Case report

Bilateral Re-Expansion Pulmonary Oedema– When the Cure Is Worse Than the Disease

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ABSTRACT

Background: Re-expansion pulmonary oedema is a potentially fatal consequence of rapid re-expansion of a lung, which has been collapsed due to a pleural effusion or a pneumothorax.

Case Report: We report a very unusual case in which the patient initially developed ipsilateral followed by contralateral pulmonary oedema following rapid drainage of a massive pleural effusion. The patient's condition deteriorated rapidly and on the third day following admission, her condition proved fatal. In addition a literature review is presented.

Conclusion: It is essential that doctors appreciate the importance of gradual re-expansion of a lung, which has been collapsed for a few days or longer and take appropriate precautions in order to minimize the likelihood of developing re-expansion pulmonary oedema.

Key words: pulmonary oedema, re-expansion, pleural effusion, pneumothorax.

Re-expansion pulmonary oedema (RPE) can occur when re-inflation of a collapsed lung, following large pneumothorax or massive pleural effusion, occurs rapidly and can prove fatal[1,2]. We report the case of a 45-year-old female who presented with a massive pleural effusion, with significant mediastinal deviation to the left side, for which a chest drain was inserted. Following uncontrolled drainage of a large volume of pleural fluid she developed bilateral re-expansion pulmonary oedema, which ultimately proved fatal. This case highlights the importance of controlled re-expansion of a large pneumothorax or pleural effusion and the early symptoms suggestive of RPE.

CASE PRESENTATION:

A 45-year-oldfemale presented to our Emergency Department (ED) with a four-week history of non-productive cough, increasing shortness of breath, poor appetite, dysphagia and weight loss. She did not complain of chest pain, palpitations or fever. A background history of liver cirrhosis, oesophageal varices and duodenal ulcer secondary to excess use of alcohol was noted. Medications included spironolactone, lactulose, thiamine and propranolol.

On examination the patient was cachectic. Her vital signs revealed marked hypotension, blood pressure of 77/55mmHg, pulse 80 beats per minute, respiratory rate 22 breaths perminute, temperature 36.4 Celsius and oxygen saturation was 95% while breathing room air. Respiratory examination revealed markedly reduced air entry on the right side, displacement of the trachea and apex beat to the left with stony dullness to percussion. Ascites with an 11cm splenomegaly was detected on abdominal examination. No hepatomegaly was noted and the patient did not exhibit any features of encephalopathy.

Investigations:

Routine bloods on admission revealed impaired renal function, urea 11.2mmol/L (2.5-6.5mmol/L), creatinine 125mmol/L

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(46-92µmol/L), hypokalaemia 2.3mmol/l (3.5-5.0 mmol/L), deranged liver function, GGT 567 IU/L (0-51IU/L), alkaline phosphatase 164 IU/L range 44-147IU/L), and onset of coagulopathy (INR 1.3). Full blood count was normal, (Haemoglobin 11.0g/dL, WCC 9.73 and platelets 221). Chest x-ray revealed a massive right-sided tension hydrothorax with a considerable degree of displacement of the trachea and mediastinum towards the left side (Figure 1). There was no evidence of myocardial infarction on serial ECGs or cardiac enzymes (Troponin I).

Treatment:

1500 ml of straw-coloured fluid was aspirated, which resulted in considerable improvement in her symptoms. Repeat chest x-ray showed that the trachea and mediastinum had returned to their normal position (Figure 2). The following day an intercostal chest drain was inserted and 2500 ml of straw-coloured fluid drained extremely quickly before the drain could be clamped. The patient complained of severe central chest pain during

this period of rapid drainage. While the drain was being secured it dislodged and needed tobe reinserted. As a result, a pneumothorax, with associated subcutaneous emphysema, was noted on the

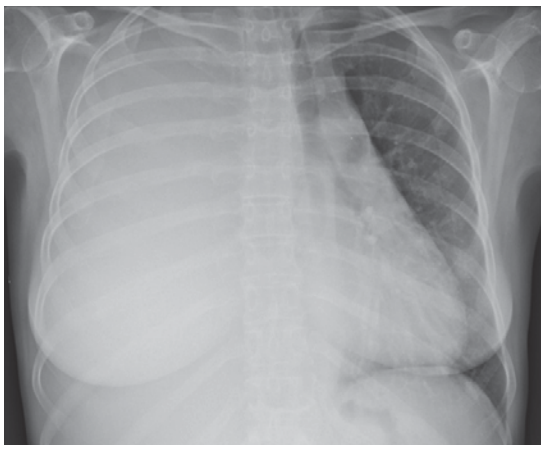

Figure (1): Massive right sided pleural effusion with tracheal and mediastinal displacement to the left side.

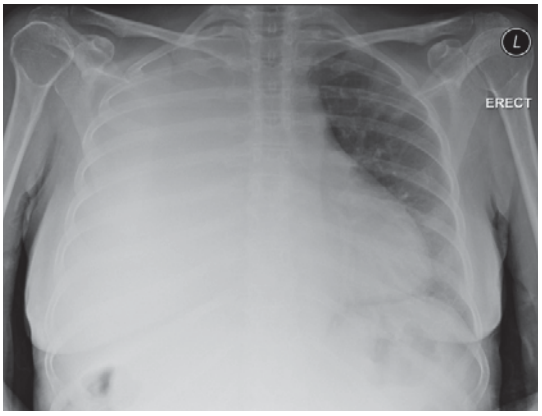

Figure (2): Erect chest x-ray following drainage of 1500ml pleural fluid. Tracheal displacement has resolved. Nopneumothorax is seen.

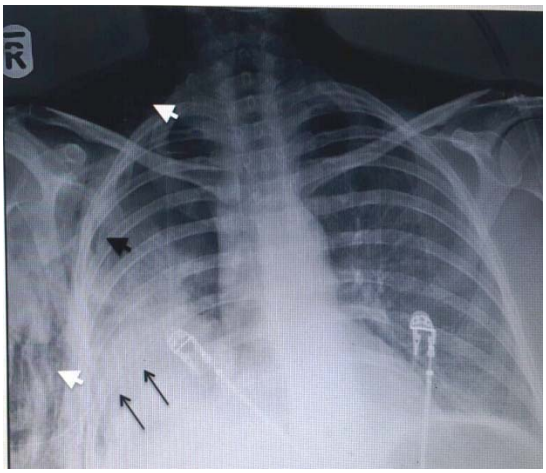

Figure (3): Right sided pneumothorax (black arrow head), subcutaneous emphysema (white arrow head), and chest drain (thin black arrow) with marked reduction in pleural effusion. Gastric distension also evident.

right side of the chest x-ray. (Figure 3) We estimated that between 3L and3.5L of fluid in total drained over 20 to 30 minutes.

Despite appropriate and timely management, the patient's condition rapidly deteriorated. She developed acute respiratory distress manifested by tachypnoea, respiratory rate 32 breaths per minute, increased work of breathing and reduced oxygen saturations, 88%, while breathing room air. Over the course of the next few hours she developed increasingly more severe pulmonary oedema

in the right lung and to a lesser extent in the left lung (Figures 4). The true extent of pulmonary oedema is clearly visible on thoracic CT scan (Figure5).

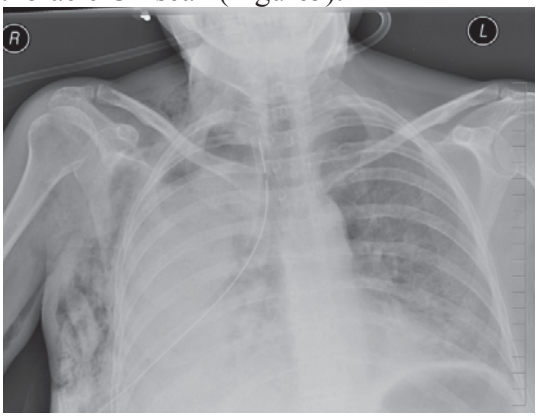

Figure (4): Increasing amount of pulmonary oedema, more marked on the right. Right-sided pneumothorax also present. Subcutaneous emphysema extending down right arm and also right side of the neck.

The patient was transferred to the intensive care unit where she was intubated and ventilated (Figure 6). Despite volume expanders and inotropic support, she remained persistently hypotensive with her systolic blood pressure less than 60mmHg. She developed acute renal failure, coagulopathy and anaemia, haemoglobin fell from 11.0g/dl on admission to 6.9g/dl, secondary to an upper gastrointestinal bleed. The patient failed to respond to treatment and on the third day following admission sadly, she died.

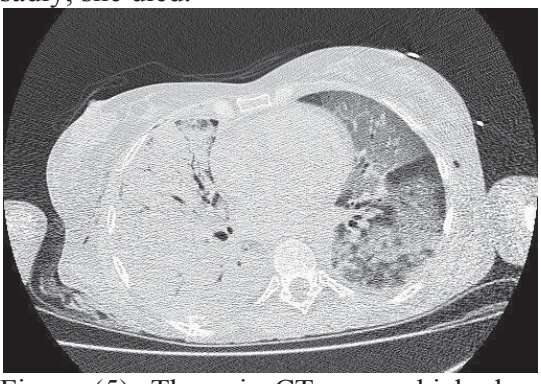

Figure (5): Thoracic CT scan which shows the presence of bilateral pulmonary oedema, worse on the right side.

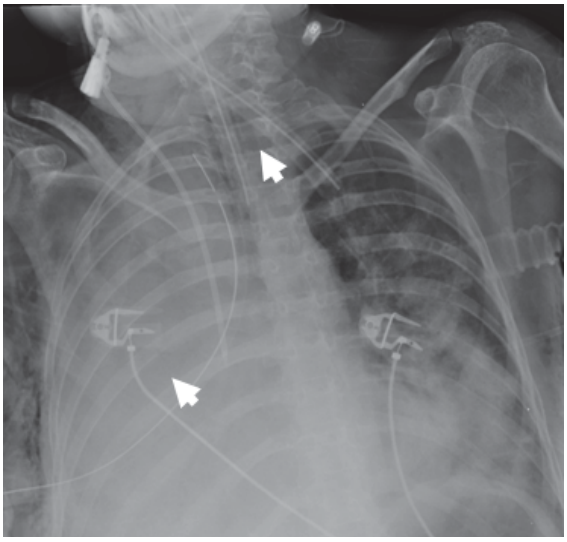

Figure (6): Continued progression of re-expansion pulmonary oedema. Patient is intubated and has a central line in place. Bilateral subcutaneous emphysema present (white arrow heads).

DISCUSSION:

Re-expansion pulmonary oedema (RPE) was first reported in 1853 by Pinault following thoracentesis[3]. This occurred following lung re-expansion after drainage of a pleural effusion. Meanwhile the first report of RPE following treatment of a pneumothorax was in 1958 by Carlson *et al*[4].

RPE can occur either following chest drain insertion or thoracentesis[5]. The incidence ranges from as low as 0.01%[6] to a high of 14%[7]. Taira *et al* reported an incidence of 32% amongst 40 patients[8]. This is far more than in any other study. However, the diagnosis of RPE was made on CT scans while all other studies used chest x-rays. It is therefore likely that CT scans would detect small asymptomatic areas of RPE which would not have been visible on chest x-rays[8]. RPE occurs approximately 4 times more commonly in male patients. While many published reports relate to mild forms of RPE, mortality rates in excess of 20% have been reported[9]. In the majority of cases RPE occurs on the same side as the pneumothorax or effusion. It occurs on the

contralateral side in 7% of cases[1,10] while 6.3% occur bilaterally[9].

The exact pathophysiological mechanism for the development of RPE is unknown. Current hypotheses include an acute inflammatory response[11], increased pulmonary capillary permeability[7,12], intrapleural pressure below -20 cmH_2O[13] lung tissue hypoxia[14] loss ofsurfactant[15] and application of negative pressure suction to re-expand the lung[16]. In 2014 Taira *et al* reported the simultaneous presence of a pleural effusion and pneumothorax increased the risk of developing RPE, odds ratios = 1.557. They did not detect any difference in the duration of symptoms, size of the pneumothorax or size of chest tubeinserted between those who developed RPE and those who did not, p=0.61[8].

Patients are at increased risk of re-expansion pulmonary oedema (RPE) if the lung has been collapsed for more than 3 days[18], in patients aged 20-39 years old[7], in large pneumothoraces[9], pleural effusions > 3L[19], when the lung is re-inflated rapidly[20] and therapeutic use of high negative intrapleural pressure suction[16]. Miller *et al*. observed, while managing a large pneumothorax of three days duration in a primate model, that RPE developed in all patients treated with negative pressure suction but not in any treated without negative pressure suction[16].

The risk factors for RPE in our patient included symptoms present for several weeks due to massive pleural effusion and uncontrolled drainage of the effusion. Rapid re-expansion, drainage with the use of negative intrapleuralpressure, and chronicity of lung collapse are considered the major risk factors for re-expansion pulmonary edema[1].

The symptoms of RPE appear within the first hour following pulmonary re-expansion in 64% of patients[2,5], but might not develop for 24 to 48 hours[2]. In a literature review involving 47 patients who developed RPE following treatment of a pneumothorax Mahfood *et al* reported a male preponderance of approximately 4 to 1, average age 42 years, pneumothorax present for at least 3 days in 87%, average of 9 days[9]. Symptoms may include chest pain/discomfort, persistent cough (>20 minutes), tachypnoea, tachycardia, hypoxia or hypotension[5]. Some patients will be asymptomatic with signs of RPE only visible on x-ray[2]. Our patient complained of sudden onset severe chest pain in association with uncontrolled drainage of large volume of pleural effusion, which initially resulted in ipsilateral and later bilateral pulmonary oedema.

RPE mainly occurs in the ipsilateral lung after re-expansion but, although rare, may also occur in the contralateral non-collapsed lung[21]. Feller-Kopman *et al* studied the effect that removal of large volume, > 1 L pleural fluid had on absolute pleural pressure, pleural elastance, and symptoms during thoracentesis[20]. Of 185 patients studied, 98 (53%) had between 1L and 1.5L drained, 40 (22%) hadbetween 1.5L and 2L drained, 38 (20%) between 2L and 3L, and 9 (5%) had more than 3L drained. Only 1 patient (0.5%, 95% confidence interval: 0.01% to 3%) experienced clinical RPE. In four patients, 2.2%, asymptomatic radiological evidence of RPE was noted. The authors concluded that clinical and radiographic RPE after large-volume thoracentesis is rare and independent of the volume of fluid removed, pleural pressures, and pleural elastance[20]. They further state that large effusions can, and should, be drained completely as long as chest discomfort or end-expiratory pleural pressure less than -20 cmH_2O does not develop[20].

No consensus has been reached on whether intrapleural pressure monitoring should be measured when draining pleural fluid. The volume of fluid, which can safely be

removed from the pleural space without precipitating re-expansion pulmonary is unknown. The American Thoracic Society recommends that pleural pressure monitoring should be performed during drainage of pleural fluid as it can help guide the clinician on the amount of fluid, which can safely be removed[12].If the intrapleural pressure does not fall below -20cmH_2O aspiration of fluid can be continued as long as the patient remains asymptomatic. If the patient develops a cough lasting more than 20 minutes, chest pain / tightness, or dyspnoea the procedure should be discontinued and the chest tube should be clamped. If intrapleural pressure is not being monitored, then only 1-1.5L of fluid can be safely removedFurthermore application of large negative pressure suction should not be used to re-expand the lung[12].

The British Thoracic Society (BTS) guideline differs somewhat. It emphasises the importance of controlled drainage of large effusions and pneumothoraces to reduce the risk of RPE[21]. A maximum of 1.5L pleural fluid should be drained in the first hour after insertion of a chest drain. The recommended maximum amount of air to be aspirated or drained via a chest drain is less than 2.5L. The use of suction should not routinely be used but if it is, high volume low pressure is recommended. High-pressure negative intrapleural suction is contraindicated as it predisposes to the development of RPE[21].

Among 52 patients with pleural effusions, Light et al measured pleural pressures as the pleural fluid was being withdrawn[22]. Pleural fluid aspiration was continued until the pleural pressure fell below -20 cmH_2O, or the patient developed excessive symptoms, or no more fluid could be obtained. The initial pleural pressure ranged from +8 to -21 cmH_2O. The rate of pleural pressure change as fluid was withdrawn was highly variable. In 13 of 52 procedures (25%), thoracentesis was terminated because the pressure fell below -20 cmH_2O. The measurement of pleural pressures in patients with pleural effusions may be useful diagnostically. More importantly, because large changes in pleural pressures are not readily detectable by the operator, pleural pressures should be monitored when large amounts (> 1L) of pleural fluid are removed to increase the safety of the procedure[22].

To avoid RPE, thoracenteses are often limited to draining no more than 1L. One hundred eighty-five patients who had large volumes of pleural fluid aspirated were studied by Feller-Kopman *et al*[20]. The volume of fluid removed, absolute pleural pressure, pleural elastance, and symptoms during thoracentesis were compared in patients who did and did not experience RPE. Other preventative measures which have been suggested include supplemental oxygenation before and during treatment regardless of the patient's oxygen status[23].

The mainstay of treatment is conservative and supportive, including sufficient oxygen supplement[8,24,25]. Some more intensive treatments, such as mechanical ventilation, steroid and diuretics administration, and circulation resuscitation, are required in severe cases of RPE[8,24,25]. Concomitant contralateral RPE is associated with more severe symptoms and higher mortality[26].

CONCLUSION:

RPE occurs following rapid re-inflation of a lung, which has been collapsed due to large pleural effusion or pneumothorax. Patients are at increased risk of RPE if the lung has been collapsed for more than 3 days, in patients aged 20-39 years old, in large pneumothoraces, pleural effusions > 3L, simultaneous presence of pleural effusion and pneumothorax and therapeutic use of high negative intrapleural pressure suction. The consequences of RPE, as reported here,

can be fatal. The diagnosis should be considered in any patient who becomes suddenly breathless during drainage of a pneumothorax or pleural effusion. It is essential that doctors appreciate the importance of gradual re-expansion of a lung, which has been collapsed for a few days or longer and take appropriate precautions in order to minimize the likelihood of developing RPE. Therapeutic use of high negative intrapleural pressure suction should be avoided. The optimum amount of fluid to drain at any one time and whether intrapleural pressure monitoring during thoracentesis is recommended in all cases remain to be answered definitively.

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