Everything you used to know about Chest Tubes

But forgot after Respiratory School

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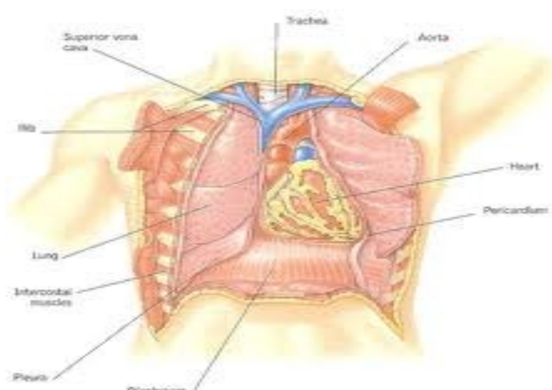
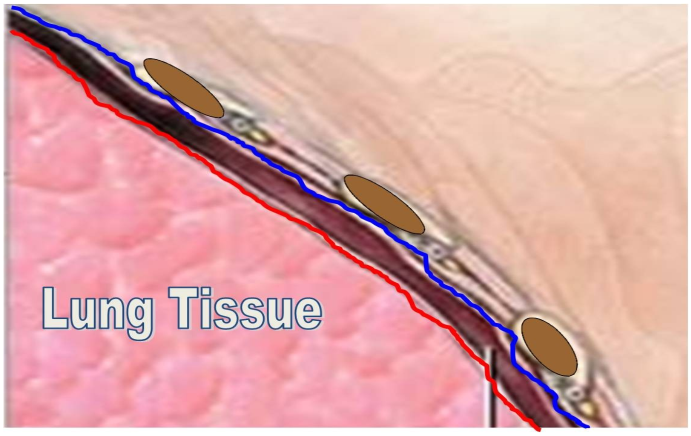
INTRODUCTION

Chest tubes are a common sight in critical care units and on trauma services. In order to understand how a chest tube works we will first review basic chest and lung physiology that will set the stage for learning more of the specifics about how chest tubes function. We will move then to a review of why a patient might need chest tubes including some of the pathological and surgical rationales. The remainder of this report will be a review of the basic principles behind the functioning of chest tubes and chest drainage collection systems. This will include some basic troubleshooting and management of urgent or emergent situations.

THE THORACIC CAVITY

The thoracic cavity is defined by the ribs, sternum, thoracic vertebrae and the diaphragm (see picture below). It is a space that serves both as a functional unit but also as a protective cavity for the heart, lungs, major blood vessels, esophagus and trachea. The thoracic cavity is lined by two thin layers known as the pleura. These two layers are known as the **parietal and visceral pleura**. The pleural space is located between these two thin layers of tissue. The inner layer or visceral pleura, pictured here as a red line (see picture below), tightly encapsulates the lung tissues. The outer layer or the parietal pleura, pictured here as a blue line (see picture below), is what lines the chest cavity. The darker purple area between these two layers is the pleural space which is filled with a lubricating fluid that allows for the lungs to expand and contract and reduces friction between the two pleural layers.





In order to keep the lungs inflated, the pleural space is actually a vacuum with negative pressure. The **intrapleural pressure**, or the pressure in that space between the parietal and visceral layers, fluctuates with breathing but generally remains negative. With inspiration the intrapleural pressure is about -8 cm H20 and with expiration it is about -4 cm H2O. What would happen if intrapleural pressure was equalized to match atmospheric pressure or the pressure in the air around us? Our lung would deflate.

An important physiological concept not to confuse is the differences between pulmonary and pleural pressures:

Intrapulmonary pressures, or pressures in the lungs, change with breathing and are what drive the movement of air in and out of the lungs.

Intrapleural pressure, pressure within the pleural space, also changes with breathing, but is different than the intrapulmonary pressure. If intrapleural pressure is not negative, as mentioned previously, the lung with deflate.

CHEST TUBE INDICATIONS

The easiest thing to remember in regards to chest tube indications is that they are primarily inserted as a **means of reversing or preventing the pressure disequilibrium**. This may mean removing air and or fluid and preventing air or fluid from accumulating. Both of these actions will ideally restore negative pressure in the intrapleural space and promote normal respiration. There are many conditions which may warrant the need for a chest tube including:

- **Post-surgical management of drainage**
- **Management of traumatic chest injuries**
- **Physiological causes such as infections or spontaneous lung collapse.**

SURGERY

In the acute care setting, chest tubes will most commonly be present following post-cardiac and thoracic procedures such as lung tumor removal or open heart surgery. In the case of cardiac procedures there may be chest tubes around the lungs and around the pericardium to prevent excess blood and fluid buildup around the heart. These are known as mediastinal chest tubes and require advanced care and management by the ICU staff.

TRAUMA

Chest injuries ranging from falls, motor vehicle accidents, gunshot wounds and penetrating trauma may all necessitate the need for a chest tube. Even if skin integrity is maintained, meaning there is no break in the skin; chest tubes may still be needed. Particularly in the case of rib fractures, sharp bone edges may damage the integrity of the pleural space. Chest x-rays, as a result, are a common means of determining the need for chest tubes in trauma patients even if there is no break in the skin.

Two of the main issues we are trying to correct or prevent following trauma and surgery are hemothorax and pneumothorax. **Hemothorax is the buildup of blood in the pleural space** and **pneumothorax is the buildup of air in the pleural space**. An important point to remember is that gravity influences where blood and air will collect and thus where the chest tube will be inserted. As in many traumatic cases, both **blood and air enter the pleural space which is called a hemopneumothorax.**

PNEUMOTHORAX

Open vs. Closed

The two main types of pneumothorax are open vs. closed. A **closed pneumothorax** is a situation where pleural integrity is compromised but there is no puncture or penetration of the chest wall. A chest injury from a patient hitting the steering wheel during a motor vehicle crash is an example of the mechanism of how a closed pneumothorax might occur.

The biggest concern with a closed pneumothorax is that it may progress to a **tension pneumothorax**. This is an emergent, life threatening situation in which air enters the pleural space but cannot escape. The pressure builds up inside the pleural space and may displace the trachea and damage or limit function of the heart, blood vessels and the other lung. This displacing of chest organs because of the pressure is called a mediastinal shift. Tension pneumothorax may occur in situations where positive pressure ventilation is being applied because the force of pressure from the ventilator may cause the pressure buildup. A sudden drop in blood pressure is sometimes the first clue that a tension pneumothorax is occurring and must be dealt with immediately.

Open Pneumothorax

Gunshot wounds to the chest are a classic cause of an open pneumothorax as they disrupt the pressure equilibrium in the pleural space because of the entry of air and often blood as well. This may result in what is known as a sucking chest wound which is the result of air entering and escaping the chest wall during respiration. Although the affected lung might deflate, the unaffected lung can sustain life and there may not be the dangerous buildup of air in the chest cavity as may be the case with a closed pneumothorax.

PHYSOLOGICAL REASON FOR CHEST TUBES

The final category of chest tube indications is those that do not have a direct link to surgery or trauma. We use this term (physiological) to categorize situations in which changes to the intrapleural space may be due to:

- Tumors
- Infections in the pleural space
- A spontaneous pneumothorax
- Pleural Effusions
- Chylothorax
- Empyema

Any one of these causes may necessitate the need for a chest tube. A spontaneous pneumothorax may occur in individuals with tall, slender body types. A pleural effusion is the accumulation of excess fluid in the pleural space that might, for example, occur in patients with congestive heart failure or with lung tumors. A

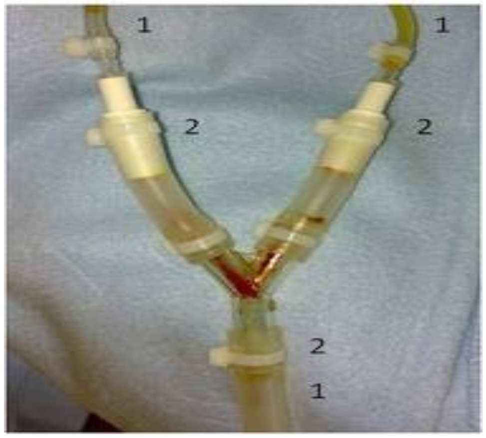
Chylothorax is when the fluid is lymphatic and empyema is when the fluid is infection related.

CHEST TUBE INSERTION

The insertion of a chest tube is often a quick procedure that may be done in the emergency trauma center, at the bedside in a post-anesthesia or critical care setting, or in the operating room during a surgical procedure. Insertion of a chest tube may be done on patients that are awake which can be a painful and traumatic experience, but often results in quick relief in some cases of respiratory distress or an emergent respiratory event related to a pneumothorax. Chest tubes come in a variety of shapes and sizes and are often inserted over a wire or with the use of metal trocar as a guide. The skin is prepped with betadine or similar antiseptic solution and local anesthetic is often used to numb the insertion pathway. Depending on the situation, it is ideal to be able to advocate for the patient to have some level of sedation or analgesic during insertion. The physician often uses their fingers to identify the pleural space and to guide the tube before inserting and suturing it in place.

Insertion

An occlusive dressing may be applied but is not always a requirement. Generally there are pre and post x-rays and the tube is attached to some type of drainage system. It is essential that the connections from the insertion site through the drainage management system are secured and evaluated as they may allow for air to leak into the system. The image below shows a Y-'d chest tube with plastic bands applied to keep the connections secure.



Location

As previously mentioned, gravity influences where fluid and air shift inside a patient's chest wall. As a result, chest tubes are often placed accordingly. Generally, to drain air, they are placed anterioraly or laterally through the 2nd intercostal space. For blood and fluid drainage they may be posted more posterior at the 8th or 9th intercostal space often at the midaxillary line. Each patient situation is different, but you can often still discern the rationale for the chest tube based on the height of the placement.

Site Management

Generally a patient will have a dry gauze dressing held in place with foam tape after surgery. There is emerging evidence as to the benefits of using petroleum gauze when dressing chest tube sites. The main indication for a dressing for chest tubes is the same for most incisions, which is to protect the wound, particularly in the key 24-48 hour time period.

HOW CHEST TUBE COLLECTION DEVICES FUNCTION

Understanding how chest tube drainage systems function can be complex. One of the best ways to break it down is to look at the three main functional aspects of these devices. We will discuss these three functional aspects as being individual chambers and then begin to put the functional aspects together. One of the key concepts to keep in mind moving forward is that one of the basic laws about how gases function is that they will move from areas of high to low pressure, essentially moving to a state of equilibrium whenever possible. For example, when we blow up a balloon, we are creating disequilibrium between the high pressure in the balloon and the atmospheric pressure. When we pop the balloon, the pressure difference immediately equalizes.

Breathing

So if we take this gas theory and the concepts discussed earlier and think about what happens when we breathe, we can see how a chest drainage collection device might help when our functional respiratory system has been compromised.

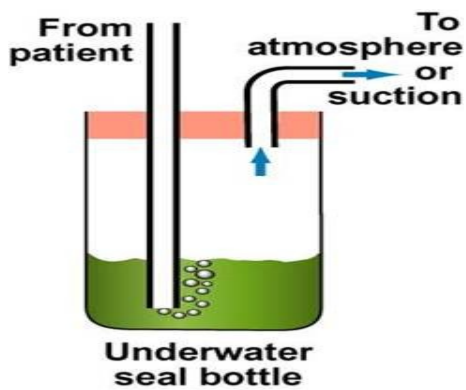
Since the pressure in our intrapleural space is negative, if we introduced a hole there then this negative pressure would become positive and our lungs would deflate. A chest tube collection device is one way to eliminate any air or fluids that have entered the pleural space and that are causing the negative pressure from becoming positive. So let's move now to the functional components of the chest tube system which we will refer to as bottles or chambers.

Chest Tube System: Chamber One

The first functional chamber of a chest tube system was literally a single bottle. (As we move forward we will be using the word chamber and bottle sometimes interchangeably.) The main reason we will go through these bottles individually is so that you will understand how the commercially available chest tube systems that the majority of us work with actually work once all the bottles are in place.

The first chamber is the most important as it acts as a one-way air valve. It prevents air from entering the chest wall, but will allow air at a certain pressure to escape.

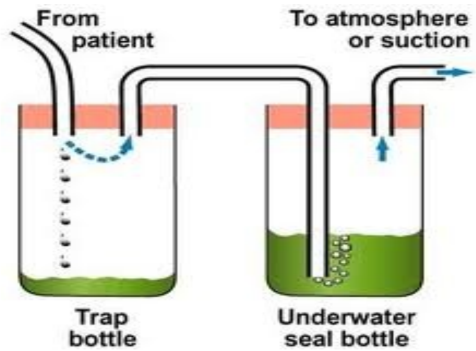
This valve is commonly referred to as a water seal because in some systems, water serves as the valve. Think for a moment of a straw in water. You could exhale and bubbles would travel through the straw and bubble out the water into the atmosphere. If the straw is submerged, you cannot pull air in from the atmosphere though. This is the basic principle of the water seal, which in some commercial devices is simply a special valve but in other products, it is actually water that is poured into the device when it is set up.



Potential Problems with Chamber One

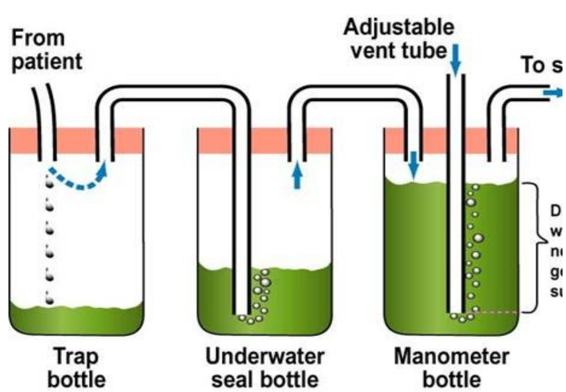
What would happen if the tubing leading to the first bottle was cut somewhere between the chest and the bottle? If a cut was made there, the system would no longer be a closed system. This would allow for the negative pressure in the intrapleural space to equalize with atmospheric pressure and potentially pull air through the tubing into the chest wall and/or collapse the lung. The integrity of the water seal relies on this being a closed system. The one-way valve, which in this case is the water, would not be able to keep air out. Having a water seal is both the most important safety aspect of chest drainage collection devices, but also the bare minimum requirement for placement of chest tubes. But what if the patient has more than just air coming from the lung? What if the patient has blood or other fluids also draining out? Time for a second bottle.

Two Chambers



When fluid is in the chest and drains through the tube into a one bottle system, it interferes with this system. The fluid would eventually add to the water in the water seal and increase the pressure that the air has to fight against to exit the chest. For this reason, a second bottle is added to act as a collection bottle. That collection bottle would allow for any fluids to be collected without interfering with the water seal (first bottle). We still have our water seal (aka our one way air valve) but now we've added a bottle or chamber to collect drainage. Now both air AND fluid can escape from the intra-pleural space. A second chamber allows us to also measure and observe the character of the chest drainage. Gravity is the force that moves fluid down the tube into the collection chamber with this setup. But what if we could add some mild suction to the system? Wouldn't it help drain the air and fluid from the patient faster? That's where the third bottle comes in.

Three Chambers



A three chamber system includes the water seal and drainage collection but now adds the option to create a pull that is stronger than gravity. The third bottle is to add suction to the system. Once again, the two bottles are connected through a closed system to the third bottle of water that is set to 20 cmH2O. This third bottle is then connected to suction. Suction is a bit of a controversial issue in chest tubes. Too much suction can cause tissue damage, but no suction can leave the patient with exudate. This is why the third bottle is calibrated to only 20 cmH2O of suction using the water column in the chamber. No matter how high you turn the valve on the suction machine, it will only pull 20 cmH2O. What makes the third chamber slightly confusing is that we do not regulate the amount of pull (suction) by using the wall suction knob. The wall suction could be set at 30cm H2O or 300cm H2O but if the column of water is set at 20cm H2O, the pull exerted will remain at 20cm H20. The wall suction is needed to create the negative pressure vacuum exerted by the column of water to function but does not determine the actual strength of pull. So again, changing the wall suction will not increase or decrease the pull on the intrapleural space. Only changing the column of water will.

Commercial Chest Tube Systems

Commercial chest drainage collection devices combine all three bottles or chambers into a durable plastic, disposable unit. These devices have a clearly marked water seal chamber that generally uses blue tinged saline to create the actual water seal. They will have an empty chamber because it is the collection chamber (seen with red fluid in the picture above). It will have numbers written along the sides of the window of this collection chamber for easy measuring of the extracted fluid. Some commercial systems may have more than one drainage collection chambers. For example, following open heart surgery in which patients may have both thoracic and mediastinal chest tubes, a chest drainage collection device with two collection chambers may be utilized. The third chamber or the chamber that exerts a pull may be an actual column of water in which water is added or extracted to change the cm of H2O pull exerted or it may be made of an intern pull system that does not rely on actual water to create the pull. A system that uses actual water is called a **wet suction system** and a system that has an internal vacuum or negative pressure system is called **dry suction system**. Both systems still rely on wall suction in order to make them function correctly.

There are a variety of commercially available devices that are used based on institution preference, surgeon preference and the type of procedure being performed on the patient. Always follow manufacturer's instructions and hospital policy when working with commercial chest tube systems.

CARE OF A CHEST TUBE

With most chest tubes, the care starts at the patient. Examine the dressing. Make sure that there is no drainage showing, and if there is, note the color and amount. Most chest tubes need an air tight seal around the skin where the tube goes in. You can achieve this with Vaseline gauze. Note, though, that not all chest tubes require this. For instance, an open heart patient with chest tubes will have them mostly for drainage and not controlling air. These are cared for with a plain dressing.

Always keep the chest tube container below the level of the patient's heart. Gravity is necessary to drain the fluids and air from the chest. If you put the chamber on the bed, the chest tube becomes useless. Make sure that the tube is long enough to keep the chamber below the patient.

Chambers have a tendency to tip over, and this will cause the readings in the fluid collection chamber to become skewed. Mark the time, date, and your initials on the chamber measuring guide once per shift to track the amount of fluid from the chest over time. If you see a great deal of accumulation, you may want to report it. Little accumulation is not necessarily cause for concern. If the patient is getting better, you may not see as much fluid output. Similarly, if a patient has a pneumothorax with no other involvement, they will not produce fluid, although the same chamber may be used for maintenance of the tube. However, if you know your patient has significant exudate or it is too soon post-operatively for no drainage, then there may be something wrong with the tube placement or the patient.

ASSESSMENT

When you are working with a patient who has a chest tube, based on your role, scope and responsibilities, here are a list of some assessments and care considerations to be familiar with. Ensuring that there is a water seal is a top priority and then examining for the presence or absence of an air leak is also essential.

Water Seal & Air Leaks

As mentioned previously, the water seal prevents air from entering the chest wall, but allows it to escape from the pleural space. If air is escaping from the pleural space, it will appear as air bubbles in the water seal chamber. Some important questions to ask when you look at the water seal chamber include the following:

1. Is the water seal intact? If not, saline or water needs to be added immediately.

2. Is there tidaling? **Tidaling** is a rise and fall of water in the water seal column which occurs when the lung is inflated and occurs as a result of the natural changes in intrapleural pressure.

3. Evaluate for an air leak: Present or absent? An air leak would appear as bubbling in the water seal chamber as mentioned earlier. We would want to consider whether the air leak we are seeing is expected or unexpected? If a patient coughs or deep breaths or had a lot of air in the pleural space, we would expect to see some bubbling.

4. We would want to look and see if the air leak is continuous or intermittent? Continuous bubbling and a large air leak may indicate that there is a break in the system, perhaps a hole in the tubing somewhere between the patient and the device. It may also indicate that the tube has migrated out of the pleural space.

5. What is the size of the leak? The size of the leak may also tell us something about whether or not the air leak is physiological or a functional problem with the device or tubing. Some devices allow for a numerical value to be placed on the size of the leak as shown in these examples with 1 being small and 5 being large.

One additional assessment related to air leaks and system integrity is the presence of air in the subcutaneous tissue around the chest tube site or in the patient's chest or shoulders. This is called subcutaneous emphysema and is sometimes caused by chest tubes. A doctor, nurse or other care provider would feel around the site and notice air pockets that are often described as "rice krispies" under the skin which is called crepitus. Although subcutaneous emphysema is generally benign, it may indicate a broader problem such as a chest tube that has slipped out.

Tubing and Drainage

The next step of assessments and care considerations relate to the tubing and drainage.

Kinked tubing may prevent air from escaping and a **dependent loop** does not allow for optimal drainage of fluid. Having the commercial collection unit lower than the patient's chest lets gravity help with drainage and ensures that fluid will not leak backwards into the chest. When trying to determine the character of the drainage coming from the patients pleural space it is best to look at the drainage in the tubing itself. The drainage in the collection device is a mix of previous drainage and may not best represent the patient's current drainage. The color of drainage may indicate the source of fluids, determine readiness for removal or suggest emergent or concerning situations. There is often an order stating that the physician should be notified if drainage reaches or exceeds a certain amount per hour.

Suction

Not all patients will have suction ordered. If they do, we want to make sure that the suction setting ordered in cm of H2O is what is actually set on the device itself. For a dry suction system, this would be a matter of looking at the dial setting. For a wet suction system, we'd want to look at the actual height of water to determine the cm of H2o setting. Remember, increasing or decreasing the amount of wall suction won't change the amount of pull.

Stripping, or squeezing the material forcefully out of a chest tube, is not recommended anymore. The suction that is caused by the forceful squeezing of the tube can sometimes damage lung tissue, and the suction from the wall is usually enough to move fluid out of the lungs.

CARE CONSIDERATIONS

These final care considerations may be done in collaboration with other care providers. Ongoing assessment of respiratory status particularly effort of breathing, respiratory rate, lung sounds and oxygen saturation are important to determine therapeutic benefit and progress. Oxygen dependence pre, during or post exercise as well as general exercise tolerance are important to consider. Pain management is vital in patients with chest tubes as they are often very painful. Many patients will have an epidural placed if they have an extensive thoracic procedure requiring chest tubes. It is vital to facilitate frequent position changes and ambulation when appropriate to help with the movement of air and fluid out of the intrapleural space. Finally, chest tube dressings may need to be changed and evaluated frequently in the immediate post-operative period.

CHANGING

Changing a chamber is a relatively easy process. **This is the only time you will clamp a chest tube** – unless specifically ordered by a doctor for some other reason – and you should quickly make the switch to avoid having the tube clamped for a long period of time. Some manufacturers produce special tube clamps that won't harm the tube like a hemostat will. If you don't have one of these clamps, use a folded 4x4 on the tube and clamp the hemostat over that. To change the chamber, simply unsnap the tube from the patient from the old chamber and snap it onto the newer one. Make sure the water for the water seal, the pressure setting, and the suction are all configured as ordered. Hook up the suction if necessary. Dispose of the old chamber in dirty utility as this is infectious material.

REMOVAL

Care protocols and orders generally guide readiness for chest tube removal. Usually chest x-rays and assessment of patient's progress towards their therapeutic goals will determine readiness. Tidaling is sometimes considered a positive sign as this fluctuation seen in the water seal chamber often indicates lung re-expansion. Removal may be painful and in some cases, patients may need pre-medication. Patients should breathe in and "hum" as they breathe out as the chest tube is removed to prevent air from leaking into the chest during the removal process. The nurse or physician removing the tube often does so quickly and with a lot of force (after removing any sutures if they are present). An occlusive dressing is immediately applied. Internally, the pleura seals itself off and the chest will usually heal within a week.

FINAL CONSIDERATIONS

If the chest tube container gets kicked over, it may be necessary to replace the unit itself, but most importantly, you should evaluate whether or not the water seal is still intact. It may be necessary to immediately add water to re-establish the water seal.

Kinked or clamped tubing can be a dangerous situation as it may lead to a tension pneumothorax. This is the condition described in the beginning of the presentation in which air builds up progressively in the chest wall resulting in pressure on internal vessels and organs.

A continuous air leak, as mentioned previously may be expected immediately after insertion of a chest tube. Otherwise, it might indicate a leak in the system and should be investigated. Troubleshooting might include determining how far into the chest the tube is and ensuring that all connections are tight.

Excessive drainage, particularly bright red drainage could indicate an active bleed. Sometimes if a patient has been in one position for a period of time, changing positions may cause a large outflow of drainage.

Helping a patient ambulate with a chest tube can be tricky. It is important to determine if the patient is ok to be off suction and to ensure that the tubing will not pull and that the chest tube remains upright and below the level of the chest.

A tube can sometimes fall out of a chest if the suture isn't tight enough or the patient is particularly energetic. When this happens, do not try to put the tube back in or push it further into the patient. Use Vaseline gauze to cover over the hole in the chest or any of the vents in the tube that are now open to air. Get a stat chest x-ray, and notify the physician.

The following emergency items should be in the patients room or readily available to handle problems with the chest drainage collection device and respiratory emergencies. A bottle of sterile normal saline is particularly important as it can be used to create a water seal "bottle" in an emergency situation or it can be used to fill a water seal chamber if a chest tube was tipped over. Vaseline gauze for emergency chest tube displacements.

CONCLUSION

As always, follow your agency protocols and procedures and be aware of your scope of practice when working with patients that have chest tubes. Hopefully this report has helped to demystify chest tube collection devices and will help you troubleshoot problems and be more informed about determining a patient's progress towards therapeutic goals which ideally include removal of the chest tubes.

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