

The procedure of bronchial thermoplasty can either be performed using moderate (or conscious) sedation or deep sedation [16]. The moderate sedation involves the spray-as-you-go administration of local anesthetic and a combination of midazolam and fentanyl, to provide sedation and analgesia. This technique is described in the article by Mayse *et al.* [17]. At our institution, there is a preference for deep sedation, usually using propofol intravenous infusion (150–200 μg/kg per min). A laryngeal mask airway may be used to facilitate passage of the bronchoscope and spontaneous ventilation is maintained. Usually, antiemetic prophylaxis is not needed.

The patient remains in the recovery area until the vital signs are stable, the gag reflex is intact, and spirometry displays baseline values. Patients are informed that often symptoms worsen in the weeks after bronchial thermoplasty. These symptoms can include dyspnea, cough, wheezes, chest discomfort and nocturnal awakenings.

CONCLUSION

Interventional pulmonology includes a variety of techniques [18] and is performed on patients, many of whom have significant lung disease and other comorbidities. Some of these procedures can be performed without the presence of anesthetists. Other patients, however, due to the severity of their thoracic disorder or comorbidities must undergo deep sedation or general anesthesia [19].

This review covered specific indications for anesthetic services and a brief description of the interventional pulmonology technique, although other reviews do describe current techniques of interventional pulmonology [20]. This review illuminated the concerns to the anesthetist and suggested a usual choice of anesthetic technique, if one is indicated [17]. Evidence in the literature, where available, was presented to help support clinical decisions [21,22].

Acknowledgements

None.

Conflicts of interest

There are no conflicts of interest.

REFERENCES AND RECOMMENDED READING

Papers of particular interest, published within the annual period of review, have been highlighted as:
▪ of special interest
▪▪ of outstanding interest
Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 98–99).

1. ▪▪ Peter Slinger, editor. Principles and practice of anesthesia for thoracic surgery. Springer: New York; 2011.

Well written and illustrated textbook with up-to-date references.

2. Ernst A, Gerard A, Silvestri GA, Johnstone D. Interventional pulmonary procedures guidelines from the American College of Chest Physicians. Chest 2003; 123:1693–1717.
3. Killian G. Ueber directe bronchoscopie. MMW 1898; 27:844–847.
4. Montgomery WW. T-tube tracheal stent. Arch Otolaryngol 1965; 82:320–321.
5. Dumon JF. A dedicated tracheobronchial stent. Chest 1990; 97:328–332.
6. Unzueta MC, Casas I, Merten A, Landeira JMV. Endobronchial high-frequency jet ventilation for endobronchial laser surgery: an alternative approach. Anes Analg 2003; 96:298–300.
7. Hautmann H, Gamarra F, Henke M, *et al.* High frequency jet vemntilation in interventional fiberoptic bronchoscopy. Anes Analg 2000; 90:1436–1440.
8. Reddy C, Majid A, Michaud G, *et al.* Gas Embolism following bronchoscopic argon plasma coagulation: a case series. Chest 2008; 134:1066–1069.
9. Brietzke SE, Meyers AD. Percutaneous tracheotomy treatment and management. http://emedicine.medscape.com/article/866567_treatment#a17. [Accessed 2011]
10. ▪ Carey B, Trapnell BC. The molecular basis of pulmonary alveolar proteinosis. Clin Immunol 2010; 135:223.

This is a good review of the genetic mechanisms of this disease.

11. Geddes D, Davies M, Koyama H, *et al.* Effect of lung-volume-reduction surgery in patients with severe emphysema. N Engl J Med 2000; 343:239–245.
12. Loddenkemper R, Mai J, Scheffeler W. Prospective individual comparison of blind needle biopsy and of thoracoscopy in the diagnosis and differential diagnosis of tuberculous pleurisy. Scand J Respir Dis 1978; 102:196–198.
13. Mouchantaf FG, Villanueva AG. The long-term prognosis of patients with the diagnosis of nonmalignant pleural effusions after pleuroscopy. J Bronchol Intervent Pulmonol 2009; 16:25–27.
14. Shaw PHS, Agarwal R. Pleurodesis for malignant pleural effusions. Cochrane Database Syst Rev 2004:CD002916. doi: 10.1002/14651858.CD002916.pub2.
15. ▪ Gonzalez AV, Bezwada V, Beamis JF, Villanueva AG. Lung injury following thoracoscopic talc insufflation: experience of a single North American Center. Chest 2010; 137:1375–1381.

A candid review of the effectiveness and the pitfalls of this therapy.

16. Danek CJ, Lombard CM, Dungworth DL, *et al.* Reduction in airway hyperresponsiveness to methacholine by the application of RF energy in dogs. J Appl Physiol 2004; 97:1946–1953.
17. Mayse ML, Laviolette M, Rubin AS, *et al.* Clinical pearls for bronchial thermoplasty. J Bronchol 2007; 14:115–123.
18. Cox G, Miller JD, McWilliams A, *et al.* Bronchial thermoplasty for asthma. Am J Respir Crit Care Med 2006; 173:965–969.
19. Miller JD, Cox G, Vincic L, *et al.* A prospective feasibility study of bronchial thermoplasty in the human airway. Chest 2005; 127:1999–2006.
20. Bel EH. Hot stuff: bronchial thermoplasty for asthma. Am J Respir Crit Care Med 2006; 173:941–943.
21. Seijo LM, Sterman DH. Interventional pulmonology. N Engl J Med 2001; 344:740–749.
22. Gonzalez R, DeLaRosa-Ramirez I, Maldonado-Hernandez A, *et al.* Should patients undergoing bronchoscopy be sedated? Acta Anesthesiol Scand 2003; 47:411–415.