Chest Tubes in the Critically Ill Patient

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This article is meant as a review for critical care nurses caring for patients with chest tubes. The types of chest tubes, equipment needed, types of chest drainage systems, chest tube placement and setup, nursing care, chest tube removal, and complications will be discussed.
Keywords: Chest tubes, pulmonary, thoracotomy

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Chest tube placement, also known as thoracostomy, is a lifesaving procedure often performed in intensive care units. Critical care nurses should be familiar with the types of equipment used for patients with chest tubes. In addition, nurses should understand the indications, placement and removal procedures, preparation of the patient and significant others, and patient education while the chest tube is in place, as well as potential complications when assisting with placement of chest tubes.

EQUIPMENT

Types of Chest Tubes

Nurses working in intensive care units most often care for patients with 2 different types of chest tubes, those placed in the mediastinal or pleural spaces. Mediastinal chest tubes are inserted into the extrapleural space between each lung's parietal pleura typically after cardiac surgery. Because postoperative bleeding in the pericardial space can lead to cardiac tamponade during the first 24 to 48 hours, mediastinal chest tubes are used to reduce the incidence of tamponade.

Alternatively, a pleural chest tube is placed in the space between a lung's visceral and parietal pleural or intrapleural space. The intrapleural space has approximately 25 mL of fluid to lubricate the visceral and parietal pleura and decrease friction during chest wall movement. When a pneumothorax or hemothorax develops in the intrapleural space, it restricts lung expansion leading to decreased gas exchange. Therefore, the goals of inserting a pleural chest tube are to promote lung expansion and restore adequate gas exchange.[1] The purpose of this article was to describe the nursing care of a patient with a pleural chest tube.

Types of Chest Drainage Systems

There are 2 primary chest drainage units (CDUs), the traditional water seal and the newer-generation dry suction. While both work to reestablish lung expansion and improve gas exchange, their mechanisms of action are different. The water-seal drainage system is designed with 3 chambers each with a distinct function (Figure) and is explained in this article.

Drainage Collection Chamber

The largest of the 3 chambers, and typically on the far right side of the CDU, the collection chamber is a reservoir in which drainage from the pleural space accumulates. Large, flexible tubing connects the patient's pleural chest tube directly to the collection chamber on the CDU. A see-through window and calibrated markings located on the exterior of the drainage collection chamber allow the nurse to assess the color, consistency, and amount of drainage in cubic centimeters as frequently as needed.

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Figure. Atrium *Ocean* single collection water-seal chest drainage unit. Photo was reprinted with permission of Atrium (Hudson, New Hampshire).

Suction Control Chamber

Typically found on the far left of the CDU, the suction control chamber regulates the amount of negative pressure applied to the chest. The purpose of applying suction is to assist with the removal of drainage and air from the intrapleural space. Prior to chest tube insertion, tubing is attached between a wall suction source and the top of the suction control chamber on the CDU. The wall suction source should provide a minimum vacuum pressure of −80 mm Hg or higher in order for the CDU to maintain adequate suction pressures.

Prior to chest tube insertion, the health care provider will determine the desired amount of suction to be applied through the suction control chamber. Generally with water-seal CDUs, the provider will order 20 cm H_2O of suction.[2] The amount of suction is regulated by the height of sterile water in the suction control chamber and not the amount of wall suction's vacuum pressure. Based on the health care provider's order, the nurse will need to add the correct amount of sterile water into the suction control chamber prior to chest tube insertion. Adding sterile water into the chamber increases the amount of suction applied, whereas removing water decreases the amount of suction. The chamber is functioning appropriately when the wall suction source is turned on, and continuous gentle bubbling of the sterile water is noted in the chamber.

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Water Seal Chamber

Typically, the middle chamber of the CDU, known as the water-seal chamber, provides a 1-way valve between atmospheric pressure and the patient's negative intrapleural pressure. Sterile water in this chamber allows air to escape from the intrapleural space on exhalation while preventing air from reentering on inhalation. When a patient with a pneumothorax exhales, the air in the intrapleural space exits through the CDU's tubing and then through the water-seal chamber, which causes the sterile water to bubble on expiration. This loss of air from the intrapleural space is called an air leak.

Dry Chest Drainage Units

The drainage collection and water-seal chambers are the same in both wet and dry CDUs. However, the dry CDU uses a self-compensating mechanism for suction instead of regulating the amount of suction with a column of water. The amount of suction ordered by the health care provider is set with a dial, and most dry units allow settings between 10 and 40 cm H_2O of suction. Advantages of the dry suction drainage system include the following: higher suction pressure levels can be obtained, easier setup, and the absence of continuous bubbling that promotes a quieter patient care environment and lack of water evaporation. Cerfolio and colleagues[3] recommend additional research to determine whether a wet or dry CDU is superior, especially for patients with a large pneumothorax after partial lung removal and persistent air leak.

CHEST TUBE PLACEMENT AND INITIAL SETUP

There are many indications for chest tube placement. This section will present those as well as the equipment, setup, patient preparation, and insertion procedure.

Indications for Chest Tube Placement

Placement of a chest tube is often required in the care and management of many critically ill patients. Patients on mechanical ventilation are at high risk of developing a tension pneumothorax related to alveolar overdistention and rupture from excessive airway pressures. A tension pneumothorax is a medical emergency, which must be immediately treated with needle decompression and the placement

of a chest tube because of the ventilator's continuous delivery of positive-pressure breaths.[4]

In addition, the health care team should consider chest tube placement in a patient with a large, symptomatic pneumothorax.[4] Frequent observation and monitoring are acceptable for patients whose pneumothorax is small and does not cause respiratory or cardiac symptoms, such as decreasing oxygen saturation (SaO_2) values or level of consciousness, tachycardia, and hypotension. Patients undergoing procedures and surgeries in which the pleural space is disrupted also frequently require a chest tube to prevent air, blood, or fluid from accumulating in the pleural space.[5] Finally, patients with an empyema, a collection of pus in the pleural space, often require a chest tube to promote drainage of the infectious material.[6]

Chest Tube Equipment Setup

Once the need for chest tube insertion has been identified, the health care team must move quickly and efficiently. Most intensive care units have preassembled "chest tube" or "thoracostomy" trays with the equipment needed to insert a chest tube at the bedside (Table). In addition to obtaining the chest tube tray, the nurse will need to obtain from the health care provider the size of the chest tube to be inserted, size of sterile gloves needed, the CDU, connecting tubing, wall suction apparatus, and a bottle of sterile water. While the health care provider inserting the chest tube is preparing materials from the tray and establishing a sterile field, a nurse is typically responsible for preparing the CDU following the manufacturer's directions. After determining the prescribed suction amount, the nurse will fill both the suction chamber and the water-seal chamber with sterile water using a funnel. Most manufacturers specify the water-seal chamber be filled to the 2-cm mark. In addition, tubing will need to be connected between the wall suction source and the CDU.

TABLE Equipment Found on a Chest Tube Insertion Tray

- Injectable local anesthetic
- Syringes
- Sterile prep solution
- Scalpel
- Hemostats
- Sutures
- Needle
- Scissors
- Sterile 4 × 4 dressings
- Xeroform gauze
- 2-in Tape
- Mask and gown

PATIENT PREPARATION

To ensure safety, proper identification of the patient with 2 identifiers, such as name and date of birth, should be performed prior to the start of any procedure.[7] Obtaining informed consent is also required because there are risks associated with chest tube insertion.[8] After obtaining consent, the patient will need to be positioned and, if medically stable, receive pain and sedation medications. Patients are positioned based on the reason for the chest tube insertion. If the patient has a pneumothorax, they will be placed in a lateral supine position, whereas for a hemothorax assist the patient to a semi-Fowler's position.[7] Immediately prior to the chest tube insertion, and if stable, the patient should receive intravenous analgesic and/or sedation medication. In addition, the health care provider may order a local anesthetic for use at the insertion site.[8] Throughout the patient's preparation, as well as during chest tube insertion, the patient's vital signs and respiratory status should be frequently monitored.[7]

INSERTION PROCEDURE

A preprocedure time-out should be performed prior to starting the sterile procedure to correctly identify the patient as well as the correct site for the chest tube.[7] The placement of the chest tube depends on the reason for insertion. If the patient is experiencing a pneumothorax, the chest tube is most commonly inserted at the midclavicular second intercostal space on the affected side to facilitate removal of air. If the patient has a hemothorax, the chest tube is placed midaxillary around the fifth or sixth intercostal spaces on the affected side to facilitate drainage of fluids.[9]

After positioning the patient and providing any ordered analgesic and/or sedation medication, the health care provider will cleanse the skin with an antiseptic solution and make stab wounds at the appropriate anatomical location, to insert the chest drain tube.[10] After the incision is made, a clamp is used to widen the incision within the intercostal space until the pleural space is reached.[7] Once the pathway is made, the health care provider will guide the chest tube into the chest with a curved Kelly clamp.[7] Once the chest tube is in place, it should be connected to the closed drain system and secured with sutures.[10] A sterile occlusive gauze dressing is applied and then secured with tape.[9] A STAT chest x-ray should be obtained to confirm placement of the tube and to assess the lung.[7,11]

CRITICAL CARE

Critical care nurses are responsible for the maintenance of the chest tube system. This section will describe the critical care nurse's role in patient assessment, pain

management, site insertion assessment, CDU assessment, care of the drainage system, care of the suction control chamber, care of the water-seal chamber, and care of the tubing.

NURSING CARE

Patient Assessment

A careful and detailed respiratory assessment is required for any patient with a pleural chest tube. The nurse should document all vital signs, bilateral chest auscultation, level of consciousness, Sa_{O_2} values, skin and mucus membrane color, and respiratory effort as often as every 15 minutes immediately after chest tube insertion.[2,12] As the patient's respiratory status improves, assessments can be performed every 2 hours, or as necessary.[1] In addition, many physicians order a daily chest x-ray to assess for a decreasing pneumothorax size.[11]

Pain Management

Pain management can often be difficult for patients with chest tubes. The critical care nurses should regularly assess a patient's pain using a self-report measurement tool and encourage patients to ask for pain medication before pain becomes too severe.[10,12] Appropriate pain management, along with repositioning and relaxation techniques, can assist patients with their deep breathing and coughing exercises, thereby reducing hypoventilation, atelectasis, and pneumonia.[2,10] However, because opioids are common for pain reduction in patients with chest tubes, careful and frequent respiratory assessments are required to avoid the complications of overmedication, such as depressed respirations.

Site Insertion Assessment

The chest tube entrance site requires a sterile dressing be applied immediately after insertion. A bacteriostatic ointment is applied to the skin and often followed by either petroleum gauze or xeroform application to the insertion site. The petroleum gauze or xeroform should not be wrapped around the chest tube, simply placed over the entrance site to prevent air leaks. A gauze 4 × 4 dressing with a split is then applied over the tube and anchored to the chest. Microfoam, or a similar all-direction stretch, water-resistant tape, is typically used over the 4 × 4 dressings. Dressing changes are performed when the dressing becomes loose or saturated with drainage. Skin irritation often occurs with frequent dressing changes; therefore, not only should the insertion site be assessed for signs of infection, but also the surrounding skin should be evaluated for maceration during every dressing change.

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Chest Drainage Unit Assessment

Nursing assessment of the CDU is also required after chest tube placement. It is imperative that the CDU remains at least 1 to 2 ft below the level of the patient's chest at all times to maintain an adequate water seal and prevent any drainage in the tubing from returning into the intrapleural space.[10] The top cover of most CDUs has attached adjustable hangers, allowing the nurse to hang the CDU off the side or end of the patient's bed. In addition, CDUs have adjustable bases that allow them to be set on the floor and stabilized to prevent them from being turned on their side.

Drainage Collection Chamber

Nurses are required to measure and document the amount and type of drainage coming from the intrapleural space into the CDU's collection chamber. As previously noted, most wet and dry CDUs have a see-through window and write-on surface that allows the nurse to document the type and amount of drainage. If the chest tube was inserted after surgery, the drainage may initially be sanguineous and up to 100 to 300 mL an hour.[10,13] However, after the first few hours, the drainage should decrease to less than 50 mL an hour and become more serosanguineous, finally turning serous.[13]

For chest tubes inserted for a pneumothorax, scant serous drainage is expected. Regardless of why the chest tube was inserted, it is important for the critical care nurse to note if the drainage suddenly increases and/or has signs of fresh blood.[2] It is also important for the nurse to identify and report to the health care provider if the drainage turns cloudy, which indicates a possible infection.

Suction Control Chamber

The majority of patients who need a pleural chest tube require suction for the first 24 to 72 hours.[10] Applying suction assists with the removal of drainage and air from the intrapleural space. As previously stated, the amount of suction typically ordered is 20 cm H_2O and is regulated by the height of the water column in the suction control chamber. Once attached to suction, the water in the suction control chamber continuously bubbles. The nurse should assess for evaporation due to the bubbling and add sterile water as needed through a port provided in the CDU. If the evaporated water in the suction control

chamber is not replaced, the amount of overall suction to the CDU decreases, which may impair removal of drainage and pneumothorax resolution.

Water Seal Chamber

As with the suction control chamber, the nurse should assess for evaporation in the water-seal chamber and add sterile water as needed through a port provided in the CDU. Tidaling, or vacillation, is the normal fluctuation of the sterile water in the water-seal chamber for a patient with a pneumothorax. When the sterile water rises with inspiration and falls with expiration, the drainage tubes are patent, and CDU is functioning appropriately. When the nurse notes tidaling has stopped, either the tubing has become kinked or obstructed, or the lung has re-expanded.[12]

If the nurse notes a sudden constant bubbling in the water-seal chamber on inspiration and expiration, the patient and the CDU must be immediately evaluated to determine the cause.[2,10] The nurse should briefly pinch or clamp the CDU tubing close to the patient and observe if the bubbling continues. If the air leak continues, evaluate the tubing inch by inch to determine if there is a hole in the tubing or a loose connection between the tubing sections or the tubing and the CDU. Either cause, a hole in the tubing or a loose connection, can be sealed with water proof tape and should stop the bubbling on inspiration.

When clamping the CDU close to the patient does not stop the continuous bubbling in the water-seal chamber, the source of the air leak may be at the chest tube insertion site or within the intrapleural space. The nurse should remove the dressing and assess if the chest tube has been partly removed, by noting if the chest tube's drainage holes are visible. The nurse can gently squeeze the patient's skin up around the tube or apply sterile petroleum gauze around the insertion site and holes. If this intervention stops the bubbling, the nurse should redress the insertion site with the added petroleum gauze and notify the health care provider. Rarely does constant bubbling indicate a intrapleural space injury; however, if the nurse rules out all other causes of the constant bubbling, replaces the entire CDU, and still notes bubbling, the health care provider should be notified immediately.

Tubing

Extension tubing between the patient's chest tube and CDU is often added to provide greater mobility for the patient and to decrease the chance of chest tube dislodgement.[12] This extended tubing, however, often causes long dependent loops that hang off the patient's bed and can impede drainage flow. The tubing should be looped horizontally on the bed but never secured to the bed or patient's gown, allowing patient freedom to turn and sit up.[2,12] In addition, all connections between the tubing sections and the tubing and CDU need to be tightly secured and taped to prevent disconnections from occurring.

Milking and stripping of the chest tube and tubing are controversial practices used by health care providers to clear obstructions, most often found when bloody drainage is present.[14,15] Milking involves massaging or twisting the chest tube or tubing, in an attempt to loosen or dislodge a clot and allow for drainage out of the intrapleural space. Stripping involves forcefully pulling the tubing in opposite directions, to create a transient subatmospheric pressure, then allowing the tubing to spring back into place. This action creates a short burst of high negative pressure within the tubing that removes thick drainage and obstructions.[15] The debate surrounding stripping centers on its efficacy of removing drainage and obstructions and the possible unintended consequences of the high negative pressures being applied to an already damaged intrapleural space and lung parenchyma.[14,15] While milking is still performed by nurses and in some facilities requires a physician order, stripping is no longer an acceptable practice.[1,11,14]

Clamping of the chest tube is typically contraindicated. Clamping can result in an obstruction that precipitates a tension pneumothorax as the escape route for air and fluid is lost.[10] The only indications for clamping include the nurse attempting to find the source of a new air leak or evaluating the patient's readiness for chest tube removal. Historically, nurses clamped chest tubes up close to the patient when tubing sections pulled apart and/or the CDU needed to be replaced. More recently, instead of clamping, nurses place the exposed end of the chest tube in a bottle of sterile water or sterile normal saline creating a water seal, or reattach it immediately to the CDU.

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REMOVING THE CHEST TUBE

Preparing for Chest Tube Removal

The chest tube can be removed once a patient's chest x-ray confirms the pneumothorax has resolved. Additional patient data supporting chest tube removal are disappearance of the air leak and tidaling in the water-seal chamber, breath sounds returning to baseline, and drainage that is minimal or has stopped. Protocols vary on how quickly to remove the chest tube once the air leak is resolved. Those protocols that recommend immediate removal of the chest tube after the air leak ceases result in an approximately

one-quarter recurrence, while waiting for 48 hours after the air leak ceases to remove the chest tube rarely results in the pneumothorax's reappearance.[16] Typically, protocols remove the chest tube 1 to 2 days after the air leak ceases.[4,10] In many hospitals, an advanced practice nurse practitioner or a clinical nurse specialist may remove the chest tubes.

Removal of a chest tube is a sterile procedure and can be painful for the patient.[10] The suction is usually turned off 24 hours before removing the chest tube. Pain medications should be administered approximately 30 minutes prior to the removal process. Once the stitches are removed, the tube is simply pulled from the pleural space while the patient holds his/her breath or, as an alternative, exhales as the tube is removed. Some physicians choose to suture the site after removal of the tube, whereas others simply allow the site to heal naturally. Petrolatum gauze and tape should be used to cover the site upon tube removal to prevent air from entering the pleural space through the remaining opening.[10]

COMPLICATIONS

Problems With Insertion

As with other procedures in the intensive care unit, problems may occur with chest tube insertion. Although these problems occur infrequently, the health care team should guard against these complications and be prepared to address them immediately. Damage to organs (including the lungs, liver, and stomach) or structures may occur during chest tube placement.[4,17] Occasionally, the diaphragm may sustain injury during chest tube insertion.[17] Pleural adhesions can also complicate placement of the chest tube as the visceral and parietal pleura are unable to separate at the adhesion site.[5] Inserting a chest tube can lead to further damage if strong adhesions are forced apart; therefore, an alternative placement of the chest tube should be considered.[5]

OTHER ISSUES RELATED TO CHEST TUBE

Subcutaneous emphysema, or air under the skin, may be present in patients who need a chest tube placed or may develop as a complication. Air that gathers under the skin prior to chest tube placement will eventually reabsorb and typically does not cause any harm to the patient other than cosmetic issues. If significant subcutaneous emphysema develops while a chest tube is in place, rapid assessment of the tube and system is necessary.[4,5] Blockage of the tube, misplacement of the tube, or the system's lack of ability to evacuate the intrapleural air may lead to the development of subcutaneous emphysema.[5] Correcting the causative issue will resolve the development of additional air accumulation. If additional subcutaneous air presents, other sources should be considered, such as a tear in the trachea.

Persistent air leaking, as observed by bubbling on exhalation and tidaling in the water-seal chamber, that does not resolve over time may indicate the development of a bronchopulmonary fistula.[16] Patients who are on mechanical ventilation are most at risk of developing this complication. Medical management of a bronchopulmonary fistula includes repositioning, or addition of another chest tube, while minimizing ventilator settings such as pressures and volumes.[4] Closure of a bronchopulmonary fistula may be performed by surgical techniques or placement of a valve within the bronchi via bronchoscope.[16] If closure is not possible, a passive drainage system using a Heimlich valve may allow the patient to go home.[5]

The health care team should also use care when rapidly draining large amounts of fluid from the pleural space. The rapid removal of large volumes of fluid, greater than 800 mL, may result in increased blood flow to the lungs, resulting in higher than normal pulmonary capillary pressures.[5] Pulmonary edema in the affected lung results from this pressure shift. The health care team should have a high level of suspicion of this complication if the patient begins coughing or has worsening oxygenation after chest tube placement.

CONCLUSION

The development of a pneumothorax or hemothorax, especially under tension, can be immediately life threatening. Proper chest tube use is imperative in the intensive care unit. As with other critical care procedures, nurses should maintain competency on this life-sustaining intervention.

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Erratum

In the article, "Creative Ways to Teach Arterial Blood Gas Interpretation," by LaShonda Barnette and Donald D. Kautz, which appeared in the March/April 2013 issue of *Dimensions of Critical Care Nursing*, an error was noted in Table 2. Beneath "Metabolic acidosis," "ph is *high*" should have read "ph is *low*."

Reference
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