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# Tube Thoracostomy

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## Overview

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Tube thoracostomy (chest tube placement) is a procedure during which a hollow tube is inserted into the thoracic cavity for drainage of fluid or air. Emergency chest tube insertion is performed for definitive treatment of tension pneumothorax, traumatic hemothorax, large-volume pleural effusions, and empyemas.

Irrespective of the cause of air and fluid accumulation in the pleural space, the drainage relieves lung compression and enables lung re-expansion. In pneumothorax, air accumulation in the pleural cavity separates pleural layers, which prevents lung expansion during the respiration. Abnormal fluid accumulation, such as in case of hemothorax or empyema, causes separation of the visceral pleura that adheres to lung tissue from the parietal pleura that forms the lining of the chest cavity. The uncoupling of the pleural layers leads to disconnection of chest wall movement from the lung movement, causing respiratory distress. In addition, excessive pressure from overwhelming amounts of air or fluid in the pleura may push the mediastinum away from the central chest, causing inability of blood to return to the heart.

In the trauma setting, a chest tube may not only treat a hemothorax but also allow monitoring of the bleeding rate. Massive hemothorax or continued brisk bleeding necessitates progression to a surgical thoracotomy, which is the opening of the chest wall to seal bleeding sites.

Chest tubes consist of clear plastic with a radiopaque strip running along their length, and fenestrations along the tip of the tube. Tube sizes vary from 12 to 42 French (Fr), with the smaller sizes used for pediatric cases. A size 36 Fr or larger is standard size to be used for hemothorax and empyema drainage.

## Procedure

### 1. Physical Exam Findings

1. On general inspection, observe the patient for tachypnea, shallow respirations, or inability to speak full sentences, as well as tracheal deviation away from the affected side, distension of neck veins, or cyanosis.
2. Place the patient on a monitor, and observe for tachycardia and increased respiratory rate, as well as hypoxia or hypotension.
3. Palpate the patient's radial and carotid pulses. The weak and thready pulses are consistent with shock from tension pneumothorax, hemothorax, effusion or empyema.
4. Auscultate both lungs, and note decreased or absent breath sounds on the affected side. Note that the chest wall may fail to rise appropriately compared to the other side, and may be hyperresonant on percussion due to increased air trapped on that side if due to pneumothorax. In patients with excessive fluid in the pleural space, auscultation may sometimes reveal crackles.
5. Stabilize the airway, breathing, and circulation of a rapidly deteriorating patient by performing other critical interventions, like intubation prior to (or simultaneously with) needle decompression and chest tube placement.
6. In emergency department or prehospital settings, auscultation may be limited by the ambient noise. Perform ultrasound assessment for absence of pleural sliding (typical for pneumothorax) and fluid within the pleural cavity if a machine is available.

### 2. Chest tube placement

Equipment needed (usually provided in a chest tube kit): antiseptic solution, sterile drapes, local anesthetic (1-2% lidocaine), a 20 mL syringe and needles to administer local anesthetic, scalpel with a No. 10 blade, Kelly clamps, needle holder, chest tubes, No. 0 or 1.0 silk suture, forceps, straight scissors, large curved scissors, drainage system with water seal and sterile tubing for connection (such as Pleurvac), petroleum gauze, cloth gauze squares, and adhesive tape.

1. Administer supplemental oxygen by nasal cannula or non-rebreather mask, and ensure that cardiac monitoring and pulse oximetry devices are connected to the patient.
2. Place the patient in a semi-recumbent position with the head of bed elevated to 30°-60°. This position lowers the diaphragm position and reduces risk of injury to the diaphragm muscle and sub-diaphragmatic organs.
3. On the affected side, place the patient's arm over their head and stabilize the arm in this position with tape or strap attached to the stretcher.
4. Administer parenteral analgesics such as morphine prior the procedure. If a patient is agitated or cannot sit still, consider administrating the procedural sedation.
5. Prepare the sterile field by liberally applying antiseptic solution (chlorhexidine or betadine) to the entire affected chest wall. The preferred location for the chest tube placement is the $4^{th}$ or $5^{th}$ intercostal space in the anterior axillary to midaxillary line, lateral to the pectoralis major muscle and the breast tissue. The $5^{th}$ intercostal space is usually found at nipple level.
6. Place sterile drapes at the borders of the anticipated insertion site. The operator and assistants should don sterile gowns and gloves before laying equipment or medications on a sterile tray. It can be helpful to have several size chest tubes ready.
7. Estimate the length of the tube to be positioned within the pleural cavity by holding the tip of the tube at clavicle level and directing the tube to the anticipated insertion site on the lateral chest wall. Ideal placement is with the tip of the tube at the apex of the lung. Clamp the tube

to mark the estimated length, and ensure that the most distal drainage fenestration will be located within the pleural space once the tube is inserted.
8. Locate the 4th or 5th intercostal space and 5th or 6th ribs in the anterior to mid-axillary line by palpation. Some operators choose to mark the site with a sterile surgical marker.
9. Administer local anesthetic (1-2% lidocaine) by infiltrating the skin over the superior aspect of the 5th or 6th rib. Then slowly inject through the subcutaneous tissue, muscle, rib periosteum and the parietal pleura along the projected pathway of tube passage. Intermittently aspirate the syringe while performing the injection. When air is withdrawn upon aspiration, it indicates that the parietal pleura has been reached. Inject liberally to infiltrate the pleural lining and then withdraw the syringe.
10. Make a 3-5 cm transverse incision, in parallel with rib direction, through the skin and subcutaneous tissue over the superior aspect of the 5th or 6th rib. This protects against accidental damage of neurovascular bundles, which lie at the inferior aspect of each rib. Ensure that the incision is large enough to allow the passage creation, fitting clamps, fingers, and the tube.
11. Insert the Kelly clamp to bluntly dissect deeper tissues and intercostal muscles over the rib. Blunt dissection may be aided by using the index fingers of both hands. Firm resistance will be felt when the tough pleura is reached.
12. Close the ends of the Kelly clamp and push it through the pleura. This may require firm force. To provide sufficient pressure it is helpful to hold the clamp with the index finger positioned near the clamp tip. Once the clamp enters the pleural cavity, a pop will be felt and a rush of air or fluid will be audible.
13. Open and spread the Kelly clamp to make an adequate hole for the chest tube to fit. Make sure that the dissection size permits to fit both a finger and the tube, while avoiding creation of excessively large opening, as it may lead to an air leak.
14. Slide a gloved finger into the pleural opening, and sweep the space to ensure there are no blockages. Leave the finger in the opening before withdrawing the Kelly clamp to avoid losing the dissected tract and the opening hole.
15. Pass the tube beside the finger into the pleural space. The fingertip can guide the tube into the appropriate direction posteriorly, medially, and superiorly until the last fenestration of the tube is in the thorax. All holes should be within the pleural space, and the tube should be able to rotate freely. Premature resistance to passage of the tube could indicate that the tube is not in the pleura and may be passing in subcutaneous tissue or abutting the mediastinum.
16. Confirm the tube placement by the presence of condensation inside the tube and listening for air movement. Note the flow and rate of blood or fluid. Attach the tube to the water seal or suction system. Bubbling within the water seal chamber is usually immediately apparent, but you may ask the patient to cough and observe for bubbles in the water seal chamber to ensure system patency.
17. Secure the tube by using a "stay" suture-the same suture that closes the skin incision-to wrap tightly around the tube. Start with a simple interrupted suture near the site of the chest tube, leaving both ends long. Once the suture is complete, use the long ends to wrap around the tube, and hand-tie tightly. The plastic of the tube should indent slightly to avoid slippage.
18. Apply occlusive petroleum gauze dressing over the chest tube site using a Y cut to fit the tube. This will prevent air leaks. Tape the dressing to the skin and the tube to avoid dislodgment.
19. Order a portable chest X-ray to confirm appropriate placement. If a tube needs to be advanced, the procedure will need to be repeated if the field has not been kept sterile. The same applies to tubes that are kinked or dysfunctional for other reasons.

## Summary

Emergent tube thoracostomy is performed in patients in extremis, or when a possibility for the rapid deterioration in the patient's condition is indicated by the size of the pneumothorax or fluid in the chest cavity, worsening symptoms, and the patient's vital signs.

Once a chest tube has been placed, the patient requires constant monitoring to assess for improvement in respiratory effort, resolution of tachypnea and hypoxia, and improving vital signs. Deterioration or plateau of the patient's condition may necessitate a second chest tube placement or surgical intervention. In addition to tube placement, staff need to understand the mechanics of suction or water seal drainage systems for troubleshooting purposes and evaluation of when a chest tube may be safely removed.

The most common complications of tube placement include local infection at the insertion site, subcutaneous emphysema due to air leaking from excessive openings, and injuries to underlying solid organs (lung, spleen, liver, diaphragm, stomach, colon) or vascular structures. The latter may necessitate surgical opening of the chest wall for ligation. Tubes may be placed in the incorrect position, either subcutaneously or intra-abdominally, especially in obese patients in whom anatomical positioning may be less clear. Tubes may also dislodge or become blocked by clotted fluid.

 