

Chest Tube Complications

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The Case

A 30-year-old woman with a history of cystic fibrosis was admitted to the hospital for management of a spontaneous left pneumothorax (collapse of her lung). She required urgent thoracostomy (chest tube) placement in the emergency department. The chest tube was connected to wall suction in order to promote reexpansion of her lung.

Over the next 2 days, the patient improved, and repeat imaging showed reexpansion of her lung. The consulting pulmonary team felt that the chest tube might be able to be removed, so they requested that the tube be disconnected from suction and clamped. The plan was to obtain a chest radiograph 1 hour after clamping the tube, and if the pneumothorax had not recurred, the tube would be removed.

About 45 minutes after the tube was clamped, the patient complained of acute, sharp pain radiating to her left arm. The nurse gave the patient pain medication. She noted that the radiograph had not yet been done but assumed that it would be done soon. Unfortunately, the radiograph was not done, and the nurse became busy with another acutely deteriorating patient.

Approximately 2 hours later (3 hours after the tube was clamped), the nurse found the patient unresponsive, in cardiac arrest with a rhythm of pulseless electrical activity. A code blue was called. The code team recognized that the arrest could have been due to a tension pneumothorax, reconnected the chest tube to suction, and eventually performed needle decompression. Despite these measures, the patient did not recover spontaneous circulation for more than 30 minutes and sustained severe anoxic brain injury as a result. The patient required tracheostomy and feeding tube placement, and she was eventually transferred to a long-term care facility with a poor neurologic prognosis.

The hospital conducted a root cause analysis (RCA). The RCA committee found that there was considerable variation around chest tube removal practices between services. For example, the trauma surgery service did not routinely perform a clamping trial before chest tube removal. Although other services did perform such a trial, there was variation in when the radiograph was performed after clamping the tube. The committee noted that this variation led to confusion among bedside nurses about how to

monitor patients and communicate with physicians immediately after chest tube removal. As a result, the committee felt the complication might still have occurred even if the radiograph had been performed.

The Commentary

by Lekshmi Santhosh, MD, and V. Courtney Broaddus, MD

In this commentary, we will review how chest tubes (thoracostomy tubes) function and examine complications and best practices associated with their management. For this patient, the chest tube was placed for spontaneous pneumothorax, a common complication in cystic fibrosis. In a spontaneous pneumothorax, a leak from the lung allows air to enter the negative pressure pleural space until there is no longer a pressure difference or until the leak closes.⁽¹⁾ As the air enters the pleural space, the lung collapses and the patient often experiences chest pain and dyspnea.

Placement of a chest tube allows a route for egress of the air. When no suction is applied, the air exits the pleural space via the chest tube across a water seal only when there is sufficient positive pressure generated, as with coughing or straining. With suction, air removal is accelerated. The drainage system most often used with tube thoracostomy functions as a three-bottle system ([Figure](#)) ⁽²⁾, which provides a one-way water seal, a collection chamber for fluid, and a pressure regulator.

Common complications of chest tube placement include malpositioning (the most common complication), recurrent pneumothorax, infection (including empyema), organ or vessel injury, and reexpansion pulmonary edema. Chest tube complications have been described most often in the trauma literature, with incidences varying from 2% to 25%.⁽³⁻⁵⁾ Complications during or after chest tube removal have rarely been reported. In one review of iatrogenic pneumothoraces, only one case was reported after chest tube removal.⁽⁶⁾

A tension pneumothorax, the likely cause of this patient's arrest, should be rare. In tension pneumothorax, air continues to leak into the pleural space until the pleural pressure rises to the point that it compresses the veins and impairs venous filling of the right heart. With a functioning chest tube in place, either on water seal or on suction, such a complication cannot develop. However, when the chest tube is clamped, kinked, malpositioned, or has been removed, there is no route of egress for the air and the positive pressure necessary to produce tension physiology can develop.

Thus, before a chest tube placed for pneumothorax is removed, one would like to ensure that any air leak (from lung into pleural space) has ceased. Generally, this is checked over a period of hours or days by placing the chest tube to water seal, seeing no air bubbles across the water seal, and obtaining a chest radiograph that shows the lung still inflated. At that point, some would remove the chest tube and monitor the patient. However, some experts argue that a safer approach is to clamp the chest tube and monitor closely for recurrence of pneumothorax. That way, if the pneumothorax recurs, one can simply unclamp the chest tube and avoid the need to place another one.

There are few guidelines and even fewer trials available on when and how to remove a chest tube safely. The British Thoracic Society ⁽⁷⁾ recommends against clamping chest tubes before removal (Grade B evidence), arguing that there is no significant difference in rates of chest tube reinsertion when comparing chest tube removal with and without clamp trials.⁽⁸⁾ In contrast, the Belgian Society of Pneumology ⁽⁹⁾

recommends a few hours of clamping followed by chest radiography when there is doubt about the safety of removal (Grade D evidence). The American College of Chest Physicians (10) convened a panel of experienced clinicians in formulating its recommendations; 53% of panel members would never clamp a chest tube before removal while 47% would. Regardless, the majority of panel members (62%) in this report would obtain a repeat chest radiograph 5–12 hours after chest tube removal.

In the absence of consistent clinical guidelines on chest tube removal, it is not surprising to find practice variability among clinicians. The *UpToDate* article on this subject acknowledges the lack of data and recommends a clamp trial if there is any doubt whether an air leak has sealed (or for all patients on positive pressure ventilation, which increases the likelihood and risk of an air leak).(11) During a clamp trial, close monitoring is recommended for clinical signs of air reaccumulation, such as hemodynamic instability or respiratory difficulty.(11)

Based on our own experience and assessment of the literature, we recommend that a clamp trial be initiated only after the chest tube has been off suction (i.e., to water seal) for a period of time without recurrence of pneumothorax. We also recommend that the clamp on the chest tube be taped on the outside of the bedclothes in full view of the medical team. Moreover, if there is any sign of tachypnea or hemodynamic instability, the chest tube should be unclamped immediately, even before ordering a repeat chest radiograph or activating a rapid response team. Responsibility for ordering the chest radiograph and following up on its results should be clearly delineated to avoid assumptions and lapses in communication.

Factors contributing to the error in this case include lack of clear guidelines on chest tube removal, such as assigning responsibility for monitoring the patient and obtaining and checking the follow-up chest radiograph. In situations like these, checklists can be helpful.(12) Checklist-style protocols have been published to help guide nurses in when to remove chest tubes.(13,14) Unfortunately, clamping trials are not described in these protocols. Funk and colleagues (15) have described a chest tube care path that outlines an algorithm for safe removal of chest tubes, including frequency of monitoring during a clamp trial. Electronic order entry could be modified to prompt the use of such a pathway and ensure that an order for chest tube removal is automatically linked to an order for a chest radiograph and a strict period of closer observation of vital signs. To our knowledge, this has not yet been studied.

Within hospitals, various stakeholders such as pulmonologists, intensivists, thoracic surgeons, interventional radiologists, and nurses should work together in a multidisciplinary team to develop a uniform policy of chest tube management to avoid conflicting advice to primary medicine teams. Because either physicians or nurses can remove chest tubes, guidelines should be clear on whose responsibility this is.

Take-Home Points

- Chest tubes or thoracostomy tubes often are used with a three-bottle drainage system involving the water seal, collection, and suction chambers.
- Common complications of chest tube placement are malpositioning and empyema; more unusual complications include organ rupture and problems arising after removal, such as recurrent pneumothorax and tension pneumothorax.

- National society guidelines differ as to whether clamp trials prior to chest tube removal are recommended; however, most practitioners advise a close period of clinical observation and repeat chest radiograph, regardless of clamp trial.
- Possible strategies to prevent chest tube complications include checklists for removal, multidisciplinary communication within hospitals to ensure uniform practice style, and electronic order entry solutions.

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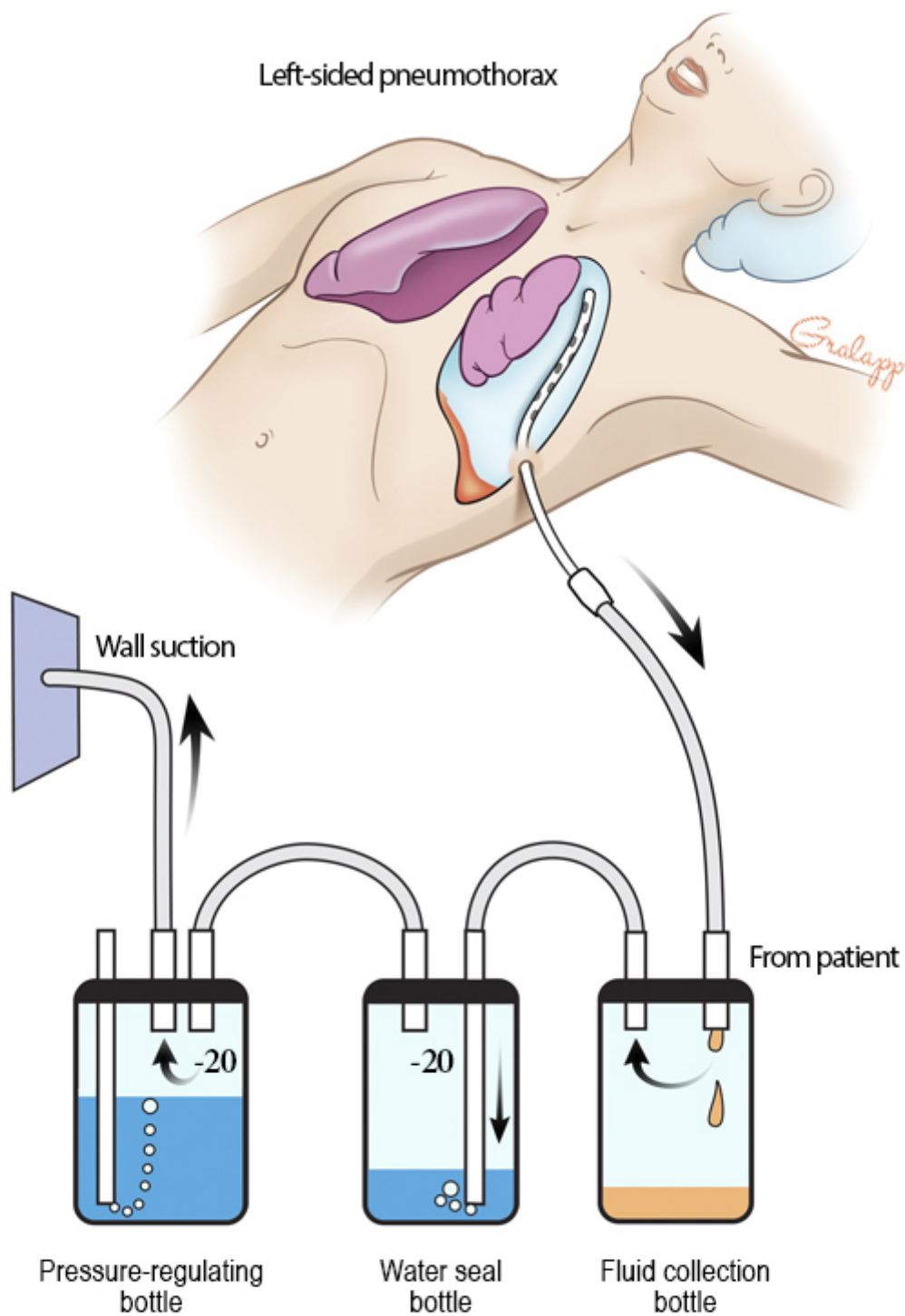
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Figure

Figure: Illustration of Pneumothorax and Chest Tube Three-bottle System (–20 Indicates Wall Suction Set to –20 cm H₂O; This Pressure Is Transmitted Throughout the System). (Illustration © 2017 Chris Gralapp.)



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