Non-Surgical Pneumoperitoneum: Causes and Imaging Findings

Gerta Repečkaitė[1], Tomas Jurevičius[1], Jurgita Zaveckienė[1]

[1] *Department of Radiology of Lithuanian University of Health Sciences Kaunas, Lithuania.*

ABSTRACT

Background: Typically, the presence of air or fluid in the thoracic and abdominal cavities is considered to be of separate origin. However, it is essential to take into consideration that a non-surgical pneumoperitoneum (NSP) may develop without a perforated viscus, and due to thoracic causes, such as mechanical ventilation, cardiopulmonary resuscitation, and pneumothorax. This is important in clinical practice, because exclusion of intestinal perforation alters patient management, and prevents unnecessary surgical interventions.

Aim: This article aims to review the causes and imaging findings of an NSP and present a patient with unilateral tension pneumothorax, pneumomediastinum, pneumoretroperitoneum, subcutaneous emphysema, and pneumoperitoneum, which were not associated with a perforated viscus.

Case report: A 65-year-old male was admitted to the Emergency Department (ED) due to seizures and impaired consciousness. Prior to arrival, the ambulance personnel had intubated the patient. A chest x-ray and chest-abdomen-pelvis CT scan showed a massive left pneumothorax with mediastinal shift to the right, lung collapse, and pronounced bilateral subcutaneous emphysema, a small pleural effusion on the right, an eighth rib fracture on the left, pneumomediastinum, ectopic air in the abdominal cavity, between the muscle/fascia layers, and in the retroperitoneum. A laparotomy and esophagogastroduodenoscopy excluded duodenal and other intestinal perforation. The patient was treated conservatively, and within fifteen days, was discharged home.

Conclusion: In conclusion, attention, critical thinking, and knowledge of atypical causes are crucial when evaluating a patient with pneumoperitoneum, as it may develop without the perforation of a hollow viscus, and may not require surgical treatment.

Keywords: pneumothorax, pneumomediastinum, pneumoperitoneum, pneumoretroperitoneum, subcutaneous emphysema.

INTRODUCTION

Typically, the presence of air or fluid in the thoracic and abdominal cavities is considered to be of separate origin. Trauma, such as rib fracture or a penetrating injury, is a common cause of intra-pleural air, better known as pneumothorax (1). Meanwhile, the presence of pneumoperitoneum is most frequently associated with a perforated hollow viscus (2). Abdominal injury may also be the cause of free air in the peritoneal cavity due to a damaged intestinal wall (3). Non-surgical pneumoperitoneum is defined as free intra-peritoneal air observed during a radiological examination, yet not related to neither a viscus perforation nor to surgical intervention. In clinical practice, however, it is essential to take into consideration that non-surgical pneumoperitoneum (NSP) may develop due to thoracic causes, such as mechanical ventilation, cardiopulmonary resuscitation, and pneumothorax (2). Other typical and atypical causes are listed in Table. The significance of this knowledge relies on the fact that, in the setting of pneumoperitoneum, clinical exclusion of intestinal perforation alters patient management, and prevents unnecessary surgical interventions.

Radiology plays a crucial role in the diagnosis of free intra-abdominal air. Although it is not the most informative imaging modality, a plain X-ray is portable, easily accessible, inexpensive, and, therefore, is usually the first radiological study to evaluate the patient when there is suspicion of pneumoperitoneum (4,5). A left decubitus or upright abdominal X-rays are typically performed, however, even supine, and chest

X-rays are useful and should not be discarded as screening tests (5). Ultrasound and CT have been observed to be far more sensitive and informative when diagnosing the origin of free intraperitoneal air. Nonetheless, CT is currently considered to be the diagnostic gold standard (6,7). All in all, X-ray, sonography, and CT are perhaps not equal yet still essential diagnostic methods that aid in the detection and assessment of pneumoperitoneum and its causes.

This article aims to review the causes and imaging findings of an NSP and present a patient with unilateral tension pneumothorax, pneumomediastinum, pneumoretroperitoneum, subcutaneous emphysema, and pneumoperitoneum, which were not associated with a perforated viscus.

CASE REPORT

A 65-year-old male was admitted to the Emergency Department (ED) due to seizures and impaired consciousness. Prior to arrival, the ambulance personnel had administered medication to stop the seizures and had intubated the patient. During the initial inspection at the ED, the patient was being sedated and ventilated, his blood pressure was 200/120 mmHg, heart rate 120 beats per second, while auscultation and percussion findings suggested pneumothorax on the left. The patient's family members denied trauma, and previous interventions, however, the patient was a known alcohol user, had been diagnosed with epilepsy in the past, and had spent a week prior to hospitalization consuming alcohol.

The patient underwent multiple imaging studies. The findings of a chest x-ray included the following: air in the left pleural cavity, mediastinal displacement to the right, left lung collapse, and bilateral subcutaneous emphysema of the thorax and neck. The end of the endotracheal tube was located in the right main bronchus and, therefore, required correction (Figure 1). A head computed tomography (CT) scan revealed no anomalies. Laboratory tests showed hyperglycemia, hyponatremia, leukocytosis, slightly elevated C-reactive protein (11.6 mg/l), elevated erythrocyte, leukocyte, protein, glucose levels in the urine. The abdominal ultrasound was inconclusive, possibly due to the pneumoperitoneum and/or subcutaneous emphysema. A chest-abdomen-pelvis (CAP) CT scan without intravenous contrast material was performed and confirmed a massive left pneumothorax with mediastinal shift to the right, lung collapse, and pronounced bilateral subcutaneous emphysema, as well as diagnosing a small pleural effusion on the right, pneumomediastinum, ectopic air in the abdominal cavity, between the muscle/fascia layers, the retroperitoneum, and an eighth rib fracture on the left without dislocation (Figure 2, 3).

Because clinical and imaging findings were indicative of a tension pneumothorax, a thoracic surgeon was consulted, and chest drains were inserted into the left pleural cavity.

Later on, a bronchoscopy through the intubation tube was performed. However, the findings were unremarkable.

The patient was moved to the Intensive Care Unit (ICU) for further care, where laparotomy and revision were performed. The surgery confirmed to air in the peritoneal cavity. However, excluded intestinal perforation, which led to the belief that the origin of pneumoperitoneum might have been the tension pneumothorax and massive subcutaneous emphysema. The patient's condition improved following drainage tube insertion, chest X-ray showed a decreased left pneumothorax, and he was extubated the very same day (Figure 1). Due to suspicion of retroperitoneal duodenal perforation, an esophagogastroduodenoscopy was performed. Nonetheless, only a diaphragmatic hernia was diagnosed. Although the abdominal X-ray was not repeated, the patient's clinical condition continued to improve, the drainage tubes were removed on the fourteenth day of hospitalization, the subcutaneous emphysema had disappeared, and no signs of pneumoperitoneum or pneumothorax were observed in the last chest X-ray (Figure 1). After fifteen days, the patient was discharged home.

Table. Most common causes of pneumoperitoneum (2,3,21).

PNEUMOPERITONEUM CAUSES			
Related to hollow viscus perforation (85 - 95%)	**Iatrogenic perforation**	**Spontaneous**	**Traumatic**
	Surgery	Ulcer perforation	Blunt/penetrating trauma that results in hollow viscus perforation
	Endoscopy	Bowel obstruction	
	Feeding tube placement	Intestinal ischemia, necrotizing enterocolitis	Miscellaneous
	Gynaecologic manipulations	Various inflammatory conditions: appendicitis, diverticulitis, etc.	Foreign bodies
	Peritoneal dialysis	Toxic megacolon	Ruptured pneumatosis cystoides intestinalis
	Respiratory resuscitation		
Non-surgical pneumoperitoneum (5 - 15%)	**Pseudoperitoneum**	**Abdominal**	**Thoracic**
	Chilaiditi's syndrome	Surgery: open or laparoscopic	Mechanical ventilation
	Hollow viscera overdistention	Peritoneal dialysis	Pneumothorax
	The air between soft tissue wrinkles	Endoscopic procedures	Cardiopulmonary resuscitation
	Gas within lesions	Enteromesenteric emphysema causes	
	Subphrenic fat pad		
	Linear lung atelectasis		
	Gynaecologic	**Miscellaneous**	
	Coitus, orogenital sex, vaginal douching	Drug use (cocaine)	
	Exercises following labour	Scleroderma	
	Pelvic inflammation	Diving with decompression	
	Gynaecologic manipulations	Tooth extraction	

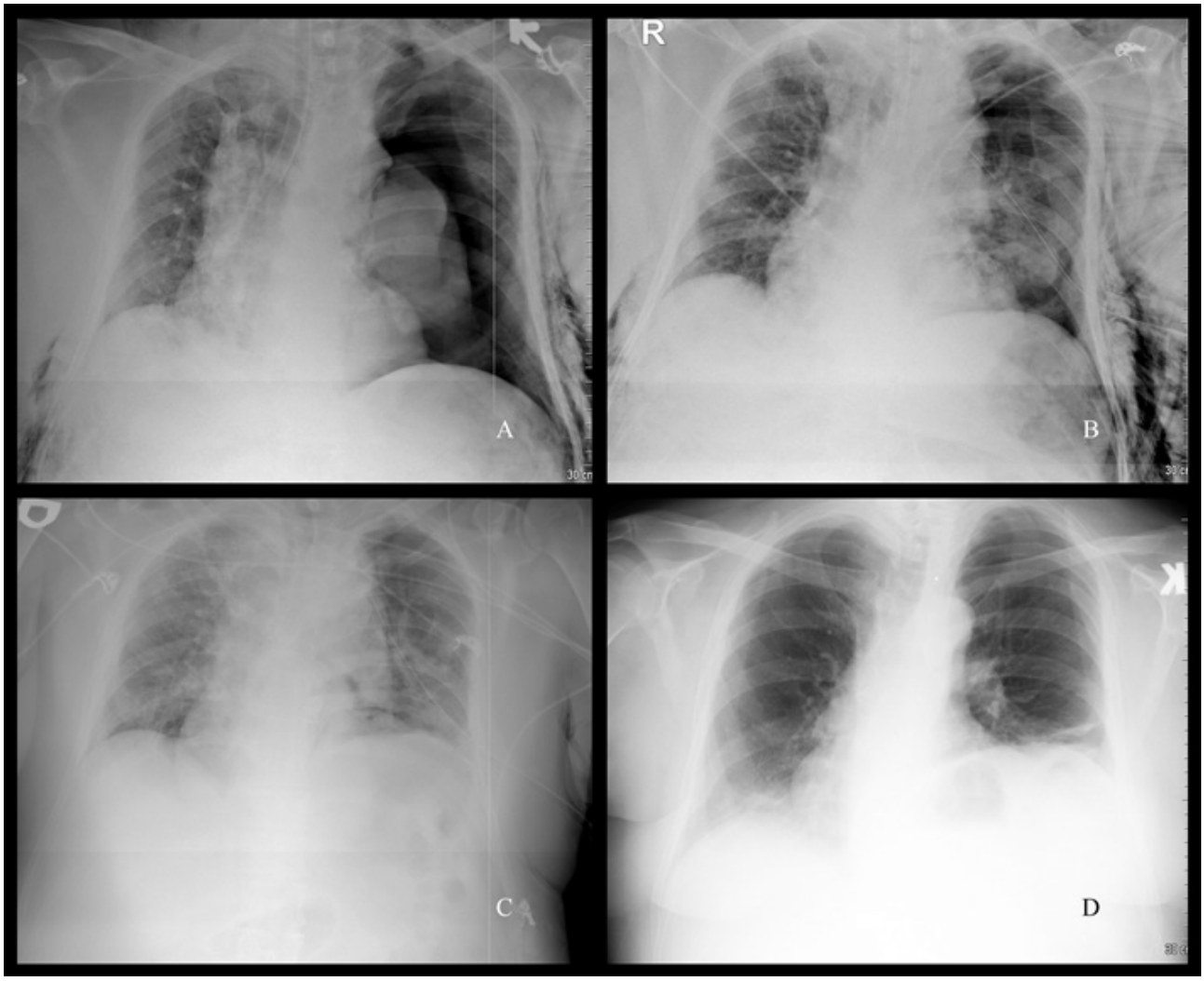

Figure 1. A, B, C - supine, C - erect chest X-rays. A - upon arrival: the patient is rotated to the right, left pneumothorax, collapsed left lung, pronounced subcutaneous emphysema, and endobronchial intubation; B - following drainage: drainage tubes have been inserted into the left pleural cavity, the amount of air has decreased, the left lung has expanded, the endotracheal tube's placement has been corrected; C - after extubation: the left pneumothorax and subcutaneous emphysema have decreased; D - fifteen days after hospitalization: the drainage tube has been removed from the left pleural cavity, a discoid atelectasis and minimal pleural effusion can be seen on the left.

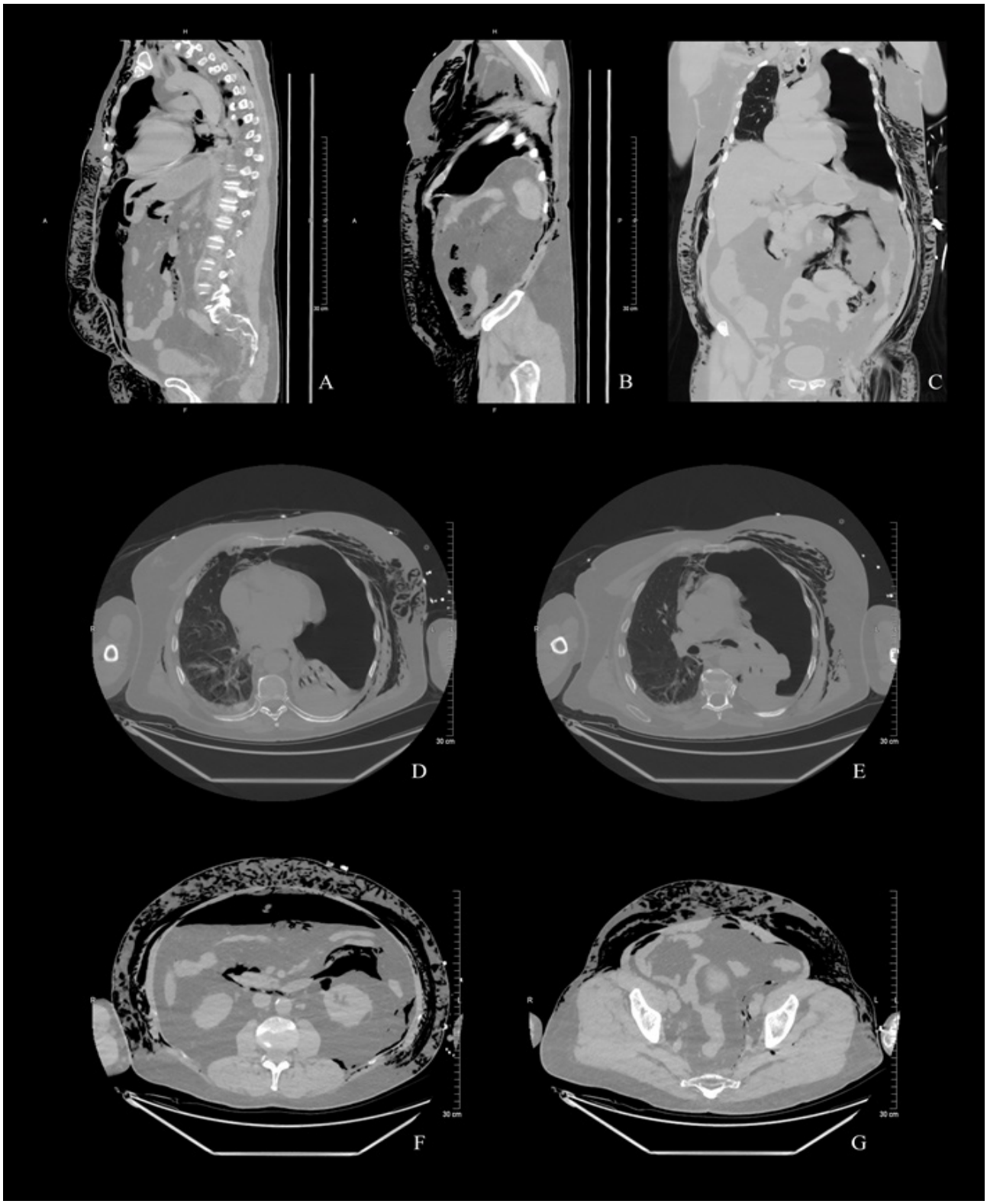

Figure 2. Chest-abdomen-pelvis CT scan findings. A, B - sagittal reconstructions; C - coronal reconstruction, D - G axial view: massive left pneumothorax with left lung collapse and mediastinal dislocation to the right, pleural effusion on the right, pneumomediastinum, pneumoretroperitoneum, pneumoperitoneum, subcutaneous emphysema.

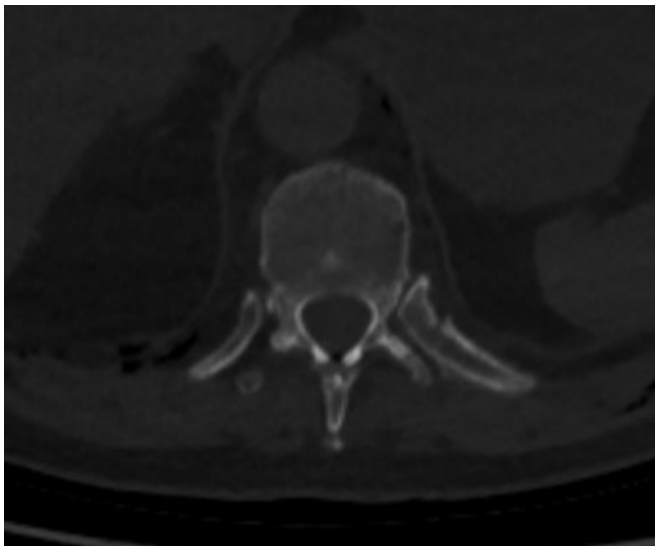

Figure 3. CT scan, axial. Fracture of the left eight rib without dislocation.

DISCUSSION

In the presented case, one of the more probably pneumothorax causes is the fracture of the left eight rib. However, multiple factors may cause doubt. First of all, the patient was a known alcoholic diagnosed with epilepsy. Therefore, we cannot exclude the possibility that the fracture may have occurred before the pneumothorax. Secondly, there was no dislocation and very little air within the soft tissues surrounding the fractured rib (Figure 3), while the amount of air in the pleural, abdominal, and other bodily cavities, as well as the soft tissues, was considerable (Figure 2). Finally, the patient's clinical condition and the chest X-rays greatly improved following the drainage and cessation of mechanical ventilation, which leads to the conclusion that the pneumothorax and the NSP could have developed due to barotrauma.

As mentioned previously, the patient had been intubated by the ambulance personnel. Therefore, the subsequent mechanical ventilation could have been complicated by the following conditions: a tension pneumothorax, pneumomediastinum, and later on - pneumoretroperitoneum and pneumoperitoneum. It has been reported that mechanical ventilation is the most common cause of iatrogenic pneumothorax in the ICU (8). Moreover, there are documented cases of intubation and mechanical ventilation related to thoracoabdominal ectopic air conditions (9–14).

In the presented case, although the patient was hemodynamically stable upon admission, the free air in the peritoneum may have developed consequently to the left tension pneumothorax. The increased intrathoracic pressure was a potentially life-threatening condition and could have progressed to a quick and severe cardiopulmonary collapse, mainly due to the patient's ventilatory status (15–17). However, the presence of intra-abdominal air without any abnormal surgical and imaging findings was suggestive of a potentially lifesaving air dissection from the thorax. Pneumoperitoneum associated with pneumothorax is rare, however, not unheard of. There are two mechanisms of intra-pleural air drainage into the abdominal cavity: the first is via mediastinal perivascular connective tissues or diaphragmatic connections to the retroperitoneum and peritoneum; while the second is directly through pleuro-diaphragmatic defects (2). Such etiopathogenesis of intra-abdominal air should be considered whenever clinical, and laboratory findings are not suggestive of peritonitis.

Free air in the peritoneum is not always indicative of visceral perforation, as is clearly illustrated by the reviewed case. Clinical and imaging data that should provoke suspicion of NSP are as follows: the lack of peritoneal irritation, the presence of a pneumothorax, and the absence of intra-peritoneal effusion (18–20). X-ray and CT findings cannot be evaluated separately from clinical and laboratory data when determining the best treatment approach (3,18–20). Nonetheless, conservative treatment should be accompanied by careful observation, as a deteriorating condition and signs of tension pneumoperitoneum would determine the need for emergency surgery, even in the setting of an NSP (14).

In conclusion, attention, critical thinking, and knowledge of atypical causes are crucial when evaluating a patient with pneumoperitoneum, as it may develop without the perforation of a hollow viscus, and may not require surgical treatment. The presence of pneumothorax and the absence of clinical/objective data indicative of peritoneal irritation should arouse suspicion of an NSP. The responsibility to consider an unusual origin of pneumoperitoneum falls on clinicians, radiologists, and surgeons alike. Therefore, a multidisciplinary approach is essential when optimizing patient management.

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