Tube Thoracostomy: A Review for the Interventional Radiologist

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ABSTRACT

Small-caliber tube thoracostomy is a valuable treatment for various pathologic conditions of the pleural space. Smaller caliber tubes placed under image guidance are becoming increasingly useful in numerous situations, are less painful than larger surgical tubes, and provide more accurate positioning when compared with tubes placed without image guidance. Basic anatomy and physiology of the pleural space, indications, and contraindications of small caliber tube thoracostomy, techniques for image-guided placement, complications and management of tube thoracostomy, and fundamental principles of pleurodesis are discussed in this review.

KEYWORDS: Thoracostomy, tube thoracostomy, pleural drain, pleurodesis

Objectives: Upon completion of this article, the reader should be able to recall basic anatomy and physiology of the pleural space, identify indications and contraindications for tube thoracostomy, select an appropriate imaging modality for guidance, list potential complications, state the principles of chest tube management, and explain the indications for and methods of performing pleurodesis.

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Tube thoracostomy is a valuable tool for the treatment of various pathologic conditions of the pleural space. Recent literature suggests that treatment with small caliber tube thoracostomy is equally effective and less painful than treatment with large caliber tube thoracostomy in the treatment of pleural infection.^{1,2} Additionally, it has been shown that wire-guided chest tube placement allows for more accurate positioning when compared with the classic surgical technique.³ Consequently, the role of small caliber tube thoracostomy is increasing and often performed under image guidance by interventional radiologists. The purpose of the article is to review anatomy and physiology of the

pleural space, indications and contraindications of small caliber tube thoracostomy, techniques for image-guided placement, and the fundamental principles of pleurodesis. Similarly, we will discuss complications of tube thoracostomy placement and provide instruction in dealing with these complications, which is an important consideration as interventionalists assume longitudinal care for these patients.

ANATOMY AND PHYSIOLOGY

The basic chest wall anatomy includes skin, subcutaneous tissue, muscle, parietal pleura, pleural space, vis-

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ceral pleura, and lung parenchyma. It is important to note the orientation of the intercostal neurovascular bundle located just inferior to the rib. From superior to inferior, the orientation is rib, vein, artery, nerve, muscle, and the next inferior rib. The parietal pleura surrounds the chest cavity and forms the more superficial component of the pleural space, a space that surrounds the entire lung. The pleural space is roughly 15–20 microns wide in a normal physiologic state.⁴ The visceral pleura forms the inner component of the pleural space and surrounds the lung. Both membranes join in the region of the hila. It is postulated that the parietal pleura is more important in pleural fluid clearance. Only the parietal pleura has lymphatic stomata that open directly into the pleural space, allowing clearance of pleural fluid via lymphatics within the parietal pleura (this lymphatic drainage also generates the negative pressure of the pleural space). The visceral pleura does not contain stomata to allow direct communication to the pleural space, but instead contains subpleural lymphatics.⁵

The basic physiology of fluid turnover in the pleural space lies within Starling's century-old postulation that under normal conditions there is a state of near equilibrium at the capillary membrane. This is well reflected in the Starling equation, which states that the fluid exiting the capillary and entering the interstitial space is affected by four basic factors. Three of these factors are forces that tend to move fluid out of the vessel: the hydrostatic pressure within the vessel, the interstitial colloid osmotic pressure, and the negative interstitial free fluid pressure. The fourth factor, the plasma colloid osmotic pressure, tends to move fluid into the vessel. Overall, in a normal physiologic state, there is a small net outward force at the capillary bed that results in a small amount of fluid that cannot be reclaimed by the capillaries. This fluid is resorbed and delivered back into the vasculature by way of the lymphatics. Much like the negative pressure generated by the lymphatics within the pleural space, this same negative pressure occurs within the interstitial space throughout the body.⁶ These dynamics occur at the pleural membranes and are responsible for fluid turnover, with the systemic vascular pressure affecting the parietal pleura and the pulmonary vascular pressure affecting the visceral pleura. The summation of the hydrostatic and colloid osmotic pressures between the parietal pleural membrane and the pleural space results in a net pressure of 7 cm H₂O (33–26) favoring entry into the pleural space. The summation of the hydrostatic and colloid osmotic pressures between the visceral pleural membrane and the pleural space results in a net pressure of 2 cm H₂O (28–26) favoring entry into the pleural space.⁷ A normal amount of pleural fluid within the pleural space of a healthy nonsmoking adult is ~0.25 mL/kg.⁸

Elevation in pleural microvascular hydrostatic pressure (namely systemic and pulmonary venous pressure), changes in colloid oncotic pressures, or disruption of the lymphatic drainage (i.e., malignant obstruction) can all result in pleural fluid accumulation. Additional etiologies include fluid from the lungs (acute lung injury), from the mediastinum (such as chyle from a thoracic duct injury), or across the diaphragm from the peritoneal space (pancreatitis, etc.).

INDICATIONS FOR TUBE THORACOSTOMY

Thoracostomy has evolved as a primary treatment for evacuation of air or fluid in the pleural space from a myriad of causes. Air within the pleural space is one of the most common reasons for a chest tube. Within the context of pneumothoraces, indications include:

1. Large (> 25% or apex to cupula distance > 3 cm) primary spontaneous pneumothorax; small pneumothorax in this patient population with no underlying lung disease can usually be managed with observation alone⁹
2. Mechanically ventilated patients with pneumothorax or effusions to decrease the work of breathing and help the patient wean off the ventilator¹⁰
3. Secondary spontaneous pneumothorax. Patients with underlying lung disease (cystic fibrosis, interstitial lung disease, emphysema, etc.) will benefit from thoracostomy. They usually have pronounced symptoms and a high recurrence rate with no intervention. There have been reports of increased mortality in those patients where clinical observation is done for small pneumothoraces. Large (> 25% or apex to cupula distance > 3 cm) pneumothorax requires chest tube placement.^{9,11}
4. Hemodynamically unstable patient
5. Recurrent or persistent pneumothorax
6. Tension pneumothorax requires needle decompression followed by an ipsilateral chest tube¹²
7. Pneumothorax related to trauma

Because of the risk of a tension pneumothorax, a chest tube should be considered for all patients with a penetrating chest injury if positive pressure ventilation will be used or if they have delayed access to definitive care.¹¹

Other substances filling the chest cavity also serve as indications for chest tube insertion:

1. Hemothorax/hemopneumothorax: Chest tubes help to guide management in hemothoraces. Indications for further intervention such as thoracotomy and blood replacement include evacuation (a) > 1000 to 1500 mL, (b) > 300–500 mL in the first hour, and (c) > 100 mL/h for the first 3 hours.^{11,13}

2. Esophageal rupture with gastric fluid/contents into the pleural space¹²
3. Effusions (first time or recurrent): Parapneumonic—Fluid collection is usually initially analyzed with thoracentesis. Frank pus, positive Gram stain, glucose < 60 mg/dL, pH less than 7.20, or elevated lactate dehydrogenase ($> 3 \times$ serum level), and recurrence are associated signs that necessitate the need for chest tube drainage. Empyema—Pus in the pleural space requires rapid intervention as the collection can become loculated, which may ultimately require thorascopic decortication. There has been reported mortality from delayed chest tube placement in patients with empyemas.¹⁴
4. Malignant effusion: May be initially managed with thoracentesis depending on the size of the collection; however repeat effusion, which is common, requires more aggressive treatment such as tunneled thoracostomy (possibly followed by pleurodesis)¹⁵
5. Chylothorax: Initial management includes chest tube drainage. The defect in a traumatic chylothorax usually closes spontaneously. However, thoracostomy will help guide management as continued drainage past 1–2 weeks obviates the need for definitive treatment such as thoracic duct ligation^{13,15} or percutaneous embolization.

Thoracostomy tubes can also be utilized for instilling sclerosing agents in the pleural space and lysis of adhesions. Chest tubes also have a role after cardiothoracic procedures to ensure appropriate and continued drainage of air, blood, and fluid.¹²

CONTRAINDICATIONS FOR TUBE THORACOSTOMY

There are relatively few contraindications for chest tube placement. The only absolute contraindication being an adherent lung to the chest wall throughout the entire hemithorax.¹² However, this stipulation is negated in a clinically unstable patient with a pneumothorax or hemothorax. In these situations, chest tubes are done empirically as the full extent of the air or fluid collection cannot be properly assessed because of resuscitative efforts.¹¹

Relative contraindications include coagulopathy, increased risk of bleeding and infection overlying the insertion site. Risk of bleeding can be addressed with platelets and clotting factor replacement relative to the deficit. Replacement is encouraged when platelets are less than 50,000, prothrombin time/partial thromboplastin time (PT/PTT), or international normalized ratio (INR) are greater than twice the upper limit of normal. Overlying cellulitis or zoster infection should be avoided by choosing another puncture site.¹¹

TECHNIQUE FOR PLACEMENT OF TUBE THORACOSTOMY

Prior to placing a thoracostomy tube, the interventionist should assess the patient and select an imaging modality for guidance. Tube thoracostomy can be performed using fluoroscopy, computed tomography (CT), ultrasound, or a combination of the above. Most placements by interventionalists at our institution are done using ultrasound guidance for puncture and fluoroscopy for tube positioning. Advantages of ultrasound include low cost, high availability, ease of use, and lack of ionizing radiation. Additionally, ultrasound can be performed on critically ill patients and on patients in nearly any position. Ultrasound does not image well through bony structures or air-filled spaces and is not suited for evaluation of fluid collections that are near the scapula, paramediastinal, or in the fissures. Conversely, CT is more costly, exposes the patient to ionizing radiation, limits patient positioning, and is not always readily available. It is useful, however, when ultrasound is technically difficult and when multiple catheters are required for complex or multifocal collections. CT placement is used for placement of tubes required for biopsy-induced pneumothorax. CT may also be indicated if simultaneous evaluation of chest disease is desired.

There are several varieties of catheters used for tube thoracostomy. Small pigtail catheters (10–14F) placed with wire guidance have become increasingly popular. Studies comparing wire-guided technique with small-bore ($\leq 14F$) and large-bore ($> 14F$) catheters have demonstrated that small bore catheters are more accurate³ with no disadvantage in clinical outcome.^{1,2,16–18} Smaller wire-guided catheters are also associated with significantly less pain and reduced risk of damage to adjacent organs, as compared with large tubes placed by the classical surgical technique.^{1,3}

The fluid or air collection to be drained is identified using an appropriate imaging modality and the target site is marked. The patient is prepped and draped in the usual sterile fashion. The skin and subcutaneous tissues are anesthetized using a buffered lidocaine solution. At our institution, we routinely use the Seldinger technique described below. Using ultrasound guidance, an 18-gauge needle attached to a syringe is guided into the desired interspace while applying negative pressure to the syringe. Free flow of fluid or air into the syringe verifies correct placement. Upon removal of the syringe, a guidewire is inserted through the needle. Fluoroscopic repositioning can be accomplished using an angled catheter, thus directing tube placement superiorly for pneumothorax decompression and inferiorly for fluid drainage. A dilator is used to expand the subcutaneous tissues and the pigtail catheter is then placed over the guidewire. The guidewire is removed and the catheter is sewn to the skin. Fluid is drained using negative pres-

sure. No more than 1000–1500 mL should be drained to avoid reexpansion pulmonary edema.

Alternatively, the trocar technique is a viable option for direct placement into a large air or fluid collection. The advantages of this technique include speed and fewer steps. However, repositioning of these tubes is more challenging (Fig. 1,2).

Tunneled Pleural Catheter Placement

Tunneled PleurX[®] catheters (CareFusion, Inc., San Diego, CA) were approved by the Food and Drug Administration for use in outpatient management of malignant pleural effusions. Since then, studies have documented the effectiveness in immediate and sustained (30 days) relief of dyspnea with few complications.^{19,20}

A target site in the low, posterior chest is identified using ultrasound. The patient is prepped and draped in the usual sterile fashion with the affected side away from the table. Ultrasound-guided access is achieved similar to above and guidewire is positioned in the dominant fluid collection. An ~4 mm nick is made at the entry site and 5 cm anterior to this site. After anesthetizing the tunnel, the catheter is passed from the anterior incision up through the entry site incision until the polyester hub is 1 cm past the incision in the subcutaneous tissues. The tunneler is cut from the distal

end of the catheter. The dilator and peel-away sheath are subsequently inserted over the guidewire into the pleural space. Upon removal of the dilator and guidewire, rapid evacuation of fluid is typically encountered and the catheter is promptly inserted through the peel-away sheath. The sheath is peeled away. The catheter is sutured to the skin with 2–0 Prolene and the incision closed with a U-stitch and 3–0 absorbable suture. Initial drainage volumes should not exceed 1000–1500 mL to avoid reexpansion pulmonary edema. The patient or caretaker should be instructed on proper drainage technique as indicated in the package instructions (Fig. 3).

Complications

Serious complications during placement of small-bore tunneled indwelling pleural catheters are rare. On multicenter review, the most common complications of small-bore pleural drainage catheter placement include empyema (3%), cellulitis (3%), catheter malfunction (4%), pneumothorax (6%), and catheter dislodgment (2%). During treatment of malignant pleural effusions, tract metastases have been reported (4%). More catheters were removed due to achievement of spontaneous pleurodesis (47%) than to complications (9%).²¹ Serious complications including significant postprocedure bleeding, extrapleural catheter placement, and hepatic injury have been reported in nonimage-guided series.^{22,23}

Figure 1 A 19-year-old man status post left apical bullectomy with recurrent pneumothoraces. Computed tomography-guided placement of an 8F locking loop catheter within recurrent left apical pneumothorax. (A) A 25-gauge needle (arrow) is placed for administration of local anesthetic and procedure planning. (B) A 19-gauge introducer needle is placed into the apical pneumothorax through the anesthetized tract. (C) Following subsequent wire placement and soft tissue tract dilation an 8F locking loop catheter was placed into the apical air/fluid collection.

Figure 2 A 77-year-old man with recurrent large volume symptomatic left pleural effusions requiring frequent thoracentesis. (A) Preliminary ultrasound image demonstrate a moderate-sized left pleural effusion. (B) Using real-time ultrasound guidance, an 8F locking loop catheter (long arrow) was placed into the pleural fluid collection along left midchest laterally. (C,D) Pre- and postprocedure chest radiographs demonstrate interval improvement.

Thoracostomy Tube Management

PROPHYLACTIC ANTIBIOTICS

A 2006 meta-analysis confirmed that a 24-hour regimen of a first-generation cephalosporin significantly reduces postinsertion pneumonia and empyema in trauma patients.²⁴ There is no evidence to support prophylactic antibiotics outside of the trauma setting if the patient has no other indication for antibiotics.

MALPOSITIONING

A chest radiograph should be obtained after placement of the chest tube to confirm appropriate location. The location of the tube can also be defined by a low-dose chest CT.²⁵ The tube should lie freely within the pleural space. Intrafissural, mediastinal, or intraparenchymal placement is unacceptable. Intrafissural location can impede drainage resulting in persistent physiologic compromise, or in the case of undrained fluid collections,

increase the risk of empyema.²⁵ Intraparenchymal location can cause lung abscess, intraparenchymal hematoma, hemothorax, and pneumothorax.²⁵ In either case, the tube should be promptly repositioned, and the patient monitored for evidence of complications. Antibiotics are appropriate to reduce the chance of abscess in the case of intraparenchymal malpositioning. In the case of mediastinal placement, it may be judicious to consult with a surgeon prior to repositioning.

DRAINAGE SYSTEM

Once the chest tube has been inserted, it must be connected to either suction or an apparatus to allow unidirectional drainage (water seal without suction or a Heimlich valve). One popular method is to use a commercially available three-chamber water seal system.²⁶ The three-chamber device drains the chest tube to a collection chamber that is sealed by a middle water chamber. The water seal chamber contains a gauge that

Figure 3 A 77-year-old woman with recurrent large volume symptomatic right pleural effusion requiring frequent thoracentesis. Computed tomography appearance of a tunneled PleurX[®] catheter (CareFusion, Inc., San Diego, CA) (arrows). (A) Subcutaneous tunnel initiation is performed laterally to ensure the externalized component of the catheter lies along the lateral body wall for patient comfort when lying down. (B,C) Right posteroinferior pleural space entrance with fenestrated catheter positioning in the dominant fluid collection. (D,E) Preprocedure and one month postprocedure chest radiographs demonstrate interval improvement.

demonstrates the degree of air leak in the system. Wall suction tubing is connected to the third (suction) chamber. A regulator built into the device controls the vacuum in the suction chamber. A low-level vacuum (5–20 cm H₂O) is recommended in most circumstances.^{27–29} A stronger vacuum will increase the flow through the

system in a diminishing manner.²⁷ A greater vacuum is required to achieve the same flow rate with longer, smaller-diameter (higher resistance) chest tubes relative to shorter, larger-bore tubes.²⁷ A simple one-way valve (Heimlich valve) may be attached to the chest tube to allow the patient freedom from wall suction; however,

this device can only accomplish passive, suctionless drainage when used in this manner.²⁷ As with thoracentesis, it is prudent to limit the amount of fluid removed initially to reduce the risk of reexpansion pulmonary edema. Again, a reasonable protocol is to drain 1000–1500 mL and then to clamp the tube for several hours prior to resuming drainage.

Drainage using tunneled PleurX[®] catheter is well documented in the training video and company materials and is relatively intuitive. Briefly, the connecting tubing is attached to the PleurX[®] catheter keeping the clamp closed. The spike on the connecting tubing is inserted into a proprietary vacuum container and the clamp is removed.

TUBE OBSTRUCTION

The level of the water seal should vary with respiration (tidaling). Lack of tidaling may indicate obstruction or complete lung reexpansion.²⁹ Similarly, absence of fluid return from a PleurX[®] catheter may indicate obstruction, lung reexpansion, or faulty vacuum bottle. The chest tube can become obstructed by either a kink or a clog from internal debris or blood clot. Rule out a kink with visual inspection and a chest radiograph. A clog can be removed by either milking or stripping the tubing manually, which creates a strong, transient vacuum and can draw the debris from the tube into the collection chamber. Some physicians are concerned about the effect of this strong vacuum,²⁶ although there is little evidence of deleterious effects in the literature. Additionally, simple flushing with sterile saline or wire passage can dislodge debris.

FIBRINOLYTIC THERAPY

Fibrinolytics can be used to lyse loculated pleural fluid collections, most commonly complex parapneumonic effusions (sterile) or empyema.^{30–33} If a fibrinolytic, most commonly recombinant tissue-type plasminogen activator (r-tPA), is instilled into a poorly draining collection before the fibrinous exudate organizes into a thick rind, then surgical debridement can often be avoided.^{31,33} Several protocols have been described, which generally entail 2- to 6-mg doses of r-tPA diluted in 25–100 mL sterile saline instilled via the chest tube.^{30,31,33} The solution is allowed to reside in the pleural space for 1–2 hours while the chest tube is clamped, then suction is resumed. The dose can be repeated several times if there is no initial effect.^{30–33} Higher doses have been used by some groups, although such doses are not definitely more effective or more likely to cause bleeding.³² Doses and volumes are reduced for children.³⁰ One retrospective study of 66 patients who received intrapleural r-tPA, showed an 86% success rate, when defined as complete drainage without need for surgery.³⁰ Four of 12 patients who were receiving therapeutic level systemic anticoagulation developed pleural

hemorrhage requiring transfusion, and all of them survived. No major bleeding occurred in patients on prophylactic anticoagulation.

Fibrinolytic solution can also be used to clear a clogged drainage catheter in a manner similar to the approved use of clearing fibrin from hemodialysis catheters. We are unaware of peer-reviewed reports of this off-label use. A small dose of r-tPA in a 1 mg to 1 mL sterile saline dilution can be infused in a volume sufficient to fill the chest tube lumen and allowed to act for 10–30 minutes prior to aspiration.

AIR LEAK

Assuming that the chest tube is properly inserted and that the hardware is intact, an air leak suggests a communication between the pleural space and pulmonary airspace, called a bronchopleural fistula. If the drainage through the chest tube is inadequate or the tube is clamped, a tension pneumothorax can develop. An overly aggressive vacuum in the system may maintain the patency of the fistula.^{28,29} Failure of the fistula to close after a trial of chest tube drainage may necessitate surgical repair.

REMOVAL OF THE CHEST TUBE

Prior to removal of a chest tube, the chest radiograph must show complete expansion of the lung, the drainage should be less than 200 mL/day,²⁷ and there should be no air leak during coughing or suction. After meeting these criteria, the chest tube can be clamped for at least 4 hours. If the chest radiograph and the clinical condition of the patient remain stable through the clamping trial, tiny sputtering leaks are excluded, and the tube can be pulled.

To remove the tube, cut the anchor sutures and have a square of petroleum gauze at hand. Pull the tube while the patient holds their breath or performs a Valsalva maneuver,²⁷ and then quickly cover the hole with the petroleum gauze to provide a seal. A previously placed loose suture may be useful to close the skin. Place a bandage over the gauze. A repeat chest radiograph can rule out a pneumothorax, which can occasionally occur during removal. A formal institutional guideline for chest tube management and removal may help standardize care and reduce unnecessary radiographs.³⁴ Removal of a PleurX[®] catheter is similar to removal of tunneled central venous catheters. The tract is anesthetized, the cuff blunt dissected free, and the catheter removed with gentle traction.

Pleurodesis

Pleurodesis is the fusion of the parietal and visceral pleura. Indications include recurrent malignant or benign pleural effusion, spontaneous secondary pneumothorax (underlying lung disease), and recurrent

spontaneous primary pneumothorax (apparently healthy underlying lung). Pleurodesis can be achieved by mechanical or chemical means during open thoracotomy or video-assisted thoracoscopy (VATS), or with chemical means via chest tube. The unifying mechanism of action in all methods is irritation of the pleura with resultant inflammation and permanent fusion of the two pleural layers, thus eliminating the pleural space, and prohibiting reaccumulation of fluid or air. Surgical poudrage (dry talc insufflation during surgery with a chlorofluorocarbon propellant) is equal or superior to chest tube instilled talc slurry^{35–38} and increases life expectancy in patients with malignant pleural effusion and body mass index > 25 and Karnofsky performance scores > 60.³⁸ In some patients, however, it is desirable to avoid general anesthesia and surgery, and in these cases, chest tube-based talc slurry is most appropriate. Patients with expected survival less than several months may be most effectively treated with a tunneled pleural drain or serial thoracentesis.³⁹

AGENTS FOR PLEURODESIS

Medical-grade, asbestos-free talc remains the gold standard for pleurodesis, with a 70–100% success rate.³⁶ Many agents have been tested, but none has proved more effective than talc.^{35,36,39,40} Doxycycline and bleomycin are used by some physicians. More recently, erythromycin proved highly effective in malignant pleural effusion with complete resolution of effusion in 27 (79%) of 34 patients.⁴¹ Talc pleurodesis has been implicated in cases of adult respiratory distress syndrome (ARDS) and respiratory failure. Several investigators have shown that the use of large doses (> 5 g) of ungraded talc (containing a higher percentage of fine-particle size) is associated with complications.^{35,36} The talc manufacturer in the United States (Bryan Corp., Woburn, MA) states that particle size is controlled, but does not specify a diameter (www.bryancorp.com). French talc, not approved for use in the United States, is the only talc with published size specifications.⁴² Even when talc is used in young patients treated for spontaneous pneumothorax, there is no evidence of adverse effects on lung function or increased malignancy with long-term follow-up.^{43,44}

PLEURODESIS TECHNIQUE

After draining the pleural fluid with the chest tube, ensure that there is full expansion of the lung with a chest radiograph. If trapped lung is present this will reduce the chances of successful pleural symphysis.^{35,36,40} Low pH effusion also strongly predicts failed pleurodesis.^{35,36,40} Administer conscious sedation and consider intrapleural buffered lidocaine to anesthetize the pleura.^{37,45} Instill a well-agitated suspension of 5 g talc in 100 mL sterile normal saline.³⁹ Clamp the chest tube for 1–2 hours and monitor the patient closely. Then

return the chest tube to suction and follow the previously described criteria for removal. Chest pain and fever may occur, and the physician should remain vigilant in monitoring for ARDS.

CONCLUSION

Tube thoracostomy placement using image guidance by the interventional radiologist has an increasing role in the treatment of patients with various pleural pathology. Smaller caliber tubes are effective and result in less pain, with image-guided placement over a wire allowing for more accurate positioning. Tunneled PleurX[®] catheters are an effective, safe treatment for malignant pleural effusions. A basic understanding of anatomy and physiology of the pleural space will aid you in placement of tube thoracostomy and treatment of pleural disease. Image guidance is typically via ultrasound and CT, each having unique advantages. It is important to know the potential complications that can occur during placement, which include malpositioning and tube obstruction. Surgical pleurodesis is equal or superior to pleurodesis accomplished via tube thoracostomy; however, in patients where it is desirable to avoid general anesthesia and surgery, pleurodesis through tube thoracostomy, using a talc-based slurry, may be most appropriate.

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