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Case Report

Chest tube insertion following a failed needle decompression in a patient with tension pneumothorax: A case report

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ABSTRACT

Pneumothorax occurs when the pleural space is filled with air due to trauma, iatrogenic injury, or underlying lung disease. If this air leak forms a one-way valve that causes air to be trapped, an uncontrolled increase in air volume can occur, causing lung collapse and shift of the mediastinum to the contralateral side, which can eventually cause respiratory and hemodynamic disturbances or even death. This case demonstrates the importance of quickly identifying a patient in respiratory distress secondary to pneumothorax and highlights the emergency management of these patients. A 46-year-old male patient presented to the emergency room with a chief complaint of shortness of breath and chest pain radiating to the left shoulder. On physical examination, the patient had severe shortness of breath, tracheal deviation, decreased expansion and air entry of the left hemithorax, hyperresonance of the left hemithorax, and a shift of the punctum maximum of the heart sounds to the left sternal line. The chest x-ray performed confirmed the suspicion of a tension pneumothorax. A needle decompression in the second intercostal space in the left midclavicular line failed to improve the tension pneumothorax. A chest tube insertion was performed, which managed to improve the patient's clinical condition.

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INTRODUCTION

Pneumothorax is a relatively common finding in emergency departments. The reported annual incidence of spontaneous pneumothorax is 17 to 2 per 100,000 in males and 1 to 7 per 100,000 in females (Santry & Simon, 2013). Meanwhile, the reported annual incidence of traumatic pneumothorax is higher, around 81 per 100,000 people or approximately 20.6% of the major trauma patients (Alghnam et al., 2020).

A patient could present to the emergency room with a tension pneumothorax or a pneumothorax that develops into a tension pneumothorax when treatment is delayed. This condition occurs when an opening to the pleural cavity acts as a one-way valve, causing air entering the pleural cavity to be trapped and causing an increase in air volume and pressure in the affected hemithorax, which will collapse the affected lung and shift the mediastinum to the contralateral side. Tension pneumothorax is a medical emergency. The mediastinal shift caused by the tension pneumothorax puts pressure on the contralateral lung and vena cava, which can result in respiratory insufficiency, cardiovascular compromise, and death if not treated promptly (Sahota & Sayad, 2022). Mortality of patients with tension pneumothorax can increase from 3-7% when treated immediately to 91% if the treatment is delayed (No, Moon, & Kim, 2012; Roberts et al., 2015). Therefore, early recognition of clinical symptoms and appropriate management in the emergency department will reduce mortality in tension pneumothorax.

In this case report, we present a patient with tension pneumothorax who underwent a failed needle decompression followed by an insertion of a chest tube connected to a water seal drainage system at a limited-resource hospital in East Lampung. We also discuss the proper emergency management of tension pneumothorax through needle decompression and chest tube insertion.

CASE REPORT

A 46-year-old man was brought to the emergency room with shortness of breath. The shortness of breath occurred one week before hospital admission and was getting worse. The patient also complained of chest pain radiating to the left shoulder. He denied any history of fever or prolonged coughing. He had never had a similar complaint before, had never been on tuberculosis treatment, and had no history of asthma or chronic obstructive pulmonary disease. He has a fall history and had his left chest bump on a brick wall one month ago. After the fall, his left chest ached for only a few days. He did not have shortness of breath or cough-up blood after the fall. He has a 30-year history of cigarette smoking.

On physical examination, the patient appeared to have shortness of breath with diaphoresis and compos-mentis consciousness. On vital signs examination, the patient had a blood pressure of 126/78 mmHg, a pulse rate of 110 times per minute with a strong pulse, a respiratory rate of 36 times per minute, a body temperature of 36.8°C, and peripheral oxygen saturation of 94%. Examination of the head, skin, abdomen, anogenital, and extremities results were within normal limits. Examination of the neck showed right tracheal deviation. Chest inspection revealed decreased expansion of the left hemithorax and no deformity or injury on the chest wall. On chest palpation, there was no tenderness over the entire thoracic field and a decreased tactile fremitus of the left hemithorax. The left hemithorax was hyper-resonant, while the right hemithorax was resonant on chest percussion. It was revealed that there were decreased breath sounds in the left hemithorax

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Figure 1. Chest x-ray of the patient on hospital admission

on chest auscultation. Auscultation of heart sounds revealed that the apex of the heart shifted to the left sternal line, and the heart sound was fast without any gallops or murmurs.

An emergency chest X-ray was performed, and it revealed a wide area of avascular lucency from the top to the bottom of the left hemithorax, collapsed left lung, and right displacement of the mediastinum and the trachea. The clinical presentation strongly suggested tension pneumothorax, and emergency treatment was immediately performed on the patient.

The patient was given adequate oxygenation, and needle decompression was immediately performed. After local anesthesia, a 14 G intravenous catheter was inserted into the second intercostal space in the left midclavicular line until a hissing sound was heard. After 30 minutes, no sound of air came out of the catheter, and the patient was re-evaluated. The patient's clinical condition had not improved. The patient still had shortness of breath with a respiratory rate of 30 times per minute. It was revealed on thoracic examination that the left hemithorax was still expanding poorly, the tactile fremitus of the left hemithorax was decreased, the left hemithorax was hyper resonant on percussion, no breath sounds were heard on the left hemithorax on auscultation, and the apex of the heart was still on the left sternal line. A chest tube insertion was then decided to be performed on the patient.

After obtaining informed consent, the patient was prepared for the chest tube insertion. The equipment prepared were: a 28 F intercostal catheter with a blunt-tipped trocar, a water seal drainage (WSD) system bottle, sterile gloves, gown, mask, sterile drapes, povidone-iodine 10% antiseptic solution, surgical kit, lidocaine 2%, non-absorbable thread silk size 1-0, sterile gauze, and a 5 cc syringe with 25G and 19G needles.

The patient was positioned to sit at 90 degrees with his ipsilateral arm raised, holding the back of his head. The chest tube insertion was performed with the following procedure:

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1. The patient was identified and re-evaluated.
2. The chest tube insertion safety triangle was identified on the left hemithorax.
3. The insertion point at the 4-5th ICS in the anterior axillary line was identified and marked.
4. Aseptic and antiseptic procedures were performed.
5. Local anesthesia by infiltration was performed from the subcutaneous layer to the pleura.
6. After adequate anesthesia, a skin incision of approximately 3 cm was made at the puncture site parallel to the superior border of the fifth rib down to the fascia.
7. Blunt dissection was performed with a clamp.
8. The chest tube was inserted with the help of a trocar. It was directed posteriorly and superiorly while releasing the trocar until all the holes entered the pleural cavity and the most peripheral hole (sentinel hole) was not visible.
9. The chest tube is connected to the WSD system bottle placed lower than the patient's chest level.
10. The chest tube was fixed to the skin of the chest wall with a U-stitch suture.
11. An evaluation of the WSD system was carried out. The fluid was found undulating along with breathing, and excessive air bubbles were shown in the WSD bottle during expiration.

After the chest tube insertion, the patient revealed that his shortness of breath improved. The patient's respiratory rate decreased to 24 times per minute. The left hemithorax expanded along respiration, and it was sonour on percussion. The air entry to the left hemithorax was improving, and the apex of the heart had returned to the left midclavicular line. There was no subcutaneous emphysema identified after the chest tube placement. One hour after the procedure, a chest X-ray was performed. It was revealed that the avascular lucency in the left hemithorax was reduced, and the lungs began to expand. The patient was then transferred to the inpatient ward for observation. The patient was positioned semi-sitting, and chest physiotherapy was performed daily during the hospitalization. The patient's condition improved, and the chest tube was removed on the fourth day. The patient was discharged on the fifth day of hospitalization.

Figure 2. Chest tube insertion at the 5th ICS in the anterior axillary line of the left hemithorax

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Figure 3. Chest X-ray of the patient after chest tube insertion

DISCUSSION

Pneumothorax occurs when a visceral or parietal pleura defect allows air to enter the pleural space. It causes loss of negative intrapleural pressure and causes the lung to collapse. Pneumothorax can be classified into simple pneumothorax, tension pneumothorax, or open pneumothorax based on the underlying pathophysiology. Tension pneumothorax is a life-threatening condition resulting from lung collapse and mediastinum displacement from the affected side, which can result in hypoxemia and decreased venous return. Tension pneumothorax can occur due to lung, bronchi, or trachea injury, which allows continuous one-way air leakage into the pleural space (Fontaine & Page, 2011; MacDuff, Arnold, & Harvey, 2010).

Pneumothorax can occur spontaneously or as a result of trauma or iatrogenic causes. Primary spontaneous pneumothorax occurs in people without underlying lung disease. Some opinions suggest that primary spontaneous pneumothorax is associated with smoking habits. In secondary pneumothorax, various lung diseases such as COPD, tuberculosis, and other infections are the underlying causes of pneumothorax (Sharma & Jindal, 2008). In this patient, the identifiable risk factors for pneumothorax were a history of cigarette smoking and blunt trauma to the left chest one month ago. Pneumothorax can occur in blunt thoracic trauma through 4 mechanisms, including 1) alveolar rupture due to increased alveolar pressure, 2) paper bag effect that occurs when the epiglottitis closes when there is a sudden increase in pressure in the tracheobronchial tree, 3) acceleration-deceleration trauma, and 4) rib fractures that injure the pleura (Dogrul, Kiliccalan, Asci, & Peker, 2020). Cigarette smoking increases the relative risk of pneumothorax up to 22 times in men. It causes the remodeling of small airways due to the induction of growth factors via increased release of active transforming growth factor-β. This remodeling of the small airways causes alveolar overdistention, which could end in alveolar rupture (Cheng et al., 2009).

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In a patient with hemodynamic instability, the diagnosis of tension pneumothorax is carried out clinically. The most common symptoms are shortness of breath and chest pain that can radiate to the ipsilateral shoulder. On physical examination, an increase in respiratory rate, asymmetric chest expansion, decreased tactile fremitus, hyperresonant sounds on percussion, and decreased breath sounds could be found (Roberts et al., 2015). Patients with tension pneumothorax should receive emergency treatment through needle thoracocentesis without waiting for chest X-ray results (Chong et al., 2016). However, suppose the patient's hemodynamics are stable, and a chest x-ray can be performed immediately. In that case, a radiological examination may be performed first to prevent morbidity due to pneumothorax decompression (Sharma & Jindal, 2008). In this case, the patient was diagnosed with tension pneumothorax based on the findings in the history taking and physical examination and supported by radiological findings. The patient's history revealed that the patient had severe shortness of breath accompanied by left-stabbing chest pain. On physical examination, the patient was found to have decreased breath sounds, decreased expansion, and hyperresonant on percussion of the left hemithorax, accompanied by a shift of the mediastinum to the right. These findings are supported by a chest X-ray showing an avascular lucency in the left hemithorax with left lung collapse and mediastinum shift to the right. A radiological examination was carried out because the patient is hemodynamically stable, and the chest X-rays can be done immediately while preparing for emergency treatment.

After ensuring a secure airway, the subsequent treatment for tension pneumothorax is adequate oxygenation and immediate decompression of the pneumothorax. Decompression with needle thoracocentesis can be performed quickly and easily in pre-hospital and during resuscitation. The latest Advanced Trauma Life Support (ATLS) guidelines recommend initial management of tension pneumothorax with needle thoracocentesis at the 4th or 5th ICS in the anterior to the midaxillary line (American College of Surgeons Committee on Trauma, 2018). Other guidelines, such as the Faculty of Pre-hospital Care of the Royal College of Surgeons of Edinburgh, still recommend needle decompression at the 2nd ICS in the midclavicular line (Leech et al., 2017). The choice of needle thoracocentesis location at the 5th ICS on the anterior axillary line is considered safer. The ATLS guidelines recommend it because the fatty tissue on the area is sparse and to avoid large muscles. However, this location can increase the risk of lung damage in a supine patient because air collects at its highest point and increases the risk of injury to the heart when using a long needle in the left hemithorax. In addition, several studies have shown that in obese and overweight patients, the chest wall at the 5th ICS anterior to the midaxillary line is thicker than the 2nd ICS in the midclavicular line (Azizi et al., 2021; Yehia Elhariri, Mohamed, AS Burud, & Elhariri, 2019). Several studies have reported that needle thoracentesis has a failure rate of up to 80%, possibly due to insufficient catheter length or kinking of the catheter. If the tension pneumothorax does not resolve with a needle thoracocentesis, the patient should be decompressed immediately with a tube thoracostomy (Kaserer, Stein, Simmen, Spahn, & Neuhaus, 2017). The needle decompression performed on the patient of this case report did not resolve the tension pneumothorax, as seen from the evaluation 30 minutes after the procedure. Therefore, a chest tube insertion was carried out immediately afterward.

Chest tube insertion is the definitive treatment of pneumothorax. A chest tube is required

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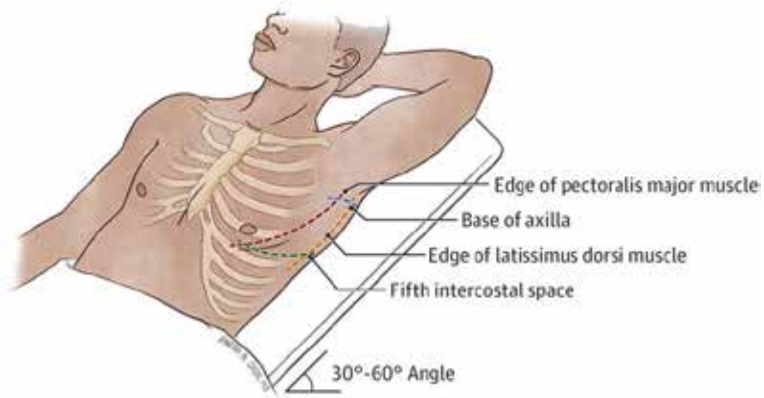

Figure 4. The safety triangle of chest tube insertion (Anderson et al., 2022)

for primary spontaneous pneumothorax not responding to needle aspiration, large (>50%) secondary spontaneous pneumothorax, and tension pneumothorax. In the emergency room setting, it can be done as the primary or second-line treatment if needle decompression fails to improve the pneumothorax. The chest tube is usually inserted in an area under the axilla called the "safety triangle", where internal organ damage can be avoided (Figure 4). It is located in the midaxillary line with the arm fully abducted. The anterior border is formed by the lateral edge of the pectoralis major, the posterior border is formed by the lateral edge of the latissimus dorsi, and the inferior border is formed by the fifth intercostal space (Anderson, Chen, Godoy, Brown, & Cooke, 2022; Ritchie, Brown, & Bowling, 2017)

There are two basic techniques to insert a chest tube: the trocar and non-trocar. The non-trocar technique included the standard procedure, employing blunt dissection to access the pleural space, and the Seldinger technique, which uses serial dilatation over a guide wire. These two non-trocar techniques are associated with a lower rate of intrathoracic organ injury than the trocar technique. (Kuhajda et al., 2014). Even with its potential complications, the trocar technique is still effective at the hands of experienced surgeons familiar with chest wall anatomy. One randomized prospective study reported that a combination technique consisting of blunt dissection into the pleural space followed by the use of a trocar to direct the chest tube was as safe as and even more effective than the standard blunt dissection technique (Dural, Gulbahar, Kocer, & Sakinci, 2010). Furthermore, using a blunt-tip trocar resulted in fewer complications than a sharp-tip trocar in a randomized prospective study of cadavers (Ortner et al., 2012). In this case, the chest tube insertion was carried out by a combination technique of blunt dissection followed by a blunt-tip trocar-guided tube insertion. No intrathoracic complication was found after the procedure.

The chest tube may be connected to a one-way valve system, which allows air to escape but not back into the chest. In the simplest one-bottle system (**Figure 5A**), the end of the chest tube is submerged under a water level, acting as a one-way valve. The air in the tube will bubble out and escape into the atmosphere when the patient's pleural pressure exceeds the water level. Meanwhile, when the patient takes a breath, the submerged end of the chest tube ensures that the negative intrapleural pressure sucks no additional air into the pleural cavity. More complex underwater seal drainage systems with two, three, or more reservoir chambers connected to suction are also used

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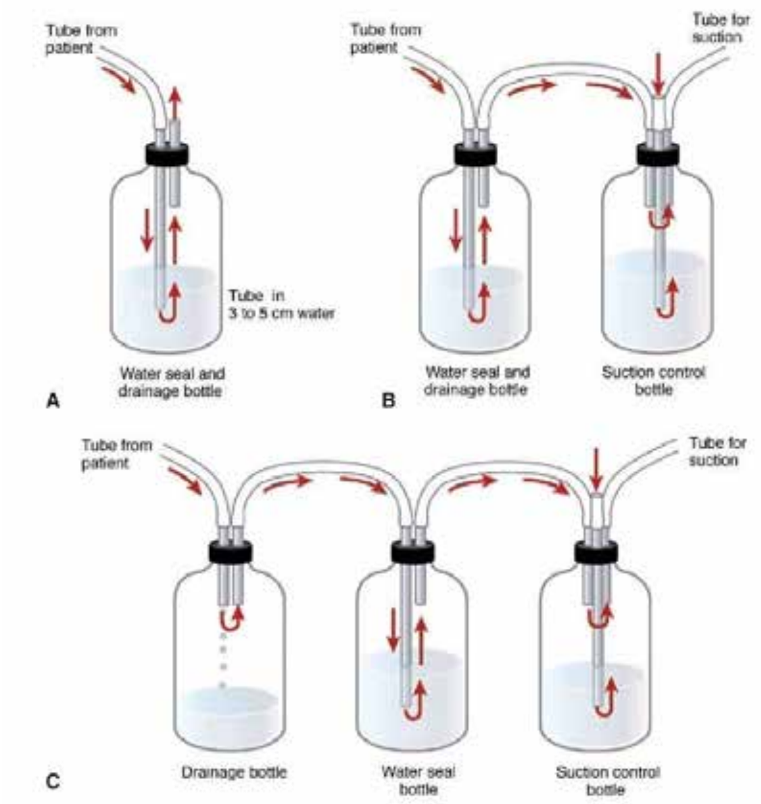

Figure 5. Types of underwater seal drainage systems used in chest tube insertion (Al Dameh et al., 2015)

(**Figure 5B-C**) (Al Dameh, Lebenthal, & McNamee, 2015). The chest tube is maintained until no air is seen for a particular period, but no more than two days, and it is confirmed that the lungs are fully inflated on a chest X-ray (Stawicki et al., 2014). Chest tube placement, in this case, was maintained until the fourth day of hospitalization, as clinical improvement was already obtained.

If the air leak continues after chest tube insertion, the patient might require further medical or surgical intervention. The surgical intervention includes video-assisted thoracoscopic surgery (VATS) with pleurectomy and pleural abrasion or chemical pleurodesis and open thoracotomy with pleurectomy. The medical option for intervention is chemical pleurodesis, which uses a sclerosant inserted through the chest tube to adhere the visceral pleura to the parietal pleura (Ritchie et al., 2017; Zarogoulidis et al., 2014).

CONCLUSION

A thorough physical examination, supported by a chest x-ray in a stable patient, can lead to a definitive diagnosis of tension pneumothorax. Early diagnosis and prompt treatment may help reduce the high mortality of tension pneumothorax. A chest tube insertion in the 5th ICS in the anterior axillary line should be performed when a needle decompression fails to improve the patient's clinical condition.

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