Common Procedure-related Complications in the ICU: A Pictorial Review

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Abstract

Several medical procedures are performed daily in the intensive care unit (ICU), and it is evident that complications still occur frequently and are potentially life-threatening. We believe that the best way to prevent the occurrence of procedure complications is to learn from the experience of others. We present this image-based review of common procedure-related complications and hope to alarm the clinicians to early identify and manage these complications. These cases have been collected from the ICU in a tertiary care teaching hospital in order to demonstrate this image-based review of common procedure-related complications. Here we introduce these procedure complications with regard to most common support and monitoring devices used in the ICU, including intravenous catheter, nasogastric tube, endotracheal tube, central venous catheter, hemodialysis double-lumen catheter, chest tube, and Sengstaken–Blakemore tube. Procedure complications involving critically ill patients are common and often potentially life-threatening. Decreasing the frequency of procedure-related complications is an important and direct way to improve medical quality. Understanding their incidence, causes, risk factors, diagnosis, management, and prevention are helpful in damage control. (J Intern Med Taiwan 2013; 24: 453-460)

Key Words: Complication; Medical procedure; Intensive care unit; Radiography

Introduction

The Institute of Medicine's report "To Err Is Human" is alarming with regard to its content–medical errors.[1] Critical care presents substantial patient safety challenges, and critically ill patients require high-intensity care and may be at considerable risk of iatrogenic injury because of the severity of their illness and the frequent need for high-risk interventions.[2] Several medical procedures are performed daily in the intensive care unit (ICU), and it is evident that complications resulting from these procedures still occur frequently and are potentially life-threatening, despite the attendance of relatively senior and experienced physicians and medical staff in the critical care setting. These complications may result from inadequate knowledge of anatomy, inadequate training or experience, urgent performance, exhausted personnel, or the severity of the patient's condition.

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Materials have been collected from the ICU in a tertiary care teaching hospital in order to demonstrate this image-based review of common procedure-related complications. Here we introduce these procedure complications with regard to most common support and monitoring devices used in the ICU, including intravenous catheter, nasogastric tube, endotracheal tube, central venous catheter, hemodialysis double-lumen catheter, chest tube, and Sengstaken–Blakemore tube. This review not only describes these images but also discusses the incidence, causes, risk factors, diagnosis, management, and prevention of the above complications.

Text

Several medical procedures are performed daily in the ICU, and complications resulting from these involving critically ill patients are common and often life-threatening. Radiographic evaluation is important because potentially serious complications are often not clinically apparent. Although mechanical procedure complications have been identified, we should become proactive in implementing damage control at the earliest opportunity.

Intravenous Catheter

Almost all patients admitted to the ICU receive intravenous catheter (IC) at least once for fluid supplementation, intravenous medication administration, or other purposes. The most common complications are infiltration, extravasation, occlusion, phlebitis, and bacterial colonization. The overall complication rate has been reported to be 10%-20%.[3,4]

Extravasation injury occurs when fluid from an IC leaks into the surrounding tissues or other extravascular space. Tissue damage occurs as a result of differences in physiochemical characteristics, including pH, osmolarity or toxicity, between the extravasate substance and the host tissue.[5] Extravasation of contrast medium (Figure 1a) is not an infrequent complication of enhanced imaging studies, and large-volume extravasation may result in severe damage (eg. extensive tissue necrosis, severe skin and subcutaneous ulceration, etc.). Risk factors include patient factors, contrast media type and volume, and injection technique.[6] In some reports, the frequency of extravasation with mechanically driven injection varies from 0.2% to 0.4%.[7-9] Conservative management is effective in most cases. It may be beneficial to ensure the correct location and functioning of the catheter before commencement of injection, and to use plastic catheters for mechanically driven injection.

Nasogastric Tube

The nasogastric (NG) tube is a device inserted into the gastrointestinal tract for feeding, gastric decompression, or medication administration. The ideal position of the tip is beyond the cardia but still within the stomach. Tube malposition is the most common complication, including displacement of the tube into the respiratory tract (Figure 1b), incomplete insertion and displacement of the tube coiling within the esophagus or hypopharynx (Figure 1c). Other conditions may embrace tube-induced perforation, rupture of the tube within the gastrointestinal tract and massive aspiration. The overall complication rate has been reported to be 1.3%-7.6%.[10,11] With the patient endotracheally intubated, incorporated or with anatomic defects, the procedure becomes more difficult to perform correctly. The traditional methods of auscultation, bubbling, and litmus paper testing are of limited value to confirm NG tube position; the use of a pH indicator and chest radiography is much preferred. Monitoring and maintaining tube placement is also an important issue.[12]

Endotracheal Tube

Endotracheal intubation is performed to maintain airway patency or provide ventilatory support. The most common complication is malposition,

which has been reported in about 15% of patients undergoing this procedure.[13] The ideal location of the tip of the endotracheal tube (ETT) is approximately 5 cm above the carina. If the location is too high, inadvertent extubation may occur, while if too low, ipsilateral lung overinflation with contralateral collapse is possible (Figure 2a).[14] In patients with trismus or under urgent condition, teeth or dental prostheses aspiration may occur (Figure 2b). Another potentially fatal complication is esophageal intubation. Radiographic points to note are ETT outside the tracheal air column and extending below the carina, and gastric overdistension (Figure 2c).[15] Continuous waveform capnography is now recommended as the most reliable and instantaneous method of confirming and monitoring correct placement.

Central Venous Catheter

Central venous catheters (CVC) are used to provide temporary vascular access for regular blood

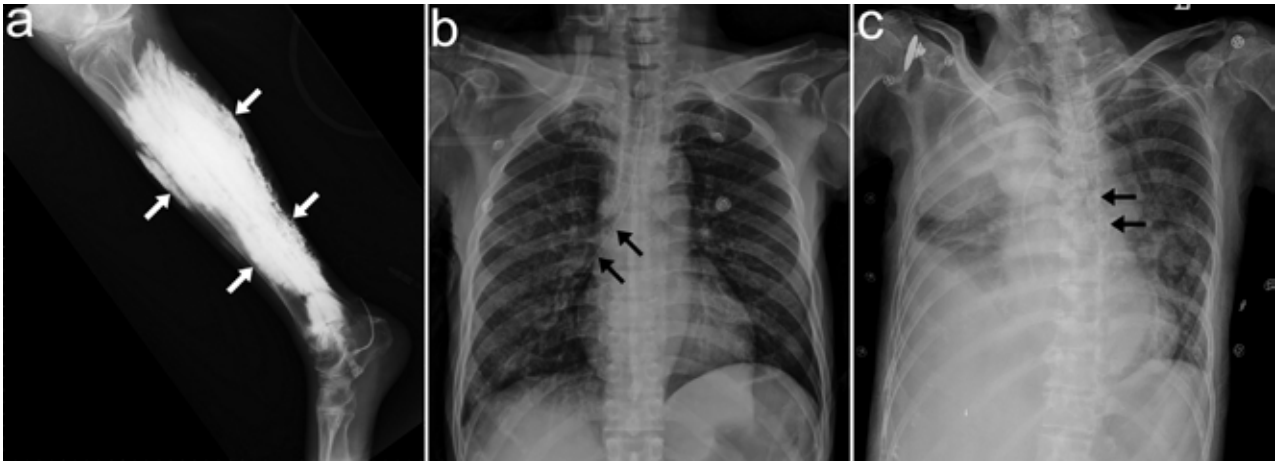

Figure 1. (a) This radiograph shows contrast medium extravasation (arrows) from an intravenous catheter placed in the foot after contrast-enhanced computed tomography (CT). (b) The radiograph shows nasogastric (NG) tube malposition (arrows) in the right bronchus. (c) The radiograph shows the NG tube kinking in a loop (arrows) in the esophagus, resulting in severe pneumonia.

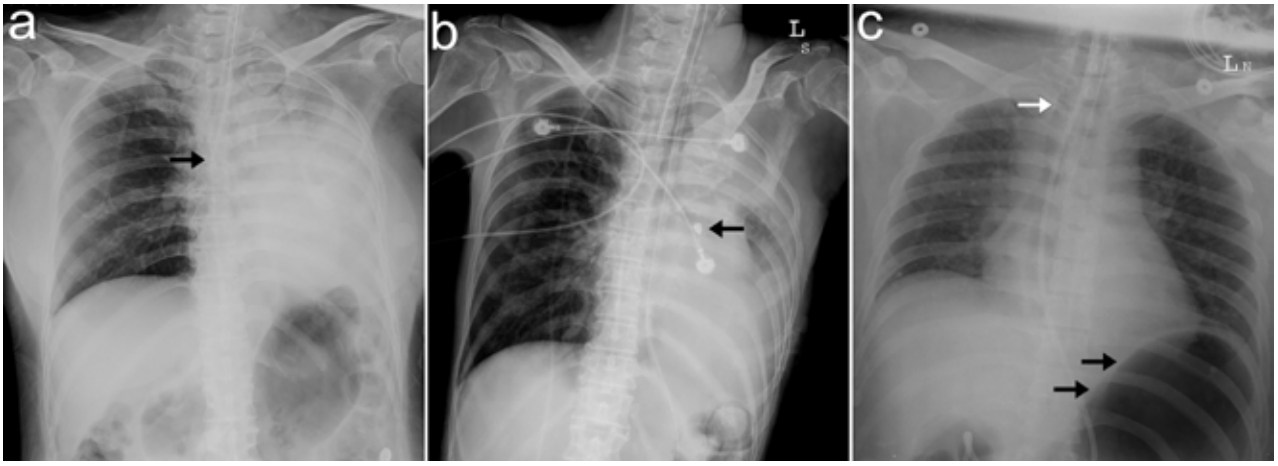

Figure 2. (a) The radiograph shows endotracheal tube (ETT) malpositioning in the right main bronchus (arrow) with total collapse of the left lung. (b) The radiograph shows a tooth impacted in the left main bronchus (arrow) with partial collapse of the left lung after performing endotracheal intubation. (c) The radiograph shows ETT malposition in the esophagus (white arrow represents trachea air column), with an extremely large amount of stomach gas present (black arrows).

sampling, total parenteral nutrition, specific medication administration, fluid management, or hemodynamic monitoring.[16] There are three common venous approaches: internal jugular, subclavian, and femoral. The most common complication is malposition which has been described in up to 40% of CVCs (Figure 3a, 3b).[17] Other insertion complications include bleeding and hematoma (Figure 3c), pneumothorax (Figure 3d), arterial cannulation (Figure 3e), guide-wire retention (Figure 3f), air embolism, arrhythmias, and nerve palsy. Risk factors include previous radiotherapy or surgery at the puncture site, prior cannulation, lack of expertise, obesity, and multiple puncture attempts.[18] There is increasing evidence that ultrasound guidance to aid cannulation can reduce insertion-related complications.[19] The frequency of severe complications with image-guided CVC insertion is reportedly only about 3%.[20]

Hemodialysis Double-Lumen Catheter

Hemodialysis double-lumen catheters (HDLC) are inserted in patients with acute kidney injury or for those requiring long-term dialysis when unstable hemodynamics mandate continuous renal replacement therapy. Catheter type, insertion site, and

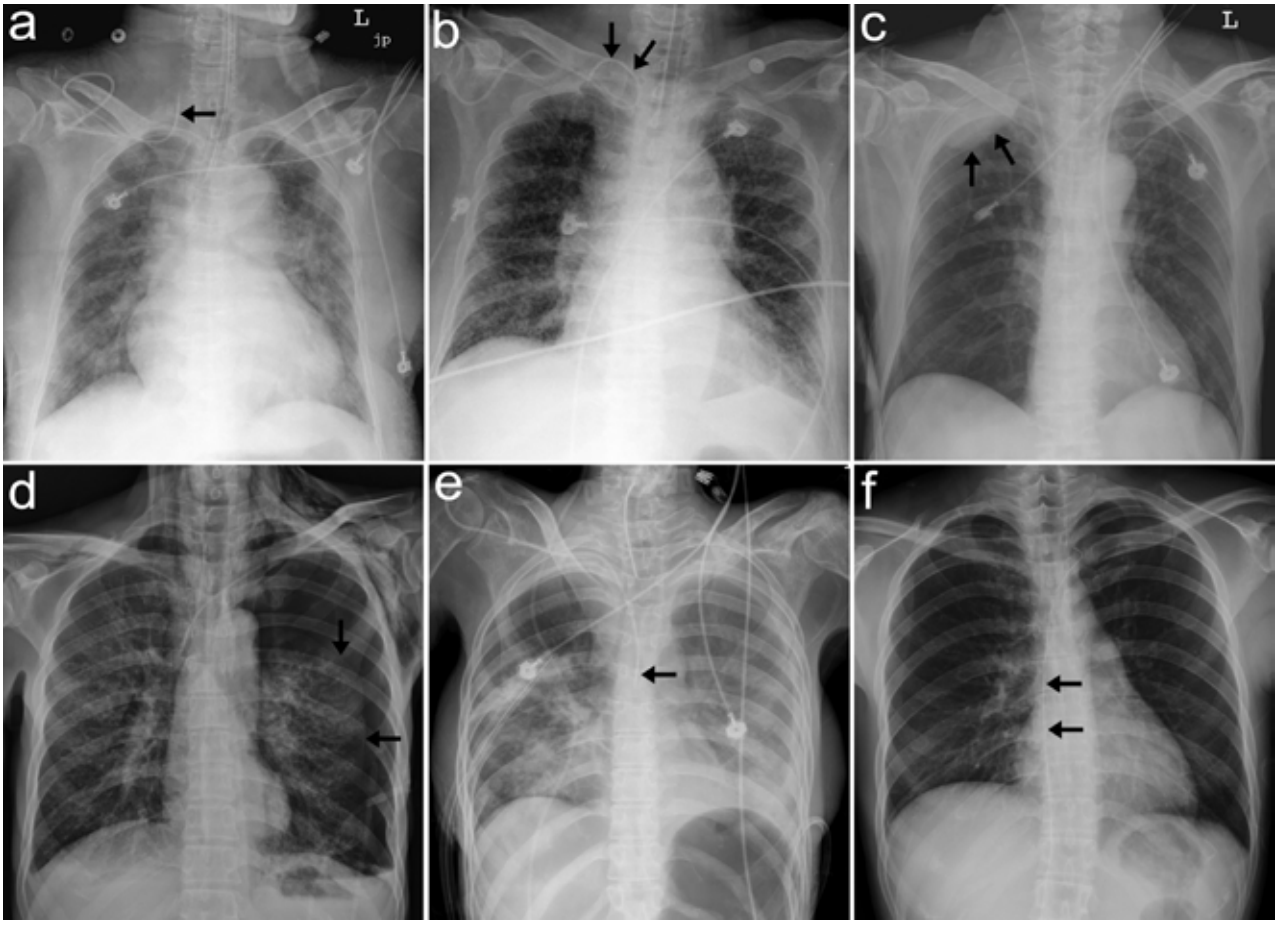

Figure 3. (a) The radiograph shows the tip of the central venous catheter (CVC) reversed into the internal jugular vein (arrow) from its subclavian indwelling position. (b) The radiograph shows CVC malposition in a loop (arrows) from the subclavian indwelling position. (c) The radiograph shows a hematoma (arrows) that had formed following the subclavian approach. (d) The radiograph shows pneumothorax (arrows) and subcutaneous emphysema following the subclavian approach. (e) The radiograph shows arterial cannulation with the tip of the CVC in the central portion of mediastinum (arrow) from a subclavical indwelling position. (f) The radiograph shows there is a guide-wire retention in the inferior vena cava (arrows) after a femoral approach.

maintenance all affect the quality of renal replacement therapy (RRT).[21] The femoral and right internal jugular insertion sites are to be recommended rather than left jugular and subclavian, on the basis of delivering the optimum RRT dose and reducing complications.[22] The major potential complications include catheter-related thrombosis and infection. Subsequent vascular bleeding may occur because of multiple puncture attempts, puncture through the artery, or use of heparin. Fasciotomy should be performed for compartment syndrome (Figure 4a, 4b), and vascular repair may be indicated for severe arterial injury (Figure 4c). To avoid injury to the femoral artery, the thigh should be rotated externally as far as possible during catheter insertion.

Chest Tube

Tube thoracostomy is a procedure used to evacuate fluid or air from the pleural space.[14] Tube malposition is most common and can be classified as intraparenchymal, fissural, chest wall (Figure 5a), mediastinal, and abdominal tube placement (Figure 5b, 5c). Other insertion-related complications include subcutaneous emphysema, nerve injuries, cardiac and vascular injuries, esophageal perforation, and fistula.[23] The overall complication rates have been reported to be 2%-25%.[24] The chest tube should be introduced over the superior margin of the rib to avoid injury to intercostal vessels and nerves. Ultrasound guidance to aid positioning of the indwelling chest tube helps in reducing insertion-related complications. Use of a trocar accompanying the chest tube, directly inserted through the chest wall, may carry a higher complication rate. Conservative treatment may be appropriate for injury to solid organs.

Sengstaken-Blakemore Tube

The management of acute bleeding from esophageal varices consists of volume replacement,

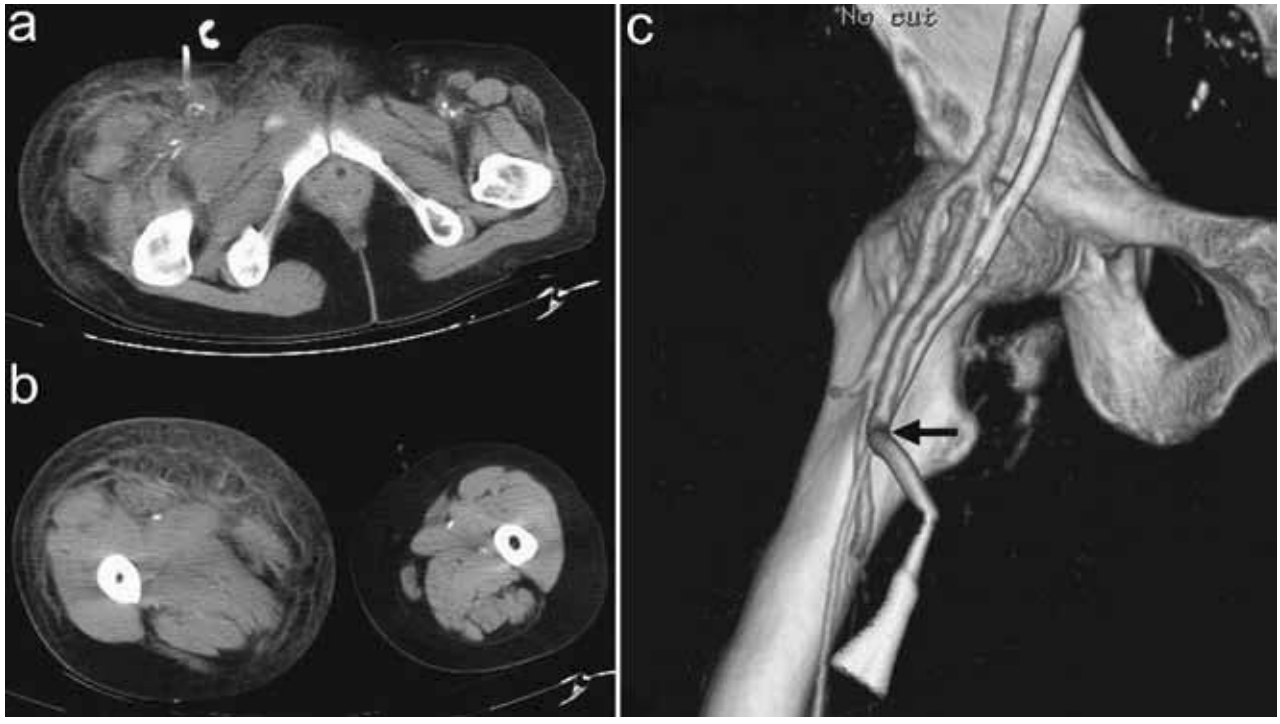

Figure 4. (a, b) The CT scan shows obvious right thigh swelling due to internal bleeding progressing to compartment syndrome after hemodialysis double-lumen catheter (HDLC) insertion using the femoral approach. (c) Reconstruction of the CT scan image reveals that the HDLC has punctured the femoral artery (arrow) and entered the femoral vein.

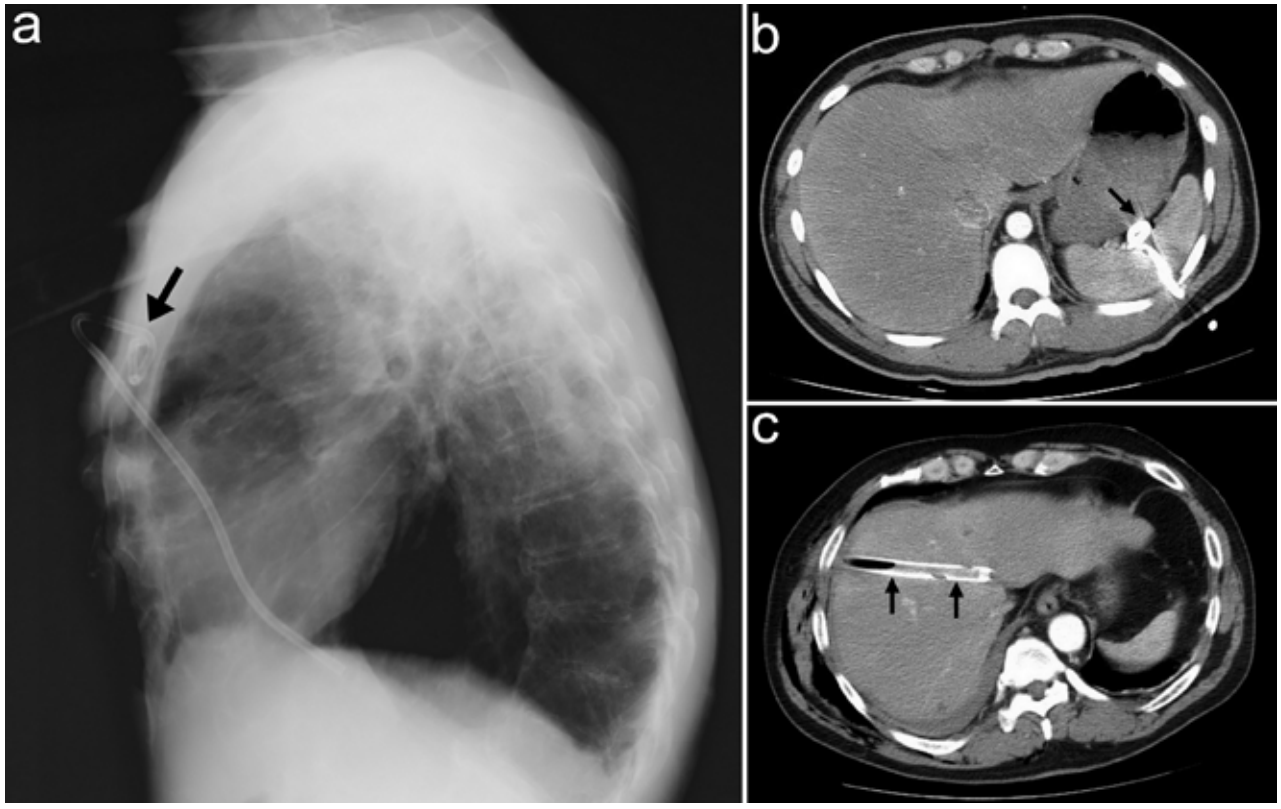

Figure 5. (a) The radiograph shows a pig-tail catheter curled in the chest wall (arrow). (b) The CT scan shows a pig-tail catheter inserted through the spleen (arrow). (c) The CT scan shows a chest tube inserted into the liver (arrows).

pharmacological, mechanical (balloon tamponade), and surgical treatment. The potential complications of Sengstaken-Blakemore (SB) tube therapy include pulmonary aspiration, esophageal perforation, and pressure necrosis of the mucosa.[25] The exact incidence of complications is difficult to determine. Pulmonary aspiration of secretions is the most common complication, occurring in approximately 10%-20% of cases.[26] Among these complications, esophageal rupture due to SB tube misplacement (Figure 6) carries a very high mortality rate from hemothorax or septic mediastinitis.[27] To prevent this severe sequela, confirmation of correct tube placement by auscultation alone is not sufficient. Routine radiography obtained after slight inflation of the gastric balloon to confirm correct tube placement is strongly recommended.

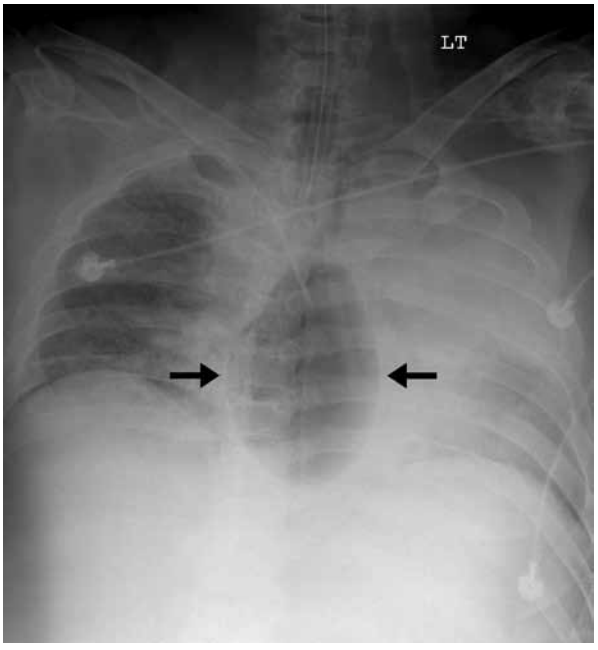

Figure 6. This radiograph shows Sengstaken–Blakemore tube misplacement (arrows) with esophageal rupture and hemothorax.

Conclusion

Procedure complications involving critically ill patients are common and often potentially life-threatening. Decreasing the frequency of these complications is an important and direct way to improve medical quality. We believe that the best way to prevent the occurrence of procedure-related complications is to learn from the experience of others. Understanding their incidence, causes, risk factors, diagnosis, management, and prevention are helpful in damage control.

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在加護病房中常見的醫療技術相關併發症：影像綜論

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摘　要

在加護病房當中，每天都有許多醫療技術被執行。許多證據指出，醫療技術相關併發症仍然時常發生並且有可能危及生命。我們相信防範此事發生的最佳方式，是經由學習他人的經驗並引以為戒。我們發表這篇常見的醫療技術相關併發症-以影像為主之綜論，即是希望提醒臨床醫師能夠早期辨認併發症的發生並及時處理，進而避免併發症的發生。這些病例蒐羅於一家醫學中心的加護病房。我們介紹數種最常見的醫療技術與其相關的併發症，包括：周邊靜脈導管、鼻胃管、氣管內管、中央靜脈導管、血液透析雙腔導管、胸管及森斯塔肯-布萊克莫爾管。於重症病人當中，醫療技術相關併發症的發生是常見且可能致命的。減少這些併發症的發生頻率是促進醫療品質重要且直接的方式。當我們了解併發症的發生率、原因、危險因子、診斷及處置，有助於對損害的控制。更重要的是，我們要能盡力去避免及預防併發症的發生。