



Acute Hemothorax Secondary to Chest Tube-Related Diaphragmatic Injury in a Patient with Traumatic Liver Laceration

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Despite its many benefits, there are several potentially significant complications inherent to chest tube insertion (CTI), a commonly used invasive procedure to evacuate air or fluid from the pleural space. The average rate of complications following CTI ranges from 5% to 10%, whereas insertion-related complications are rare. Here, we present the case of a 45-year-old female suffering from a motor vehicle accident who developed Grade IV liver laceration complicated with intra-abdominal hemorrhage and right-sided fractures from the fourth to the ninth rib. Misplacement of the preventive CTI for potential hemopneumothorax during the first attempt was observed by computed tomography and simultaneously led to diaphragmatic penetration. Subsequently, massive bloody pleural effusion from the abdominal cavity through the defect in the right hemidiaphragm was noted through a newly inserted chest tube when the patient coughed due to endotracheal suctioning. This case illustrates the significance of identification of patients at high risk for complications related to CTI and the utility of ultrasound guidance during CTI.

Key words: Hemothorax, chest tube insertion, iatrogenic diaphragmatic injury, intra-abdominal hemorrhage

INTRODUCTION

Chest tube insertion (CTI), i.e. tube thoracostomy, is a commonly used invasive procedure that is designed for evacuation of air or fluid from the pleural space to restore homeostasis of intrathoracic pressure, maintain intrathoracic volume for lung expansion, and monitor possible intrathoracic bleeding.¹⁻⁴ Nevertheless, there are several potentially significant complications inherent in CTI. Herein, we present the case of a 45-year-old female suffering from a motor vehicle accident who developed Grade IV liver laceration complicated with intra-abdominal hemorrhage and right-sided fractures from the fourth to the ninth rib, which required preventive CTI for potential hemopneumothorax. In the emergency department, misplacement of the chest tube during the first insertion attempt, which was observed by computed

tomography (CT), led simultaneously to diaphragmatic penetration. When the patient received endotracheal suctioning and had a significant cough reflex in the surgical intensive care unit (SICU), massive bloody pleural effusion was drained from the chest tube newly inserted under ultrasound guidance. The current case highlights the significance of potential CTI-related complications, identification of high-risk patients, and utility of ultrasound-guided CTI.

CASE REPORT

The current patient provided informed consent for anonymized reporting of the clinical details. A 45-year-old female (height, 159 cm; weight, 58 kg; and body mass index, 22.9 kg/m²) with a history of left-sided modified

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radical mastectomy for breast cancer presented to the emergency department due to blunt thoracic and abdominal injury resulting from a motor vehicle accident. Endotracheal intubation and large-bore central venous catheterization for prompt resuscitation were rapidly performed because of altered consciousness (Glasgow Coma Scale: E1M4V2) and declining blood pressure. Chest X-ray revealed right-sided fractures from the fourth to the ninth rib [Figure 1]. Thus, preventive CTI for potential hemopneumothorax was performed with traditional landmark-guided blind technique, and approximately 300-ml bloody fluid was drained. Brain CT showed no early signs of intracranial hemorrhage; however, abdominal CT revealed Grade IV liver laceration with hemoperitoneum. Furthermore, misplacement of the inserted chest tube at sixth intercostal space, which passed from the right pleural space through the diaphragm into the perihepatic space, was also noted in the CT images [Figure 2]. The chest tube was promptly removed, and the second CTI was performed under ultrasound guidance with a 12-to 4-MHz linear array transducer (Sparq Ultrasound System, Philips Healthcare, Andover, MA, USA). The probe was initially placed in the midaxillary line over the fifth intercostal space. At this location, the inflated lung was identified by the presence of comet tail artifacts and confirmed with M-mode. The ultrasound probe was moved inferiorly, and the interface of normal lung was identified. Then, we moved the probe further inferiorly to ensure an adequate distance from the diaphragm to proceed CTI. The procedure was uneventful, and only 50-ml bloody discharge was evacuated.

The patient with relatively stable vital signs was transferred to the angiography procedure room for transarterial embolization due to moderate contrast extravasation from an inferior branch of right hepatic artery. She was then admitted to the SICU for subsequent monitoring and care after

transarterial embolization. However, massive bloody pleural effusion of approximately 2000 ml was drained from the chest tube following a coughing episode related to endotracheal suctioning by an intensive care nurse at the time of arrival to the SICU. Due to possible rupture of the intrathoracic vessels, emergent surgical intervention with video-assisted thoracic surgery was performed. Initially, massive blood accumulation was observed in the right pleural cavity; however, there were no obvious active sites of bleeding in the chest wall or the pulmonary parenchyma. Instead, a defect in the right hemidiaphragm with passage of blood from the abdominal cavity was noted [Figure 3]. Iatrogenic injury due to CTI was clinically diagnosed, and the diaphragmatic defect was closed with primary sutures. Due to adequate fluid resuscitation and blood transfusion, there were no catastrophic hemodynamic events during surgery. The patient received multidisciplinary care, gradually recovered, and was discharged without obvious sequelae after 42 days of hospitalization. Her 1-month follow-up was uneventful.

DISCUSSION

The average rate of complications following CTI varies from 5% to 10%,¹⁻⁴ whereas immediate complications during the insertion are rare.^{1,4} In addition, the cumulative rates of early (≤ 24 h) and late (>24 h) complications following CTI are approximately 3% and 8%, respectively.^{1-3,5} Common CTI-related complications in the early period are drainage malposition and pneumothorax, whereas those in the late period include tube dislodgement, kinking, and infection.^{2,5}

The fifth intercostal space is usually regarded as the lowest safe space on the lateral chest wall for CTI.^{2,6} However, Bowness *et al.*⁶ demonstrated that the skin mark for CTI was

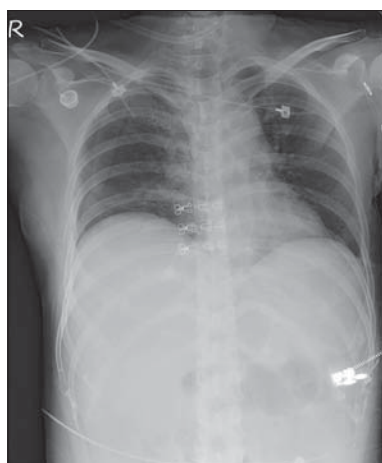


Figure 1: Right-sided fractures from the fourth to the ninth rib, with increasing interstitial markings



Figure 2: Grade IV liver laceration with hemoperitoneum complicated with chest tube insertion from the right pleural space into perihepatic space (arrow)

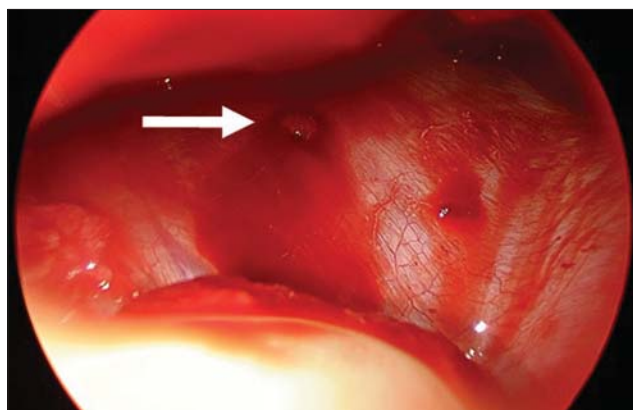


Figure 3: A defect (arrow) on the right hemidiaphragm with passage of blood from the abdominal cavity

significantly more likely to locate the sixth intercostal space or below in women when the horizontal level of the nipple is used to identify the fifth intercostal space and therefore risked causing lower or even subdiaphragmatic drain insertion. Once malposition of the chest tube, especially its lower placement,² developed, it may result in dysfunction, laceration, or perforation of the diaphragmatic muscle.¹⁻³

The reported incidence rate of CTI-related direct diaphragmatic injury ranges from 0% to 0.67%.^{4,7} Although the incidence of diaphragmatic injury is very low, several conditions may increase the risk for this serious complication. During full expiration, the diaphragm rises as high as the fourth intercostal space,³ and incorrect placement may occur even if CTI is inserted in a standard intercostal level. Primary diaphragmatic dysfunction, paralysis, or hernia may also increase the risk of CTI-related diaphragmatic injury.¹⁻³ The trocar technique was reported to be associated with a higher risk of diaphragmatic injury in patients with CTI in lower intercostal levels,^{1,2} and blind CTI should be avoided in patients with a history of intrathoracic surgery, scarring, and pleurodesis.¹⁻³ Moreover, intra-abdominal neoplasms, massive ascites, obesity, and late pregnancy, which can increase intra-abdominal pressure (IAP) and lead to diaphragmatic elevation, are regarded as risk factors.¹⁻³ In the current case, the elevated diaphragm caused by hemoperitoneum might have resulted in the insertion-related diaphragmatic injury following CTI that was placed at a lower position. Subsequently, an abrupt increase in IAP associated with the cough reflex might have worsened the already elevated IAP due to intra-abdominal hemorrhage, forcing blood within the peritoneal cavity to enter the pleural space through the diaphragmatic defect.

Patients with the above-mentioned risk factors may require exhaustive imaging studies before CTI, and real-time ultrasound-guided insertion can improve safety and ensure correct chest tube position despite an elevated diaphragm.^{3,6}

Ultrasonography has several practical advantages, including easy availability, allowable real-time interpretation, and guidance for CTI.⁸ Although patient-related limitations, such as obesity and the presence of subcutaneous emphysema, may exist, ultrasonography is a useful, safe, and practical tool for CTI in patients with thoracic trauma. Since soft-tissue landmarks have been shown to hold a variable relationship to underlying bony structures, real-time ultrasonography can be used to confirm the intercostal space during CTI.⁶ Nonpulmonologists have been reported to have the ability to perform ultrasound-guided thoracic procedures with similar complication rates as pulmonologists.⁹ In addition, the increased safety of ultrasound-guided CTI even in patients with significant coagulopathy, such as those receiving clopidogrel therapy, was reported.¹⁰ Therefore, appropriate training in thoracic ultrasonography is necessary for medical personnel involved in emergencies and in the care of patients with thoracic disease.

In cases where ultrasonography may not be available immediately, percutaneous and blunt dissection methods usually provide better control of the tube placement and are the preferred approaches for blind CTI.^{1,2} The trocar puncture technique is associated with a greater risk of iatrogenic injury and is thereby not a preferred procedure.^{1,3,4} During blunt dissection, the practitioner should perform a finger sweep within the thoracic cavity to confirm pulmonary adhesion to the chest wall before introducing the chest tube. If a lower tube position is required to achieve drainage, more care should be taken to avoid diaphragmatic damage during placement or tube misplacement in the abdomen.² To confirm the correct position and prevent complications related to possible injury to the anatomic structures in proximity to the tube, chest radiography following the procedure is mandatory. Furthermore, review of both the preprocedural and postprocedural radiographic images for significant differences or abnormalities is another crucial step.^{2,3} Prompt recognition and tube repositioning can result in limited damage and improve outcomes in cases of tube malposition.

CONCLUSION

CTI is a life-saving and widely used approach in many medical, surgical, critical, and emergency care specialties. Utilization of the chest tube based on appropriate indications, selection of optimal tube size, and proper CTI are important. Due to the invasive approach, clinicians should be vigilant in prevention and recognition of many potential complications associated with CTI. During the decision-making for CTI, identification of patients with risk factors is critical to minimize the incidence of tube misplacement and diaphragmatic injury.

Moreover, the use of ultrasonography has been demonstrated to reduce the risk of errors in CTI, especially when a lower tube position is desired.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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