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# Traumatic Rib Fractures Complicated by Extensive Subcutaneous Emphysema: Is the Macklin Effect the Culprit?

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## Abstract

Subcutaneous emphysema is a recognised complication of blunt thoracic trauma and most commonly occurs at the time of injury due to disruption of the pleura or alveoli from rib fractures. This case highlights that delayed progression remains uncommon and unpredictable. A 47-year-old man presented following a fall, sustaining multiple right-sided rib fractures, and was initially clinically stable. Approximately 72 hours after admission, the patient developed sudden and rapidly progressive subcutaneous emphysema with facial, chest, abdominal, and scrotal swelling, dysphonia, and increasing oxygen requirements. CT imaging at the time revealed the development of extensive subcutaneous emphysema, pneumomediastinum, and new bilateral pneumothoraces. The patient was managed with bilateral chest drain insertion, and over the following days, clinical stabilisation and gradual radiological improvement were achieved. Our findings highlight the potential for delayed and sudden deterioration following blunt chest trauma and the potential limitations of early clinical stability in predicting disease progression.

**Categories:** Trauma, General Surgery
**Keywords:** blunt thoracic trauma, delayed subcutaneous emphysema, hemopneumothorax., pneumomediastinum, pneumothorax, rib fractures, subcutaneous emphysema

## Introduction

Subcutaneous emphysema is a common complication in patients with rib fractures and/or pneumothorax resulting from blunt thoracic trauma [1]. In most patients, subcutaneous emphysema is diagnosed promptly and resolves with conservative treatment. However, this complication may have a delayed onset, making it difficult to predict.

Subcutaneous emphysema refers to the presence of air within the subcutaneous tissues and most commonly arises secondary to trauma, thoracic surgery, or invasive airway procedures. In blunt chest trauma, it typically results from alveolar or pleural disruption, allowing air to dissect along fascial planes into the chest wall, neck, and face [1,2]. In most cases, subcutaneous emphysema is mild and self-limiting and resolves with conservative management of the underlying cause. However, in rare instances, it may progress rapidly and extensively, possibly leading to airway compromise, dysphonia, or respiratory distress [1]. These patients require high-flow oxygen to help promote the resorption of subcutaneous air and chest drain insertion to relieve the symptomatic impact of the subcutaneous emphysema and prevent further clinical deterioration [2-6]. The severity and delayed onset of subcutaneous emphysema can be unpredictable, highlighting the importance of ongoing monitoring in patients with thoracic injuries despite initial clinical stability.

Early clinical stability and reassuring initial imaging do not exclude subsequent clinical deterioration. This case study illustrates the unpredictable course of complications that may follow blunt chest trauma by presenting a patient who experienced extensive subcutaneous emphysema and bilateral pneumothoraces approximately 48 hours after an initially stable presentation.

## Case Presentation

A 47-year-old man presented to the emergency department by ambulance after falling 10 steps down a staircase while under the influence of alcohol.

Initial assessment and trauma CT imaging revealed multiple right-sided rib fractures alongside a small haemopneumothorax secondary to the rib fractures.

The CT thorax highlighted fractures of the lateral and posterior aspects of the right eighth rib and the posterior aspect of the right ninth rib, as well as a subtle fracture of the anterior aspect of the right sixth rib.

Mild subcutaneous emphysema was noted. These injuries resulted in a Rib Injury Score (RAS) of 15, which signifies moderate injury and required referral to the pain team, physiotherapists, and general surgeons according to the local hospital protocol.

The patient experienced significant pain during deep inspiration and was unable to cough effectively due to the rib fractures. He was reviewed by the anaesthetic team for pain management and followed hospital protocol given his RAS score. Although an ESP block was recommended by the anaesthetic team, the patient initially preferred to trial patient-controlled analgesia (PCA) due to the extent of his injuries. At the time, the patient's prescribed analgesia included intravenous paracetamol, oral ibuprofen, a 5% lidocaine plaster, PRN codeine, and PCA opioid analgesia. Despite these measures, pain control remained suboptimal; the patient was unable to take deep breaths or cough due to ongoing chest pain, and on day 2 of admission, a right-sided ESP block was performed.

On day 3 post-admission, a chest X-ray was performed to monitor the progression of the haemopneumothorax. At that time, the patient's observations were stable; he required no supplemental oxygen, and lung markings were present on the right side. Slight subcutaneous emphysema was noted (Figure *1*), consistent with the findings on the initial trauma CT scan (Figure *2*). However, the patient reported new-onset scrotal swelling.




**FIGURE 1: Initial X-ray on admission showing mild right-sided subcutaneous emphysema (black arrow).**



**FIGURE 2: Initial trauma CT following X-ray, consistent with steady improvement (arrow).**

Three days after admission, a medical emergency call was activated on the ward due to rapid-onset facial and chest swelling. Nursing staff reported the progression of swelling over approximately 20-30 min, involving the right chest, left periorbital region, and scrotum. The patient developed marked facial swelling with distended facial veins, preventing him from opening his eyes. At this time, the patient had an oxygen requirement of 4 L/min to maintain an oxygen saturation of 95%. On examination, air entry was difficult to auscultate on the right side; however, the trachea remained central, and there was no clear evidence of respiratory distress or signs of angioedema or rash.

A portable chest X-ray obtained at the time of the medical emergency demonstrated extensive subcutaneous emphysema, which had progressed rapidly compared with prior imaging (Figure *3*). Repeat CT of the thorax with oral contrast was performed for comparison and to exclude oesophageal rupture or worsening pneumothorax. The CT thorax showed extensive subcutaneous emphysema extending from the chest wall into the neck and inferiorly into the abdominal region, marked pneumomediastinum, and mild to moderate bilateral pneumothoraces, with no evidence of oesophageal rupture. Additional findings included right lower lobe consolidation and collapse, left basal atelectasis, and multiple right-sided rib fractures involving ribs 6 to 9, in keeping with previous imaging (Figures *4*-*5*). Therefore, pneumoperitoneum was interpreted as air progressing through the diaphragmatic hiatus.

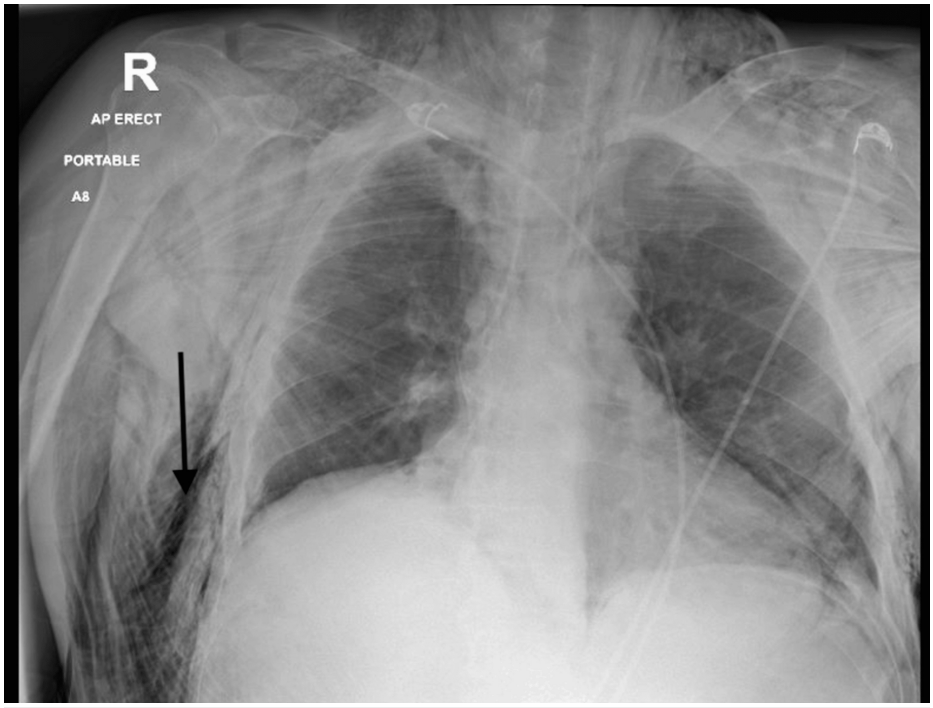



**FIGURE 3: Repeat portable semi-erect anteroposterior (AP) X-ray after a medical emergency call showing extensive subcutaneous emphysema throughout the chest and extending up the neck.**

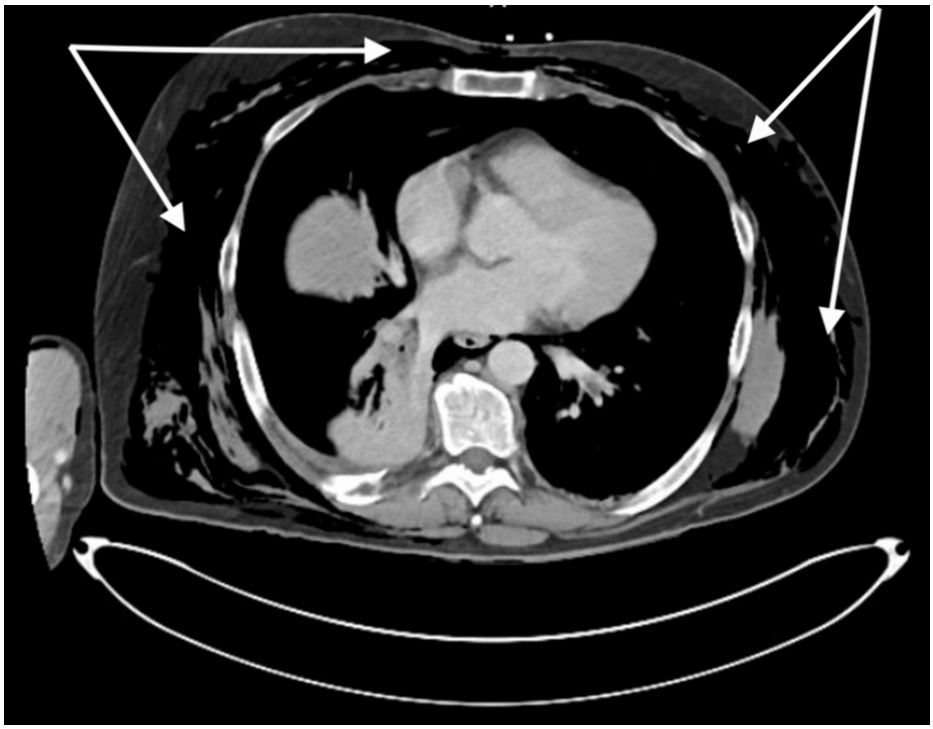


**FIGURE 4: CT scanogram showing extensive subcutaneous emphysema very well (arrows).**

Subcutaneous emphysema, pneumomediastinum, and bilateral pneumothoraces are shown, along with right-sided lateral sixth and seventh rib fractures.

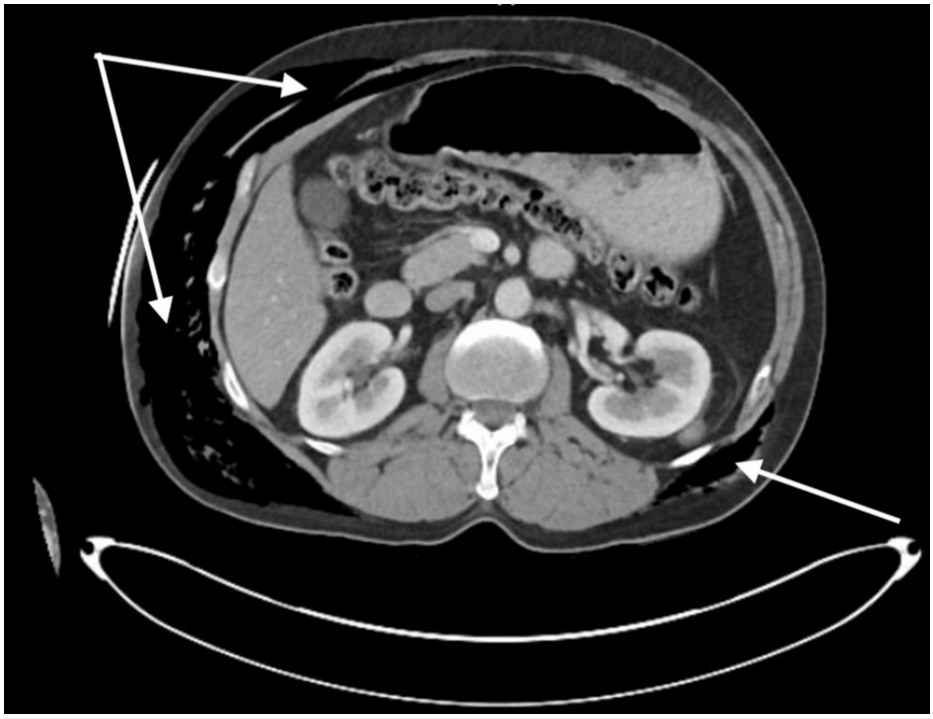


**FIGURE 5: CT scanogram showing further extensive abdominal pneumoperitoneum (arrows).**

Subcutaneous emphysema continued to progress, with extensive swelling extending to the chest, neck, and periorbital region, associated with dyspnoea and dysphonia. Therefore, given the ongoing clinical deterioration, the patient was taken to the theatre for insertion of bilateral 20-Fr chest drains.

After chest drain insertion, facial swelling persisted; however, the patient appeared clinically more comfortable. On initial examination, there were no signs of airway compromise, oxygen saturation remained stable at 94%-96% on 4-5 L of oxygen, and the patient's dyspnoea improved.

On day 6, repeat chest radiography demonstrated extensive subcutaneous emphysema, pneumomediastinum, and multiple rib fractures, consistent with previous imaging. No gross pneumothorax or mediastinal shift was identified, and bilateral chest drains remained in situ. Comparison with prior imaging showed no significant interval changes.

The cardiothoracic team advised continuing conservative management after remote review, which included optimisation of analgesia, saline nebulisation, chest physiotherapy, and continued monitoring for any progression of the subcutaneous emphysema. On day 7, the left chest drain was removed, and a subsequent chest radiograph showed no increase in subcutaneous emphysema (Figure *6*).




**FIGURE 6: Chest X-ray with a right-sided drain showing an expanded lung (arrow).**

On day 9, the in-hospital respiratory team reviewed the patient face to face and advised ongoing observation of the right chest drain while bubbling and swinging persisted. At this stage, subcutaneous emphysema had significantly improved. The plan was to obtain a chest X-ray once the right drain stopped swinging and/or bubbling and, if radiological resolution was demonstrated, the drain could be removed. On day 10, the right intercostal chest drain was removed, and a post-removal chest X-ray showed no evidence of lung collapse or pneumothorax and no acute changes compared with previous imaging. Subcutaneous emphysema remained visible but was significantly improved (Figure *7*).

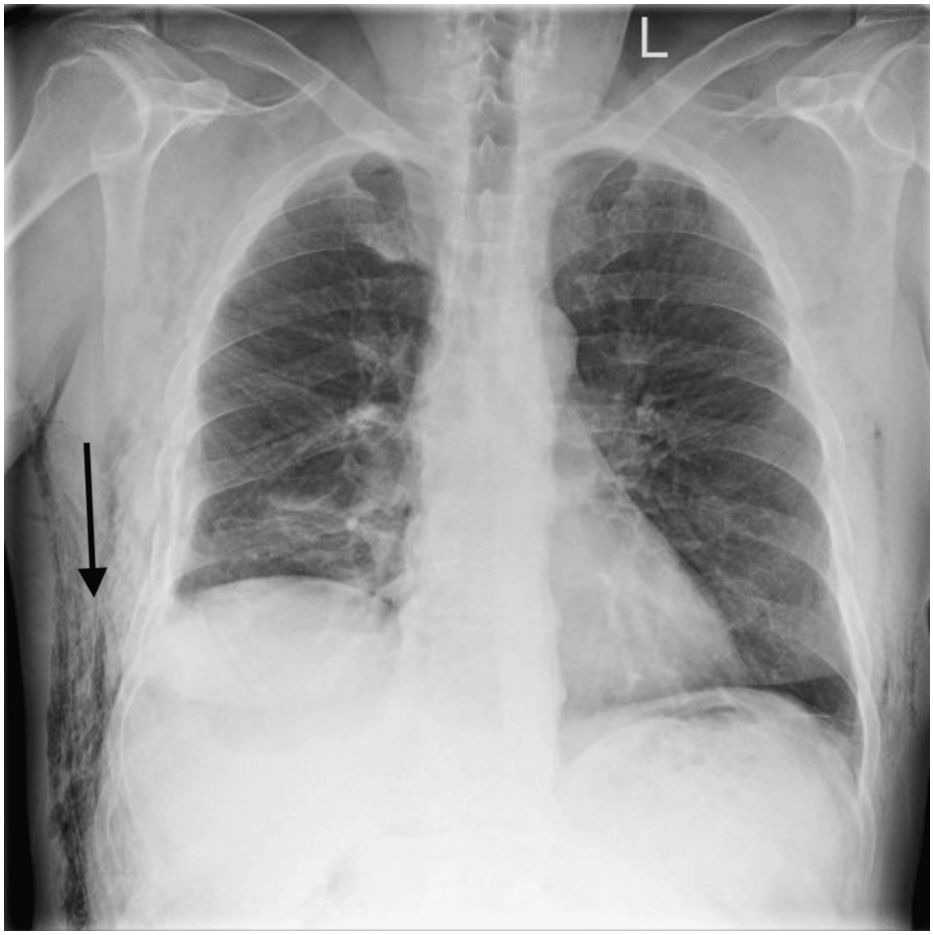



**FIGURE 7: Chest X-ray post chest drain removal.**

The arrow indicates the residual subcutaneous emphysema as it resolves.

By day 11, the patient's observations were stable, and he was asymptomatic. Sutures were removed, and the patient was discharged home in a stable condition with oral analgesia and no formal follow-up.

## Discussion

Subcutaneous emphysema is the accumulation of air beneath the dermis. When the accumulation of air beneath the dermal layer of the skin becomes symptomatic, such as causing dyspnoea, dysphonia, and palpebral closure, it is referred to as massive or extensive subcutaneous emphysema [2]. The severity of symptoms depends on the amount of trapped air [1]. As in this patient, who initially presented with mild subcutaneous emphysema and was clinically stable but then deteriorated with sudden massive emphysema, increasing oxygen requirements, dysphonia, and discomfort.

It can occur secondary to spontaneous pneumothorax, traumatic pneumothorax (blunt or penetrating trauma), or infection. It is commonly associated with pneumothorax, as it is a recognised complication of it [2-4,6-8]. This could be explained by the rib fractures the patient sustained after falling down the stairs.

In certain instances, subcutaneous emphysema can also present with pneumomediastinum. This can be due to perforation of a hollow organ, such as the oesophagus, or to the Macklin effect [6]. The Macklin effect was first described in 1939; ruptured alveoli secondary to trauma or an increased pressure gradient across the alveoli lead to leakage of air from the alveoli into the extra-alveolar space. The air subsequently follows the bronchovascular tracts or pericapillary pulmonary interstitial space and enters the mediastinum. The air in this space then dissects across the fascial planes to the cervical and peritoneal/retroperitoneal spaces via the diaphragmatic hiatus [1,7-10]. Although there is no definitive evidence that the emphysema was due to the Macklin effect, this does not rule it out as a cause. Alternatively, the rib fractures likely caused alveolar/pleural injury, resulting in a sustained air leak that persisted over the following days, entered the mediastinum, and then spread further.

The major concern in such a presentation is airway compromise, followed by cardiovascular compromise

[2,8]. Therefore, it is crucial to be aware of the presentation, its cause, and its mechanism of action because, although subcutaneous emphysema is a benign condition [1,3,4,11], the possible association with pneumothoraces significantly increases the risk of rapid deterioration and the development of life-threatening complications, such as tension pneumothorax, leading to airway compromise.

Clinical signs include visible swelling, reduced breath sounds, and crepitus on palpation of the affected body [3,8,11]. The patient's condition could be mistaken for anaphylaxis on initial observation [12]. Swelling was widespread in this patient, with abdominal, thoracic, cervicofacial (including palpebral closure), and scrotal crepitus. The optimum imaging modality to identify pneumothorax and subcutaneous emphysema is a CT scan, which can identify small pneumothoraces and emphysema that could otherwise be missed by chest radiography [3]. Therefore, it is crucial to follow up an X-ray with a CT scan to identify the cause of a presentation of massive subcutaneous emphysema when the initial workup is inconclusive.

In addition to immediate-onset subcutaneous emphysema, there is evidence of delayed-onset massive subcutaneous emphysema in the literature. Some case reports attribute the delayed onset to sudden spikes in intrathoracic pressure, such as coughing, sneezing, and straining, against a background of existing thoracic trauma [13]. As in this patient, who developed extensive subcutaneous emphysema with bilateral pneumothorax numerous days after admission, this challenges the notion that emphysema usually occurs at the time of trauma, as noted in multiple other case reports.

There are currently no established guidelines for the management of extensive subcutaneous emphysema; however, there are numerous case reports with recommendations according to the respective setting, including targeting the underlying cause; high-flow oxygen to aid subcutaneous oxygen resorption [6]; angio catheters; subcutaneous catheters; incisions; and chest drains [2-4,6,8]. Approaches vary depending on the cause of subcutaneous emphysema and pneumothorax, whether spontaneous or secondary [11]. As in this patient, who developed pneumothorax and subcutaneous emphysema secondary to rib fractures [9], the initial aim was to manage the rib fractures and conservatively manage the emphysema. In this case report, the indication for inserting bilateral chest drains was increasing dyspnoea, dysphonia, and visible discomfort [2].

However, there is no concrete threshold for when to intervene in patients with emphysema. In the absence of a clear cause of the air leak, this would raise concern about airway compromise and require urgent treatment.

### Learning outcomes

Subcutaneous emphysema can have a delayed onset following blunt thoracic trauma, such as rib fractures. CT imaging is the preferred imaging modality during the initial workup of patients suspected of having subcutaneous emphysema. Subcutaneous emphysema is commonly associated with pneumothorax. Important differentials, such as anaphylaxis (which has a similar presentation) or oesophageal perforation (a potential source of air leakage causing pneumomediastinum), need to be excluded.

## Conclusions

Delayed presentations of extensive subcutaneous emphysema, pneumomediastinum, and pneumoperitoneum are possible in the presence of thoracic trauma. It can present similarly to anaphylaxis because swelling can spread rapidly after onset. It is vital to differentiate between the two, as any delay in decision-making increases the risk to the patient. Rapid decision-making and management in a controlled environment, such as a hospital, can greatly improve treatment outcomes compared with those for patients who present from home.

## Additional Information

### Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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**Acquisition, analysis, or interpretation of data:** Montasir Ismail, Adegoke Ijanusi, Karim Sillah, Ali Yasen Mohamedahmed

**Drafting of the manuscript:** Montasir Ismail, Leena Medani

**Critical review of the manuscript for important intellectual content:** Montasir Ismail, Adegoke Ijanusi, Karim Sillah, Ali Yasen Mohamedahmed

**Supervision:** Karim Sillah

## Disclosures

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