NURSING PRACTICE & SKILL

Chest Tubes and Closed Chest Drain: Dry-Suction – an Overview

What is a Dry-Suction Closed Chest Drain?

› A dry-suction closed chest drain (CCD; **Figure 1)** is a closed-system device that permits the evacuation of air and fluid via chest tubes (CTs) placed in the mediastinum or pleural space of a patient's thoracic cavity. CCDs can utilize either a dry- or wet-suctiontechnique. The suction pressure of the wet-suction CCD is established by a column of sterile water within the suction-control chamber. The dry-suctionCCD utilizes an adjustable bellows to set the suction pressure below atmospheric pressure. Both types of CCDs can function by gravity alone if the external source of suction is removed. The focus of this paper is an overview of the function of a dry-suction CCD (for information about the wet-suction CCD, see *Nursing Practice & Skill … Chest Tubes and Closed Chest Drain: Wet-Suction — an Overview*)

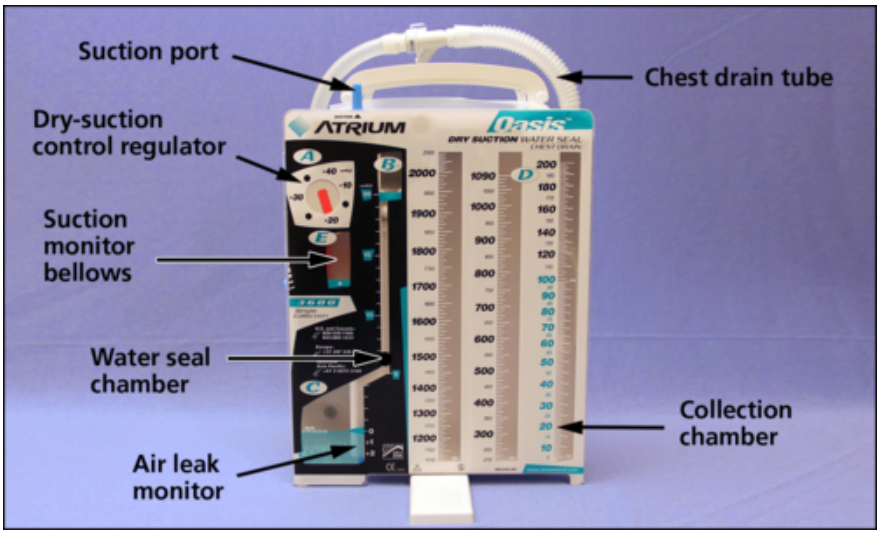

Figure 1: Dry-suction water seal closed chest drain.

- *What*: A dry-suction CCD is a self-containeddisposable device designed to promote the evacuation of air and fluid from the mediastinum or pleural space, depending on the CT placement, and, during inspiration, restrict entry of air into the thoracic cavity
- *How*: A dry-suction CCD has a drainage/collection chamber, a one-way valve or water-seal chamber to permit evacuation of air but prevent air reentry into the thorax during inspiration, and a suction-control chamber that can be set to the desired level of suction. The combination of a manual/radial dial and an external source of suction is used to set suction pressure above atmospheric pressure
- *Where*: Patients with CTs connected to CCDs are typically cared for in the acute care setting, primarily in critical care and thoracic units, and on a short-term basis in the emergency department (ED)
- *Who*: CTs can be inserted by physicians or advanced practice clinicians at the patient's bedside, in the ED (e.g., for treatment of spontaneous pneumothorax), or in the operating room (e.g., placement tubes into the mediastinum following cardiac surgery, placement of tubes into the pleural space following pneumonectomy). Licensed nurses assist with

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the set-up and connect the CTs to the dry-suction CCD. Due to the need to preserve sterile technique, the presence of visitors is discouraged during the initial set-up or replacement of the dry-suction CCD, but visitors can be present when the CCD is in use

What is the Desired Outcome of Using a Dry-Suction Closed Chest Drain?

› The desired outcome of using a dry-suction CCD is to promote the evacuation of air and/or fluid from the pleural space or mediastinum while preventing entry of air

Why is Using a Dry-Suction Closed Chest Drain Important?

› Because the thorax is a closed system, air, blood, or/or fluid in the mediastinum or pleural space can cause respiratory and/or cardiovascular complications
  • Air, blood, and/or fluid in the pleural space competes with the lungs for expansion space. The lungs will collapse if they cannot expand and result in respiratory compromise or failure (i.e., pneumothorax, tension pneumothorax)
  • Air, blood, and/or fluid in the mediastinum competes for space with the heart, trachea, esophagus, and major vessels and can lead to hypotension, impaired cardiac output, cardiac arrest, and death
  • Fluid collection within the pericardial sac can exert pressure on the heart and lead to cardiac tamponade (i.e., a type of acute effusion in which the pericardial sac fills with blood and impedes normal heart function)
› The advantages of using a dry-suction over a wet-suction CCD include
  • the potential for suction pressures up to -40 cm H2O/-30 mm Hg, if necessary; wet-suction CCDs use a maximum of -20 cm H_2O/-15 mm Hg. High suction pressures are typically utilized for patients with
    – empyema (i.e., pus) in the pleural space or viscous pleural effusion
    – reduced pulmonary compliance
    – a large leak through the lung surface
  • easier set-up and less nursing management because the suction-controlchamber does not require fluid and, therefore, does not require intermittent refilling to compensate for evaporation
  • no continuous bubbling when attached to external suction, which allows for quieter operation

Facts and Figures

› CTs should not be “stripped” (i.e., using the thumb and forefinger to compress the CT tightly close to the insertion site, then sliding the finders down the CT toward the collection device) to remove potential clots and increase drainage as this can increase negative pressure to a dangerous level; opinions vary as to whether it is safe to “milk” (i.e., gently squeeze and release the CT along its length); (Carroll, 2013; Chotai et al., 2016)
  • Researchers in a prospective, randomized trial involving 145 surgical patients determined that milking of CTs did not decrease postoperative morbidity, mortality, incidence of air leak, or length of stay (LOS), but rather was associated with an increase in postoperative pleural effusion (Dango et al., 2010)
› In a systematic review, researchers concluded that there was insufficient evidence to determine whether CTs should be used with or without suction following surgery to repair a pneumothorax (Pompili et al., 2017)
› Australian pediatric clinical guidelines indicate that canister or collapsible drains that provide continuous low-level suction can be used in lieu of a conventional CCD to drain the pleural space and mediastinum following cardiothoracic surgery (The Royal Children’s Hospital Melbourne, 2016)

What You Need to Know Before Using a Dry-Suction Closed Chest Drain

› Prior to caring for a patient with a dry-suction CCD, the clinician should have knowledge of the following:
  • Anatomy and physiology of the thorax, particularly the pulmonary and circulatory systems
    – The pleural space, also referred to as the pleural cavity, is a potential space between the visceral pleura (also known as the pulmonary pleura; i.e., a thin serous membrane covering the lungs and inner chest walls) and the parietal pleura (i.e., a thin serous membrane lining the chest walls and diaphragm). The pleural space is normally a closed system that requires negative pressure to permit the lungs to remain fully expanded; it contains ~ 50 mL of pleural fluid, which lubricates the visceral and parietal pleurae to reduce friction during respiration
  • Indications for placement of CTs, including
    – pneumothorax (i.e., air in the pleural space) or tension pneumothorax (i.e., a medical emergency marked continuous and worsening air trapping in the parietal space—air flows in with inspiration but cannot escape with expiration), which can result in thoracic hyperexpansion, displacement of the mediastinum toward the opposite side of the thorax (called

a mediastinal shift), and decreased cardiac output. For more information, see the *Nursing Practice & Skill*series about caring for a patient with pneumothorax and tension pneumothorax
  - hemothorax (i.e., collection of blood in the pleural space)
  - hemopneumothorax (i.e., collection of air and blood/fluid in the pleural space)
  - thoracic surgery requiring drainage
  - treatment of pleural effusion, such as
    - empyema in the pleural space
    - hydrothorax (i.e., pleural effusion containing serous fluid—often related to ascites associated with cirrhosis)
    - chylothorax (i.e., lymphatic fluid in the pleural space, commonly the result of damage or obstruction to the thoracic duct [e.g., due to malignancy])
    - chylothorax (i.e., pleural effusion containing bile)
- Potential adverse effects of CT placement are many, and can include
  - bronchopleural fistula
  - hemothorax
  - cardiac/great vessel injury
  - pulmonary bleb rupture
  - diaphragm injury
  - infection
  - nerve/organ compression
  - CT displacement
  - erosion into vascular structures
  - cardiac compression
  - lung injury
  - phrenic nerve injury
  - abdominal organ injury
  - re-expansion pulmonary edema
- Use of aseptic technique. Management of a dry-suction CCD is usually performed using general aseptic non-touch technique (ANTT; i.e., nothing that must remain sterile comes in contact with anything non-sterile)
- How to perform a thorough cardiovascular and respiratory assessment (for more information, see *Nursing Practice & Skill ... Physical Assessment: Performing a Cardiovascular Assessment in Adults* , and *Nursing Practice & Skill ... Physical Assessment: Performing a Respiratory Assessment in Adults*)

› Prior to setting up a patient with a dry-seal CCD, the clinician should be familiar with the dry-suction CCD, which includes a drainage/collection chamber, a one-way valve or water-seal chamber to permit evacuation of air but prevent air reentry into the thorax during inspiration, and a suction-control chamber that can be set to the desired level of suction.

- The volume capacity of the drainage/collection chamber varies among models. The drainage/collection chamber is manufactured so drainage is visible and the volume can be assessed by calibrated markings. One or two (i.e., dual-chamber) drainage/collection chambers may be present
  - The CCD is connected to the patient's CT by a drainage tube. In some models, the drainage tubing includes a sampling port (i.e., needleless Luer-lock style port)
  - The drainage/collection chamber of some CCD models includes a sump port that permits attachment of a collection device for autologous blood for autotransfusion
- A water-seal chamber will be present, and should be filled to the 2 cm/0.8 inch level; it should not be over-filled. The water-sealchamber creates a one-way valve (permits release of air from the pleural space but prevents re-entry of air into the patient's thorax) and the viewing panel permits air leak detection. For models that have a one-way valve and do not rely on the water-seal chamber to prevent reentry of air into the thorax (referred to as a dry-drysystem), the water-seal chamber is typically still filled as it allows for detection of an air leak (i.e., the escape of air from the thorax) and is referred to as the air-leak chamber as it no longer functions as a water-seal
  - The level in the water-seal chamber should *tidal*, or *oscillate*, (i.e., move up and down with respirations). If tidaling is not observed, check for kinked or occluded tubing, or the lung may be completely reinflated
    - Continuous bubbling in the water-seal chamber is abnormal except upon forceful exhalation or coughing. Continuous bubbling in the water-sealchamber indicates an air leak—check for leaks within the system by examining for poor tubing connections or an inadequately sealed thoracic insertion site. Also consider a patient-related air leak (e.g., bronchopleural dysfunction)

– Many models include dye in the chamber so that when water is added it becomes tinted blue to aid in visualization of water level and bubbling/tidaling. The water-seal chamber in some models is designed so that a portion of the chamber is flattened out for better visualization of air leaks—bubbles moving from right to left confirm an air leak with the system or a bronchopleural leak. Maintain the one-way valve by keeping the CCD in an upright position at all times and refilling the chamber when the water level drops due to evaporation

• Unlike the wet-suction CCD, which uses a column of sterile water to establish suction pressure beyond atmospheric pressure, the suction-control chamber of the dry-suction CCD has an adjustable bellows that is controlled by a manual or rotary dial that can be adjusted to set the suction pressure higher than that allowed in a wet-suction CCD (i.e., -20 cm H_2O/-15 mm Hg). Compared to wet-suction CCDs, dry-suction CCDs require higher levels of air-flowfrom an external suction source for efficient drainage. Some models require a minimum vacuum pressure of -64 mmHg at 16 liters of air flow/minute, others require as much as -80 mmHg at 20 liters/min. Always check the manufacturer's requirements for the specific model to be used

– The suction control chamber has a stopcock or valve that must be kept open ***at all times*** to provide a vent for air escape. Normally, air exits through the port in the suction-control chamber; however, the valve is designed to automatically open if this exit is obstructed (e.g., the suction port is capped after external suction is stopped; if the suction tubing is clamped or kinked; or if the wheels of the bed or other equipment inadvertently occlude the suction tubing)

- **Occluding the stopcock valve can cause air to be trapped in the pleural space and lead to a tension pneumothorax**

– The typical level of suction for an adult patient who does not have friable lung tissue is -20 cm H_2O/-15 mm Hg, and most models of dry-suction CCDs are preset by the manufacturer for this level

• A one-way positive-pressure relief valve is present to prevent tension pneumothorax if the CT becomes kinked or otherwise occluded

› Factors that influence evacuation and drainage, which include

• gravity. CCDS are designed to be positioned below the level of the patient's chest because the lower position of the CCD will create a lower pressure gradient and promote air and fluid removal. Never place the CCD on its side (e.g., during transport, when the patient is undergoing MRI or other procedure). It must be kept in an upright position and below the level of the patient's thoracic cavity to promote optimal function

• increased expiratory positive pressure from the patient (e.g., coughing, deep breathing), which increases the rate at which air and fluid are expelled from the thoracic cavity

• the level of external suction, which is required by a dry-suction CCD to provide the ordered level of suction

› The nurse's primary responsibilities surrounding the care of a patient with a dry-suction CCD include the following:

• Patient assessment, particularly of the respiratory and cardiac systems

• Performing routine care associated with use of a CT and CCD, including

– monitoring and maintaining the functionality of the equipment

– assessing and recording the amount of drainage

– monitoring the patient's response to treatment and for complications

– performing routine patient care associated with the CTs and CCD system (e.g., changing dressings, facilitating tube drainage, refilling water-seal chamber of the CCD)

• Reporting any abnormal findings or events to the treating clinician

• Performing autotransfusion, if ordered (for more information, see *Nursing Practice & Skill … Autotransfusion: Performing*)

• Educating the patient/family about the purpose of CT placement and function of the CCD

› Preliminary steps that should be performed before setting up a dry-suctionCCD include the following:

• Review the facility/unit specific protocol regarding use of dry-suction CCDs, if available

• Review the treating clinician's orders. Note

– level of suction

– any laboratory specimens ordered

– autotransfusion, as appropriate

• Review the manufacturer's instructions for the dry-suction CCD model to be used, and verify that all equipment is in good working order

– Note the minimum requirements for vacuum pressure and air flow for the external suction source

• Review the patient's medical history/medical record for

– indications for CT placement

– amount and type of drainage, if present

– results of previous assessment
– any allergies (e.g., to latex or other substances); use alternative materials, as appropriate
• Verify completion of facility informed consent documents, as appropriate
– Typically, the general consent for treatment executed by patients at admission to a healthcare facility includes standard provisions that encompass care of the patient with CTs and CCD

› Gather equipment and supplies necessary for setting up a dry-suction water seal closed chest drain with external suction source,which typically includes the following **(Figure 2)** :
• Nonsterile gloves and other personal protective equipment (PPE; e.g., gown, face mask), if exposure to body fluids is anticipated
• Dry-suction CCD unit
• Additional tubing for connecting the CCD to the patient's CT, if needed
• Sterile water and 20 mL syringe with needle to fill water-sealchamber
• Adhesive tape (~ 2.5 cm/1 in wide)
• Suction set-up (e.g., tubing, canister, suction regulator/wall register)
• Equipment for monitoring vital signs, including pulse oximeter
• Two hemostats (padded or with rubber tips)
• Petrolatum-impregnated gauze
• Sterile 4 x 4 gauze
• Tape
• Facility-approved pain assessment tool
• Any prescribed analgesic agents
• Written materials to reinforce patient education

Figure 2: Supplies required for setting up a dry-suction water seal closed chest drain with external suction source. Copyright©2013, EBSCO Information Services

How to Set Up and Use a Dry-Suction Closed Chest Drain

› Perform hand hygiene and don nonsterile gloves; don other PPE if exposure to body fluids is anticipated
› Identify the patient using at least two unique identifiers, according to facility protocol
› Establish privacy by closing the door to the patient's room and/or drawing the curtain surrounding the patient's bed
› Position and drape the patient for privacy, comfort, and accessibility; raise the bed to a height that is optimal for access to patient
› Ask visitors to leave the patient's room to promote privacy, as appropriate
› Introduce yourself to the patient and explain your clinical role
• Assess the patient for knowledge deficits and anxiety regarding CTs and use of a dry-suction CCD
– Determine if the patient requires special considerations regarding communication (e.g., due to illiteracy, language barriers, or deafness); make arrangements to meet these needs if they are present
- Use a professional certified medical interpreter when a communication barrier exists
• Explain nursing interventions, answer any questions, and provide emotional support as needed

› Adhere to facility infection control standards and employ correct aseptic technique throughout the procedure

› Perform the following steps to set up a dry-suction CCD:

- Open the packaging and the swing out floor stand. Note: Although most models include a built-in floor stand for use in setting up the unit, infection protocols of many facilities require the unit be removed from the floor and hung from the bedframe, not the side rails
- Use a needle and syringe, as needed, to fill the water-seal/air-leakchamber through the built-in port to the 2 cm line/0.8 inch level
- Adjust the rotary dial for the bellows on the suction-control chamber to the prescribed level of suction. Typically, -20 cm H_2O/-15 mm Hg is used for most adults. Pressure for pediatric patients or adults with fragile lungs is set at 7–14 cm H_2O/-5–10 mm Hg. In most models, the suction monitor displays the bellows, which, when properly expanded, extend to the preset mark of -20 cm H_2O/-15 mm Hg. If a suction pressure < -20 cm H_2O/-15 mm Hg is desired, the bellows do not need to reach the preset mark; they need only show visible expansion to confirm that suction is operational. Note: Some dry-suction CCD units include a regulator design that automatically and continuously adjusts for changes in patient air leaks or fluctuations in the external suction source to maintain a consistent suction level to the patient
- Connect the patient's CT(s) to the drainage tubing extending from the drainage/collection chamber. Secure the connection to reduce the risk of inadvertent dislodgement and disruption to the closed system **(Figure 3)**
  - **When changing a CCD (e.g., when the drainage/collection chamber is full), clamp the CT(s) only briefly as clamping the CT(s) can result in worsening pneumothorax**

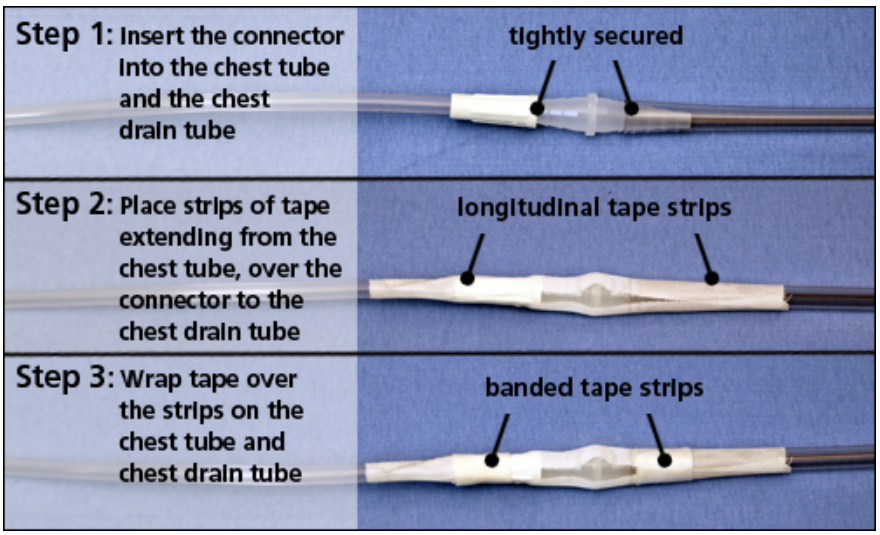

Figure 3: Secure the connections between the chest tube and the chest drain tube. Copyright©2013, EBSCO Information Services

- Attach tubing extending from the suction-control chamber to the source of external suction; set the level of suction according to manufacturer's instructions—typically -80 mmHg—and turn on
- To promote drainage, confirm the tubing from the CT to the CCD is not kinked or has any dependent loops **(Figure 4)**

Figure 4: Chest drain tube positioned for optimal drainage. Copyright©2013, EBSCO Information Services

› Assess the patient's general health status, including level of pain using a facility-approved pain assessment tool, as pain can prevent the patient from breathing deeply
  • Administer prescribed analgesia, if indicated
› Assess the patient's vital signs
  • Hypotension can occur if the major vessels in the chest are being compressed
  • Tachycardia can occur if the heart is compressed and preload is reduced
› Assess the patient's respiratory status
  • Monitor oxygen saturation level using pulse oximetry
  • Auscultate breath sounds in all lung fields; report diminished or absent breath sounds or reduced chest wall movement
  • Assess the patient's effort to breathe and for signs of hypoxia (e.g., increased respiratory, respiratory distress, shortness of breath [SOB], use of chest *and* abdominal muscles to breathe, pursed lip breathing)
    – The patient will breathe more rapidly to compensate for the decrease in inspiratory volume if air accumulates in the pleural space
› Assess the patient's cardiovascular status
  • Assess the patient's hemodynamic status, as appropriate (for more information, see the related series of *Nursing Practice & Skill* papers on hemodynamic monitoring)
  • Auscultate for muffled heart sounds, which can indicate fluid build-up around the heart
› Assess for signs of tension pneumothorax (e.g., neck vein distension, hypotension, crepitus)
  • **Notify the treating clinician immediately if tension pneumothorax is suspected**
› Assess the patient's mental status for anxiety and restlessness, which can indicate hypoxemia
› Confirm CT patency. *Gently* milk or manipulate to resolve occlusions, as necessary and if according to facility protocol
  • **Use extreme caution when manipulating CTs due to the risk of increasing negative pressure that can injure tissue; *never strip the extension tubing*** as stripping or *vigorous* milking can increase negative pressure within the thoracic cavity to -450 cm H_2O/-331 mm Hg and can result in trauma to mediastinal and graft tissue
› Assess for air leak by observing for continuous bubbling in the water seal chamber
  • If an air leak is suspected, *briefly* clamp a padded hemostat near the insertion site. If the bubbling stops, the leak is at the insertion site, and if the bubbling continues, the leak is in the tubing or in a connection
› Assess the amount, color, and consistency of the fluid in the drainage/collection chamber. Drainage is assessed more frequently immediately after CT placement (e.g., every 15 minutes for the first 4 hours following surgery, and then at hourly intervals for the next 24 hours)
  • Mark the level of drainage on the chamber
  • Assess for increasing, rather than decreasing, drainage over time, and notify the treating clinician if the volume exceeds the expected level within a prescribed time period (e.g., > 100 mL within an hour on the second post-operative day). Drainage should decrease over time
    – **Notify the treating clinician immediately of any increase in bleeding or indications of new hemorrhage**
    – Blood or fluid can pool in the chest when the patient is lying down; when the patient sits or stands, there can be increase in dark red blood/drainage (i.e., not fresh blood) as this pooled blood is drained

- Do not empty the drainage/collection chamber; the entire CCD is replaced, as needed (for more information, see *Nursing Practice & Skill … Chest Tubes: Replacing a Closed Chest Drain*, referenced above)

› Assess the dressing over the CT insertion sites to verify that it is intact and palpate the skin around the dressing for subcutaneous emphysema (i.e., the presence of air in the subcutaneous tissues; also called crepitus)
- Replace the dressing using petrolatum-impregnated gauze wrapped around the CTs and secured with dry 4 x 4 gauze, or according to facility protocol, only if loosened or soiled or as needed if subcutaneous emphysema present

› Perform autotransfusion, if appropriate and ordered, if the drainage reaches a threshold level and within 6 hours of collection (for more information, see *Nursing Practice & Skill … Autotransfusion: Performing*, referenced above)

› Notify the treating clinician of any changes in vital signs, occlusion in the system, increase in drainage, or unresolved air leak

› Dispose of used equipment appropriately and perform hand hygiene

› Update the patient's plan of care, and document the following in the patient's medical record:
- Date and time dry-suction CCD was set-up and connected to the patient's CT(s). Note if the level of external suction in use
- Clinical assessment information, including
  - vital signs
  - hemodynamic status
  - respiratory status
  - cardiovascular status
  - amount, color, and consistency of drainage
    - Note drainage on patient's I & O sheet
  - level of pain, before and after analgesia administered, if ordered
- Status of the CCD system, and any troubleshooting required
- Patient's tolerance of the procedure
- Any unexpected patient events or outcomes, the nursing interventions performed, and whether the treating clinician was notified
- Patient/family member education, including topics presented, response to education provided/discussed, plan for follow-up education, and details regarding any barriers to communication and/or techniques that promoted successful communication

Other Tests, Treatments, or Procedures That Can Be Necessary Before or After Setting Up and Using a Dry-Suction Closed Chest Drain

› For information on CT tube insertion, see *Nursing Practice & Skill … Chest Tubes: Assisting with Insertion*
- Chest X-rays are typically taken before and after CT insertion, daily while the CT is in place, and after removal

› Supplemental oxygen or mechanical ventilation will be ordered if oxygenation is inadequate

› Arterial blood gases (ABGs) may be ordered to monitor respiratory status, particularly if the patient is receiving mechanical ventilation

What to Expect After Setting Up and Using a Dry-Suction Closed Chest Drain

› The dry-suction CCD will be used to evacuate excess air and fluid from the thoracic cavity, and the patient will not experience complications related to air and/or fluid in the mediastinum or pleural space

Red Flags

› If changing out an existing CCD with a new CCD, ensure that disposal of the replacement CCD and its contents is in accordance with facility infection control policies

› **It is critical to maintain the thoracic cavity as a closed airspace to permit lung re-expansion or prevent complications that could result if the normal negative pressure is disrupted**

› Neck vein distension, hypotension, subcutaneous emphysema, or a change in cardiac function suggest a **tension pneumothorax, which can occur if fluid or air cannot escape from the pleural space** . This is a **medical emergency** and the treating clinician should be notified immediately

› A sudden increase in blood drainage or the presence of bright red blood in the CT or CCD indicates potential **hemorrhage** and should be reported immediately

› Restlessness, anxiety, and central cyanosis can indicate **hypoxemia** . Oxygen therapy should be initiated if indicated by facility protocol and the treating clinician should be notified immediately

› Inflammation, drainage, and/or exudate at the CT insertion site suggest **infection** . These findings should be reported to the treating clinician, and a sample of the drainage/exudate should be collected and forwarded for laboratory analysis, if ordered

› Sudden dyspnea, hypoxia, and tachypnea in connection with a large volume of CT drainage can indicate **re-expansion pulmonary edema** and should be reported immediately

What Do I Need to Tell the Patient/Patient's Family?

› Once the CCD is connected to the patient's CT(s)

- emphasize the importance of maintaining the CCD in an upright position below the level of the patient's chest and that all connections must remain sealed
- encourage the patient to immediately report chest pain or SOB

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