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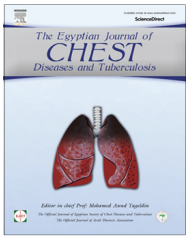

REVIEW

# Chest tube care in critically ill patient: A comprehensive review

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**KEYWORDS**

Chest tube;
Chest drainage unit;
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Visceral pleurae

**Abstract** Breathing is automatic. We don't usually think too much about it unless we develop a problem. Lack of adequate ventilation and impairment of our respiratory system can quickly become life-threatening. There are many clinical conditions that may necessitate the use of chest tubes. When there is an accumulation of positive pressure in the chest cavity (where it should normally be negative pressure between pleurae), a patient will require chest drainage. Chest tubes may be inserted to drain body fluids or to facilitate the re-expansion of a lung. It is important for the clinician to determine the most appropriate tube size to use prior to intubation. The position of the chest tube is related to the function that the chest tube performs. When managing the care of patients who have chest tubes it is important to fully understand what to do in case problems arise. It is also important to be able to assess when the chest tube is ready to be discontinued. Nurses and other healthcare professionals who are responsible for the safe delivery of care should be knowledgeable about respiratory pathophysiology, signs of respiratory compromise, and the care and management of interventions that may be utilized to ensure adequate respiration.


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*Abbreviation*: CDU, chest drainage unit

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## Introduction

Breathing is automatic. We don't usually think too much about it unless we develop a problem. Lack of adequate ventilation and impairment of our respiratory system can quickly become life-threatening [1]. It is important that the healthcare professional understands the risks associated with chest tube insertion and drainage. Healthcare professionals also need to know how to assist with the preparation of the chest drainage unit, perform ongoing patient assessments, document appropriately, and troubleshoot possible problems related to the use of a chest tube [2].

## It's all about negativity

Chest tubes aren't placed in the lungs but in the pleural space—a potential rather than actual space between the parietal and visceral pleurae. The parietal (outer) pleura covers the chest wall and diaphragm. It contains a small amount (about 50 mL) of serous fluid that coats the opposing surfaces, allowing the visceral and parietal pleurae to glide over each other without friction while enabling the pleural surfaces to adhere to each other. The ability to adhere creates negative pressure within the pleural space, which becomes more negative as the visceral and parietal pleurae are pulled in opposite directions during inspiration. The negative intrapleural (and thus intrapulmonary) pressure generated causes air to flow from positive (atmospheric) pressure into the lungs [3]. Expiration increases intrapleural and intrapulmonary pressures to the point where they exceed atmospheric pressure, creating an opposite pressure differential and causing air to flow out of the lungs into the surrounding atmosphere. A breach in pleural integrity creates a separation between the parietal and visceral pleurae, allowing air or fluid to fill this potential space. The visceral pleura collapses inward along with the lungs, while the parietal pleura recoils outward along with the chest wall (Fig. 1) [4,5].

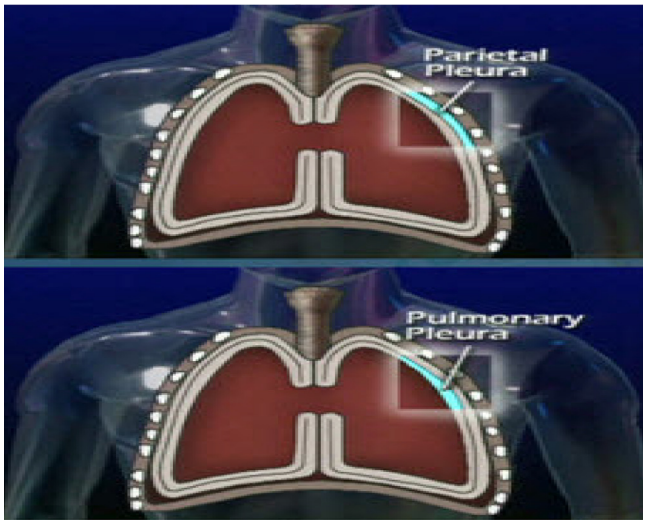


**Figure 1** The negative pressure in the parietal and pulmonary pleura.

## Use of chest tubes

There are many clinical conditions that may necessitate the use of chest tubes. When there is an accumulation of positive pressure in the chest cavity (where it should normally be negative pressure between pleurae), a patient will require chest drainage. Chest tubes may be inserted to drain body fluids or to facilitate the re-expansion of a lung. No matter what the reason or underlying cause, chest tubes help to resolve the problems associated with large volumes of air or fluid that have collected in the pleural space. When air or fluid enters the pleural space, the lung cannot expand properly. In some cases, chest tubes can also be used for certain therapy-related patient management as well [6].

## Indications for chest tubes

There are various reasons for excess air and/or fluid in the pleural space. Specific common indications for chest tubes include [2,5,6]:

- Pneumothorax (open and closed).
- Tension pneumothorax.
- Hemothorax.
- Hemopneumothorax.
- Pleural effusions.
- Chylothorax (a type of pleural effusion that results from lymphatic fluid (chyle) accumulating in the pleural cavity).
- Penetrating chest trauma.
- Pleural empyema (collection of purulent material in the lungs).

*Other indications include*

- Excess air and/or fluid accumulation in the pleural space. For example, chest tubes are often placed after cardiac surgery to drain blood associated with the surgery.

- Need for pleurodesis: Pleurodesis is a procedure used to treat patients with recurrent pleural effusions or recurrent pneumothorax. This procedure involves administering a sclerosing agent into the pleural space which causes the visceral and parietal pleura to adhere to each other without the thin coating of fluid between them. Chemical pleurodesis is a painful procedure, and patients are often pre-medicated with a sedative and analgesics. A local anesthetic may be instilled into the pleural space, or an epidural catheter may be placed for anesthesia.
- Chemotherapy administration: May be administered through a chest tube.

## Contraindications to chest tube insertion

There are no definite contraindications to a chest tube especially when a patient is experiencing respiratory distress. If multiple adhesions, giant blebs, or coagulopathies are present and the patient is relatively stable, the benefit of chest tube therapy can be carefully weighed against the higher risks of complications for these patients. In less clear-cut scenarios, it is often helpful to know the amount of lung collapse to better support a decision to insert a chest tube in higher risk patients. Also, a CT scan of the chest may be necessary to guide chest tube placement should the patient have a condition (e.g. lung transplant, multiple loculations from previous pleurodesis) where blind insertion could be an issue [7].

## Chest tube placement

### *Selecting appropriate tube sizes*

It is important for the clinician to determine the most appropriate tube size to use prior to intubation. In general, the following size guidelines can be used to select the most appropriate tube size for the patient, based on the patient's age included in Table 1 [2,8].

### *Preparing for chest-tube insertion*

Before inserting a chest tube, informed consent should be obtained from the patient, a healthcare proxy, or next of kin. The patient should be informed that the tube is necessary to help with his or her breathing; and that it will become easier to breath as the lungs re-expand. The patient should be instructed that he or she may feel pressure in that area but that the goal is to keep him or her as pain-free as possible. When placing a chest tube, medicating the patient is an important step. A mild sedative and a pain medication would be appropriate in this type of situation. Some physicians even prefer moderate or conscious sedation (which requires specific training and competencies) [9,10].

If the patient is not intubated, provide oxygen. Keep the patient supine with the arm of the affected side above the head. During the procedure, be sure to monitor cardiac rhythm as poor oxygenation may cause an arrhythmia. The physician will also need equipment for the procedure included in Fig. 2 [11].

**Table 1** The most appropriate tube size based on the patient's age.

| Tube size | Age of patient |
|---|---|
| 8 FR–12 FR | Infants, young children |
| 16 FR–20 FR | Children, young adults |
| 24 FR–32 FR | Most popular adult sizes |
| 36 FR–40 FR | Larger adult sizes |

### *Patient positioning and chest tube insertion*

Patient positioning depends on the insertion site, whether air or fluid will be drained, and the patient's clinical status. Generally, the patient is positioned flat, with a small wedge or bolster (several folded towels or a blanket) placed under the shoulder blades to elevate the body and give the practitioner easier access. The arm on the procedural side must be kept out of the way; usually, it's brought over the patient's head and secured [12,13]. Pendulous breasts or excessive adipose tissue may need to be secured out of the way as well. The specific insertion site may vary with the condition being treated. Commonly, a chest tube is inserted at the midaxillary line between the fourth and fifth ribs on a line lateral to the nipple (Fig. 3) [2].The position of the chest tube is related to the function that the chest tube performs. If the chest drainage tube is to be used to drain air, the tube is placed anteriorly near the apex of the lung (second intercostal space). If the function of the tube is to drain fluid, the tube is placed posteriorly near the base of the lung (fifth or sixth intercostal space) (Fig. 4) [1]. In the case of a hemothorax or when both air and blood are present, a chest tube may be placed at the base of the lung as well as at the apex [10].

### *Understanding chest drainage units*

An integrated chest drainage unit (CDU) is a variation of the old three-glass-bottle system in which one bottle was used for collection, one for water seal, and a third for suction (Fig. 5) [6]. CDUs have a water-seal chamber, a suction-control chamber, and a collection chamber; a one-way valve prevents air and fluid from returning to the chest. Almost all newer systems are self-contained and provide everything needed for rapid set-up and function. The nurse will need a vacuum gauge and tubing ready to apply suction to the CDU. Start by filling the water-seal chamber to the level specified by the manufacturer (usually the 2-cm mark) [1,4]. Next, fill the suction-control chamber with sterile water to the $-20$ cm $H_2O$ level, or as ordered. Keep in mind that the water level in this chamber determines the suction level, not the amount of vacuum applied from the vacuum gauge to create the negative pressure that draws air out of the pleural space. Connect the drain to the vacuum, and slowly increase the suction until you see gentle bubbling in the suction-control chamber. Excessive bubbling is loud; besides disturbing the patient, it may cause rapid evaporation, which lowers the suction level. Monitor water levels, adding sterile water when necessary. The nurse can gain useful information by assessing the water-seal chamber. As air leaves the chest, bubbling appears here, indicating an air leak. Also, the water level may reflect intrapulmonary dynamics: A slow, gradual rise over time indicates more negative pleural-space pressure and signals healing [1].


**Figure 2** Necessary equipment needed for chest tube insertion.

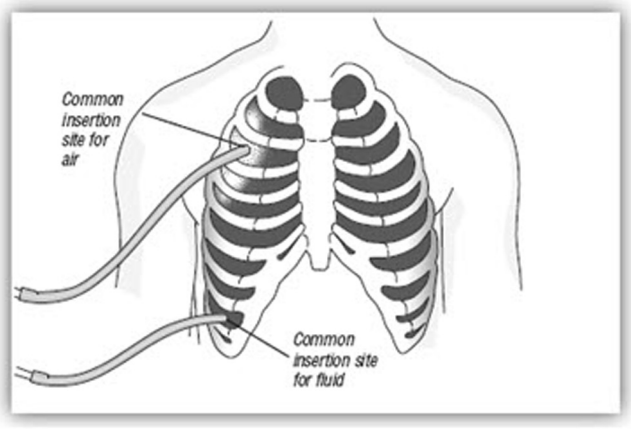


**Figure 3** Common insertion site of chest tube for air and fluid.

After chest-tube insertion, connect the tube's distal end to the CDU. Secure the tube at the insertion site with sutures. Apply an occlusive sterile petroleum gauze dressing around the tube; then apply a dry, sterile split $4'' \times 4''$ dressing over everything. Secure all tube connections from the chest tube to the drainage container, using either tape or zip ties. A post insertion chest X-ray confirms proper tube position and lung expansion [6].

**Potential complications associated with chest tube insertion**

Chest tube insertion can be performed with basic surgical skills. Risks can be minimized if attention is paid to careful technique and monitoring of the patient for complications. Any potential complications are often outweighed by life-threatening intrapleural collections which are included in Table 2 [2–4,6].

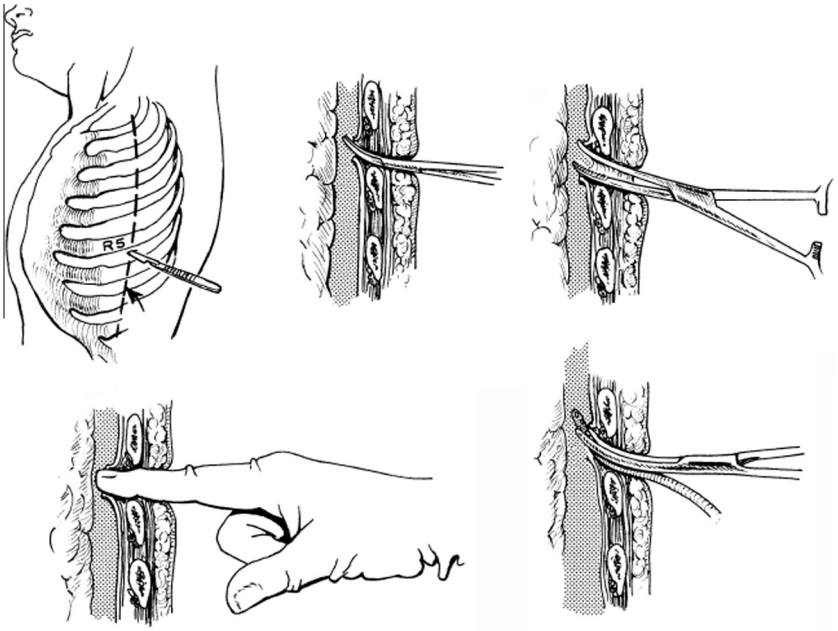


**Figure 4** A view of chest tube insertion (the main steps of chest tube insertion).

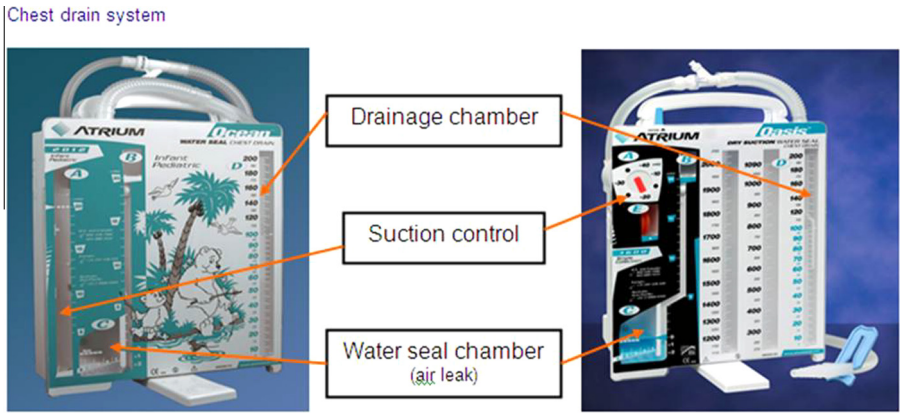


**Figure 5** Chest drain system.

**Table 2** Potential complications of chest tube insertion.

| Potential complications | Cause | Signs/symptoms | Prevention/intervention |
|---|---|---|---|
| Bleeding | Laceration of an intercostal vessel | Continued bleeding despite adequate pressure to the wound | – Use blunt dissection technique<br>– Direct tube insertion over superior edge of rib<br>– Ligate vessel<br>– Consult thoracic surgeon |
| Organ perforation | Traumatic perforation of the lung, heart chamber, diaphragm, or intraabdominal organs | Pain and varied signs depending on organ perforated | – Digitally pleural space prior to inserting tube<br>– Avoid trocar insertion technique |
| Intercostal neuralgia | Trauma of the intercostal neurovascular bundle | Persistent pain | – Use blunt dissection technique<br>– Direct tube insertion over superior edge of rib |
| Subcutaneous emphysema | Escape of air into subcutaneous tissues | "Puffed out" skin "crackles" on palpation of skin | – Treat cause of air leak<br>– Confirm tube patency |
| Reexpansion of pulmonary edema | More than 1–1.5 L of fluid drainage in less than 30 min | Dyspnea<br>Cough<br>Decreased $O_2$ saturation | – Remove less than 1–1.5 L in 30 min<br>– Supportive treatment |
| Local infection | Commonly related to the emergency nature of the procedure | Redness, pus, and increased pain at insertion site | – Antibiotics as indicated |
| Recurrent pneumothorax | Entry of air into the pleural space through the chest tube tract<br>Re-clamping or removing chest tube despite ongoing air leak<br>Loss of tube patency | Dyspnea<br>Asymmetric chest move<br>Sudden, sharp chest pain<br>Decreased/absent breath sound<br>Hypotension if tension-pneumothorax | – Apply air occlusive dressing<br>– Remove tube at beginning of exhalation or during Valsalva<br>– Insert new chest tube<br>– Ensure no air is leaking prior to tube removal<br>– Obtain CXR<br>– Insert new chest tube |
| Tension pneumothorax | Re-clamping or removing chest tube despite ongoing air leak<br>Loss of tube patency | Acute chest pain<br>Dyspnea<br>Tachypnea<br>Deviated trachea<br>Hypotension | – Insert sterile 14-guage angiocath<br>– Unblock chest tube |

## Nursing care

*From patient to chest drain system*

At least every 2 h, document a comprehensive pulmonary assessment, including respiratory rate, work of breathing, breath sounds, and arterial oxyhemoglobin saturation measured by pulse oximetry (SpO2). Inspect the dressing and note any drainage. Assess the insertion site for subcutaneous emphysema and tube migration. Keep all tubing free of kinks and occlusions; for instance, check for tubing beneath the patient or pinched between bed rails. Take steps to prevent fluid-filled dependent loops, which can impede drainage [1].

To promote drainage, keep the CDU below the level of the patient's chest. Monitor water levels in the water-seal and suction control chambers. Water in both chambers evaporates, so

be sure to add water periodically to maintain the water-seal and suction levels. Be aware that tidaling—fluctuations in the water-seal chamber with respiratory effort—is normal. The water level increases during spontaneous inspiration and decreases with expiration. However, with positive-pressure mechanical ventilation, tidaling fluctuations are the opposite: the water level decreases during inspiration and increases during expiration. If tidaling doesn't occur, suspect the tubing is kinked or clamped, or a dependent tubing section has become filled with fluid [8,14]. Also, don't expect tidaling with complete lung expansion or with mediastinal tubes, because respirations don't affect tubes outside the pleural space. Intermittent bubbling, corresponding to respirations in the water seal chamber, indicates an air leak from the pleural space; it should resolve as the lung reexpands [15]. If bubbling in the water-seal chamber is continuous, suspect a leak in the system. To locate the leak's source, such as a loose connection or from around the site, assess the system from the insertion site back to the CDU. When searching for the source of an air leak, use rubber- tipped or padded clamps to momentarily clamp the tubing at various points; bubbling stops when you clamp between the air leak and water seal [1,16].

*Assess drainage*

Assess the color of drainage in the drainage tubing and collection chamber. Know that old drainage in the collection chamber may inaccurately reflect current drainage as shown in the tubing [17]. At regular intervals (at least every 8 h), document the amount of drainage and its characteristics on the clinical flow sheet. Report sudden fluctuations or changes in chest-tube output (especially a sudden increase from previous drainage) or changes in character (especially bright red blood or free-flowing red drainage, which could indicate hemorrhage). Frequent position changes, coughing, and deep breathing help reexpand the lung and promote fluid drainage [1,18].

*Don't milk, strip, or clamp the tube*

Avoid aggressive chest-tube manipulation, including stripping or milking, because this can generate extreme negative pressures in the tube and does little to maintain chest-tube patency. If you see visible clots, squeeze hand-over-hand along the tubing and release the tubing between squeezes to help move the clots into the CDU [1]. As a rule, avoid clamping a chest tube. Clamping prevents the escape of air or fluid, increasing the risk of tension pneumothorax. You can clamp the tube momentarily to replace the CDU if you need to locate the source of an air leak, but never clamp it when transporting the patient or for an extended period, unless ordered by the physician (such as for a trial before chest-tube removal). In the event of chest-tube disconnection with contamination, you may submerge the tube 1″–2″ (2–4 cm) below the surface of a 250-mL bottle of sterile water or saline solution until a new CDU is set up. This establishes a water seal, allows air to escape, and prevents air reentry [8,18].

## Chest-tube removal

Indications for chest-tube removal include [8,10,19]:

- Improved respiratory status.
- Symmetrical rise and fall of the chest.
- Bilateral breath sounds.
- Decreased chest-tube drainage.
- Absence of bubbling in the water-seal chamber during expiration.
- Improved chest X-ray findings.

Before starting chest-tube removal, inform the patient that the chest tube will be removed, and briefly describe the steps involved. Make sure the patient is premedicated to relieve pain and ease anxiety. Teach the patient how to do the Valsalva maneuver, which he or she must perform before tube removal to prevent air from reentering the pleural space [1]. Another chest X-ray should be taken several hours later to ensure that the lung is still fully inflated [8,20].

Nursing care after chest-tube removal includes [1]:

- Ongoing respiratory assessment.
- Vital-sign documentation.
- Monitoring the site for drainage.
- Assessing the patient's comfort level.

## Chest tube maintenance

Keep all tubing patent and free of kinks or obstructions. Dependent loops with the chest tube tubing should be avoided since they obstruct chest drainage into the collection system and increase pressure within the lung. The tubing should also never dangle; coil it on the bed and anchor tubing when securing the chest tube.

It is acceptable for the nurse to gently milk the tubing when a visible clot or obstructing drainage is in the tubing by squeezing hand over hand along the tubing and releasing the tubing between squeezes. However, excessive chest-tube manipulation should be avoided, as this can create negative pressures in the tube and does little to maintain chest-tube patency. If the nurse sees visible clots, squeeze hand-over-hand along the tubing and release the tubing between squeezes to help move the clots into the CDU [21–23].

In conclusion, when managing the care of patients who have chest tubes it is important to fully understand what to do in case problems arise. It is also important to be able to assess when the chest tube is ready to be discontinued. Nurses and other healthcare professionals who are responsible for the safe delivery of care should be knowledgeable about respiratory pathophysiology, signs of respiratory compromise, and the care and management of interventions that may be utilized to ensure adequate respiration.

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