Chest Tube Insertion

INTRODUCTION — Tube thoracostomy is a procedure in which a chest tube is placed into the pleural cavity to drain abnormal collections of fluid or air. The indications, contraindications, technique, and complications of tube thoracostomy will be reviewed here.

INDICATIONS — Tube thoracostomy permits continuous, large volume drainage of air or fluid from the pleural space. Specific indications for tube thoracostomy include:

- Spontaneous pneumothorax (particularly if the pneumothorax is large or progressive, or the patient is symptomatic or has underlying lung disease).
- Iatrogenic pneumothorax (particularly if the pneumothorax is large, progressive, or if the patient is symptomatic).
- Pneumothorax of any size in a patient receiving mechanical ventilation.
- Tension pneumothorax.
- Penetrating chest trauma.
- Hemothorax.
- Complicated parapneumonic effusion or empyema.
- Chylothorax.
- Management of recurrent symptomatic malignant effusion with a tunneled indwelling catheter.
- Chemical pleurodesis for symptomatic or refractory pleural effusions, which are usually malignant.
- Bronchopleural fistula.

CONTRAINDICATIONS — There are no absolute contraindications to tube thoracostomy, particularly if the patient is in respiratory distress or has a tension pneumothorax. Anticoagulation or a bleeding diathesis is a relative contraindication in a patient undergoing elective chest tube placement for pleurodesis. Blind insertion of a chest tube is dangerous in a patient with adhesions from infection, previous pleurodesis, or a lung transplant; guidance by CT scan without contrast is preferred in these patients.

TECHNIQUE — Once the decision has been made to insert a chest tube, the operator must select the type of tube, the size of the tube, the insertion site, and the insertion technique to be employed.

Type of tube — Silastic® tubes are preferred because older rubber tubes have fewer drainage holes, are not well visualized on chest radiographs, and produce more pleural inflammation. Silastic chest tubes contain a radiopaque strip with a gap that serves to mark the most proximal drainage hole.

Size of tube — A chest tube's internal diameter and length are the critical determinants of flow. Select the appropriate chest tube size to account for the viscosity and accumulation rate of the pleural material to be drained. As an example, drainage of viscous fluids requires a larger bore chest tube than that required for drainage of a similar volume of air. Chest tubes typically come in two standard lengths. While either length is appropriate for an adult, the shorter length is better for children.
Pneumothorax — The rate of air leakage determines the tube size in patients with a pneumothorax. A 16 to 24 Fr chest tube is usually sufficient to maintain evacuation of the pleural space in patients with a spontaneous or iatrogenic pneumothorax. In patients who are not at risk for a large air leak (eg, pneumothorax after needle aspiration of a pulmonary nodule), a smaller catheter (8 to 14 Fr) may be used in combination with a unidirectional flutter valve.

In our practice, we use a 28 Fr or larger chest tube in patients who develop pneumothorax during mechanical ventilation because they are at risk for developing a large air leak due to a bronchopleural fistula. We also prefer a 28 Fr or larger chest tube in patients with severe underlying lung disease who suffer an iatrogenic pneumothorax or spontaneous pneumothorax because these patients are also at risk for a large air leak and/or may require mechanical ventilation.

For traumatic pneumothoraces, we prefer to use 28 to 40 Fr chest tubes as drainage of blood in addition to air may be necessary.

Malignant effusion — A small-bore catheter (8 to 14 Fr) placed under ultrasound or CT guidance is usually adequate to drain a malignant pleural effusion and achieve pleurodesis. Chronic indwelling catheters are available for outpatient treatment of recurrent malignant effusion and require creation of a short tunnel during insertion.

Parapneumonic effusion and empyema — For a complicated parapneumonic effusion or empyema that is amenable to drainage with a single catheter, we prefer initial image-guided placement of small-bore catheters (10 to 14 Fr), with or without intrapleural fibrinolytic agents. We prefer the smaller tube size as this is generally more comfortable for patients, particularly if more than one tube is needed. Alternatively, when the fluid appears viscous, a larger bore tube (16-24 Fr) may be used. In either case, correct tube placement should be confirmed with CT imaging.

Unsuccessful drainage with a small-bore catheter either indicates the presence of multiple loculations or very viscous material. Multiple small-bore catheters may be used in multiloculated effusions or large bore catheters in case of very viscous material. Failure to drain with a single small-bore tube should also lead to thoracic surgery consultation to avoid delays in case video assisted thoracoscopy (VATS) becomes necessary.

Hemothorax — The goals of tube thoracostomy in acute hemothorax are drainage of fresh blood, quantification of the rate of bleeding, evacuation of any coexisting pneumothorax, and tamponade of the bleeding site. Large bore catheters (32 to 40 Fr) are required to reliably achieve these goals. Once a hemothorax is defibrinated in situ, that is after the acute phase, success of drainage is less dependent on the size of the tube, than on the degree and mode of clot formation. Large amounts of clotted blood should be evacuated via video assisted thoracoscopy. Occasionally, a hemothorax may result in a sonographically complex septate pattern and may be treated with small-bore catheters. Treatment of hemothorax should be individualized and done in consultation with thoracic surgery.

Insertion site — Most clinicians insert the chest tube via an incision at the fourth or fifth intercostal space in the anterior axillary or mid-axillary line. For evacuation of a pneumothorax, the second intercostal space in the mid-clavicular line has been suggested as an alternate site; however, this requires dissection through the pectoralis muscle and leaves a visible scar. We suggest this approach only for a loculated anterior pneumothorax with the use of a small bore catheter (10 to 14 Fr) rather than a standard chest tube. For evacuation of a pneumothorax, the chest tube should be directed
apically, while for drainage of a pleural effusion the chest tube should be directed inferiorly and posteriorly.

Insertion techniques — Two techniques are most commonly used to place a chest tube. The standard technique employs blunt dissection to access the pleural space. In contrast, the Seldinger technique uses serial dilatation over a guide wire.

Equipment list — The equipment needed for tube thoracostomy is listed in the table. Dry and wet suction control drainage systems are most commonly used; these are effective for draining both pleural fluid and air. Unidirectional flutter valves are used in patients who have small pneumothoraces with minimal to no air leak or nonviscous malignant pleural effusions.

Standard technique

The following steps are the most common method employed to place a chest tube:

- Some clinicians use local anesthesia alone while others administer conscious sedation prior to beginning the procedure. We prefer to use conscious sedation if the patient's hemodynamic status permits.
- Place the patient in the supine position with the arm of the involved side over the head.
- Prepare the skin around the area of insertion with 10 percent povidone-iodine solution or chlorhexidine and drape with sterile towels.
- Using 1 percent lidocaine, anesthetize a 2 to 3 cm area of skin and subcutaneous tissue one intercostal space below the intercostal space that will be penetrated. This will allow for the development of a subcutaneous tunnel through which the chest tube will be placed to prevent air entry after the chest tube is removed. Ten to 20 ml of lidocaine is needed for optimal analgesia.
- To confirm that the proposed site of chest tube insertion is correct, perform a thoracentesis under ultrasound guidance, if available. Ultrasonography cannot directly image a pneumothorax, but will demonstrate a fluid collection directly and may prevent organ laceration in case of pneumothorax. If air or fluid is not obtained during diagnostic thoracentesis, reassess the site of insertion and review the chest radiographs and chest CT scans. Occasionally, fluid may not be obtained with a small needle due to high viscosity of the pleural fluid.
- Make a 2 cm skin incision parallel to the intercostal space, immediately above the rib in order to reduce the risk of injury to the neurovascular bundle.
- Using additional lidocaine, anesthetize the periosteum of the ribs above and below the site of insertion as well as the tissues of the intercostal space at the site of insertion. In addition, infiltrate the parietal pleura at the site of insertion with anesthetic. Up to 30 mL of 1 percent lidocaine may be required to produce adequate local anesthesia.
- Using blunt dissection with a Kelly clamp, create a subcutaneous tunnel from the incision site cephalad towards the intercostal space through which the chest tube will be inserted.
- With the Kelly clamp in a closed position, push the clamp over the superior portion of the rib (to avoid injury to the neurovascular bundle that runs along the inferior aspect of the rib) and through the parietal pleura. Open the Kelly clamp to spread the intercostal muscles and parietal pleura.
- Insert a finger through the tract into the pleural space to confirm proper position and make sure there are no adhesions between the lung and the pleural surface. Only easily disrupted
adhesions should be lysed with the operator's finger, as significant bleeding can occur if more organized adhesions are disrupted.

- Clamp the chest tube at the insertion end with the Kelly clamp. With the aid of the clamp, insert the chest tube through the tract into the pleural space and direct it either apically for a pneumothorax or inferiorly and posteriorly for a pleural effusion.
- Remove the Kelly clamp and confirm the location of the chest tube by the visualizing condensation within the tube with respiration, or by observing pleural fluid drain through the tube. Advance the chest tube until the proximal hole is at least 2 cm within the rib margin. Position of the chest tube so that all drainage holes are within the pleural space, as assessed by palpation.
- Close the skin incision with mattress or interrupted sutures, and tie one of the sutures to the chest tube to anchor it. Cover the site with sterile gauze and surgical tape. Alternatively, cover the site with sterile petroleum gauze.
- Connect the chest tube to the pleural drainage system. Make sure that all connections between the chest tube and pleural drainage system are tight and taped securely.
- Following chest tube placement, obtain a chest radiograph to confirm tube position and assess lung expansion. Make sure that the gap in the radiopaque marker in the chest tube, marking the most proximal drainage hole, is within the pleural space.

Although the use of a trocar to aid in the insertion of a chest tube has been utilized by some clinicians, we and others believe the trocar method should never be used, as it significantly increases the risk of organ perforation.

Seldinger technique — As an alternative approach to chest tube placement, some clinicians prefer to use commercially available kits that employ a Seldinger technique. For such insertions, we suggest the following technique:

- Prior to placing a chest tube using the Seldinger technique, carefully inspect the chest radiograph for adequate separation of the lung and parietal pleura due to pleural air or fluid. Ultrasonography is useful for this purpose only if drainage of fluid is the objective.
- Some clinicians use local anesthesia alone while others administer conscious sedation prior to beginning the procedure. We prefer to use conscious sedation if the patient's hemodynamic status permits.
- Place the patient in the supine position with the arm of the involved side over the head.
- Prepare the skin of the area of insertion with 10 percent povidone-iodine or chlorhexidine and cover with sterile drapes.
- Using 1 percent lidocaine, anesthetize a 2 to 3 cm area of skin and subcutaneous tissue along the intercostal space that will be penetrated with the tube. Ten to 20 ml of lidocaine is usually needed for optimal analgesia.
- Using ultrasonography, if available, perform thoracentesis at the intended insertion site to confirm an appropriate site for chest tube insertion.
- Make a skin incision parallel to the intercostal space, immediately above the rib in order to reduce the risk of neurovascular injury.
- Insert an introducer needle into the pleural space and aspirate for air or fluid.
- Insert a guide wire through the introducer needle into the pleural space. Direct the guide wire apically for a pneumothorax or inferiorly for a fluid collection. Verify guide wire position using ultrasonography, unless pneumothorax is present.
• Pass graduated size dilators over the guide wire serially to dilate a tract for the chest tube.
• Pass the chest tube with its dilator into the pleural space.
• Remove the guide wire and dilator, leaving the chest tube in place.
• Connect the chest tube to the pleural drainage system. Make sure that all connections between the chest tube and pleural drainage system are tight and taped securely.
• Suture the chest tube into place using mattress or interrupted sutures and dress it with sterile gauze.

A disadvantage of the Seldinger technique for chest tube insertion is that the presence of adhesions between the lung and pleural surface cannot be assessed by palpation during tube insertion. If the introducer needle and guide wire are inserted at a place where there are pleural adhesions, the chest tube may inadvertently pass into the lung parenchyma.

COMPLICATIONS — Complications of chest tube placement, excluding recurrent pneumothorax, are infrequent, ranging from 1 to 3 percent when placed for acute trauma. Reported complications include empyema (1 to 3 percent), lung parenchyma perforation (0.2 to 0.6 percent), diaphragmatic perforation (0.4 percent), and subcutaneous placement (0.6 percent). In an analysis of 126 chest tube placements by pulmonologists at a teaching hospital, the complication rate was 11 percent; however, 10 of the 14 reported complications were related to clotting, kinking, or dislodgement of the chest tube. Pulmonary laceration and subcutaneous placement were each noted in one patient (0.8 percent).

In addition to perforation of the lung, perforation of the right ventricle, right atrium, and abdominal organs (spleen, liver, stomach, colon) have all been reported. Delayed pulmonary perforation by a chest tube has also occurred, and autopsies have noted pulmonary perforations that were not suspected antemortem.

Other complications include cardiogenic shock from chest tube compression of the right ventricle, mediastinal perforation with contralateral hemothorax and pneumothorax, bleeding from intercostal artery injury, and infection at the chest tube site.

With respect to antimicrobial prophylaxis during chest tube insertion and while the chest tube is in place, most trials show no benefit, although some have shown a reduction in infection in patients with penetrating chest trauma. The two largest trials found a low rate of empyema in the placebo group and little or no benefit with antimicrobial therapy. We suggest not using prophylactic antibiotics after tube thoracostomy, unless traumatic injury is thought to increase the risk of pleural infection in an individual patient.

Chest tube malposition — Chest tube malposition is the most common complication of tube thoracostomy. In one study of 77 chest tubes placed emergently in 51 trauma patients, malpositioning was detected in 20 (26 percent) of the 77 chest tubes following CT scanning. Nine chest tubes were intrafissural, 5 were intraparenchymal, and 2 were subcutaneous. In 4 chest tubes, intraparenchymal versus intrafissural placement could not be determined. Persistent pneumothorax and hemothorax (including 2 tension pneumothoraces) were associated with 16 of the 20 (80 percent) chest tube malpositions. Only 1 of the 5 intraparenchymal chest tubes was diagnosed by chest radiograph, and only 4 of the 9 intrafissural chest tubes were suspected on chest radiograph.
Thus, a CT scan should be obtained if either a patient's plain films or clinical course is consistent with chest tube malposition.

Reexpansion pulmonary edema — Reexpansion pulmonary edema (RPE) represents a potentially life-threatening complication of tube thoracostomy. It usually occurs unilaterally after rapid reexpansion of a collapsed lung in patients with a pneumothorax; however, it may also follow evacuation of large volumes of pleural fluid (>1.0 to 1.5 liters) or removal of an obstructing tumor. The possible association of larger volume removal with RPE was studied in a series of 185 thoracenteses (over one liter); the incidence of symptomatic RPE was less than 1 percent. No correlation was found between the volume of fluid removed or the pleural pressure with symptomatic or radiographic pulmonary edema.

Patients typically present soon after the inciting event, although presentation can be delayed for up to 24 hours in some cases. The clinical manifestations vary from isolated radiographic changes to complete cardiopulmonary collapse.

A mortality rate as high as 20 percent has been described. Treatment is supportive, mainly consisting of supplemental oxygen and, if necessary, mechanical ventilation. The disease is usually self-limited.

Prevention — In our clinical practice, we limit initial fluid drainage to 1 to 1.5 liters; drainage is stopped by clamping the chest tube and waiting 2 to 4 hours before draining additional fluid. We prefer this approach due to the high morbidity and mortality in patients who develop RPE, even though a moderate sized study did not show a relationship between volume of fluid removed and RPE.

Pleural pressures are not typically measured after chest tube insertion and drainage of fluid. In addition, an amount and/or rapidity of fluid removal that is unlikely to significantly lower pleural pressure and cause reexpansion pulmonary edema has not been determined. If the patient develops chest pain, shortness of breath, or oxygen desaturation, no additional fluid is removed until symptoms have resolved.

Patients with large effusions and contralateral mediastinal shift may tolerate a larger amount of initial fluid removal. In contrast, patients without mediastinal shift or with ipsilateral mediastinal shift may have a marked decrease in pleural pressure with removal of a small amount of fluid and may have a greater risk of reexpansion pulmonary edema.

CHEST TUBE REMOVAL — Remove the chest tube when the original indication for placement is no longer present or the tube becomes nonfunctional.

The following criteria should be met prior to removing the chest tube if it was placed for drainage of pleural fluid:

- The lung should be fully expanded
- Daily fluid output should be less than 100 to 200 mL/day
Similarly, the following criteria should be met prior to removing the chest tube if it was placed due to pneumothorax:

- The lung should be fully expanded
- An air leak should not exist, either during suction or coughing

Once these criteria are met, place the chest tube on water seal. Some clinicians will remove the chest tube if the lung remains fully expanded on a chest radiograph performed on water seal. Other clinicians prefer to clamp the chest tube for four to six hours, and then confirm the absence of pneumothorax recurrence prior to removing the chest tube. Proponents of this approach suggest that this will identify small, intermittent air leaks that are not detected by monitoring the pleural drainage unit. The likelihood of developing a tension pneumothorax or respiratory distress due to recurrent pneumothorax should be considered prior to chest tube removal and the patient monitored accordingly.

Opinion is divided as to whether a chest tube placed for a pneumothorax in a patient receiving mechanical ventilation should remain in place as long as the patient requires mechanical ventilation, if no air leak is present.

In preparation for removal, prepare a petroleum gauze dressing and cut the suture anchoring the chest tube to the skin. Ask the patient to inspire and then perform a Valsalva maneuver; remove the tube while simultaneously covering the insertion site with the gauze dressing. If a loose mattress suture was placed at the time of initial thoracostomy, tighten this at the time of chest tube removal. Obtain a chest radiograph immediately following chest tube removal and 24 hours later to evaluate for pneumothorax and/or reaccumulation of fluid.

SUMMARY AND RECOMMENDATIONS

- Tube thoracostomy is a procedure in which a tube is placed into the pleural cavity to drain abnormal collections of fluid or air.
- Indications for tube thoracostomy include symptomatic, progressive, or tension pneumothorax, penetrating chest trauma, hemothorax, complicated parapneumonic effusion, empyema, chylothorax, recurrent symptomatic malignant pleural effusion, bronchopleural fistula, and pleurodesis of a symptomatic or refractory pleural effusion.
- In patients with adhesions from infection, previous pleurodesis, or a lung transplant, a computed tomography scan without contrast is suggested to guide chest tube placement. Blind insertion of a chest tube is dangerous in these patients.
- Silastic® tubes are preferred as older rubber tubes have fewer drainage holes, are not well visualized on chest radiographs, and produce more pleural inflammation.
- The appropriate chest tube size is selected to account for the viscosity and accumulation rate of the pleural material to be drained. Chest tubes typically come in two standard lengths; while either length is appropriate for an adult, the shorter length is better for children.
- The chest tube is inserted via an incision at the fourth or fifth intercostal space in the anterior axillary or mid-axillary line. In patients with a loculated anterior pneumothorax, an alternative is to use a small catheter (8 to 14 Fr), rather than a standard chest tube, and place
it in the second intercostal space in the mid-clavicular line; using a larger tube in this location is more likely to leave a visible scar.

- Two techniques are most commonly used to place a chest tube. The standard technique employs blunt dissection to access the pleural space; the Seldinger technique uses serial dilatation over a guide wire. A disadvantage of the Seldinger technique is that the presence of adhesions between the lung and pleural surface cannot be identified by palpation, causing the chest tube to pass into the lung parenchyma.

- Dry and wet suction control systems are most commonly used and are effective for draining pleural fluid and air. Unidirectional flutter valves are used in patients who have small pneumothoraces with minimal to no air leak or nonviscous malignant pleural effusions.

- We suggest limiting initial drainage to 1 to 1.5 liters in order to prevent reexpansion pulmonary edema, a potentially life-threatening complication of tube thoracostomy (Grade 2C). We generally clamp the chest tube and wait 2 to 4 hours before draining further fluid.

- In most patients, we suggest not administering prophylactic antibiotics after tube thoracostomy (Grade 2B). We suggest administering prophylactic antibiotics in patients with a traumatic injury that is felt to increase the risk for pleural infection (Grade 2C).

REFERENCES


GRAPHICS

Equipment list for tube thoracostomy

- 1 or 2 percent lidocaine
- Needles (size 25 and size 18-21) and syringes for anesthetizing the skin
- Scalpel, with No. 10 or 11 blade
- Large Kelly clamp
- Straight scissors
- Chest tube
- Silk suture (1 to 0)
- Needle holder
- Petroleum gauze
- Drain sponges
- Elastic tape
- Sterile drapes, gown and gloves
- Mask, protective eyewear
- 2 percent chlorhexidine or povidone-iodine
- Drainage system