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Case Reports

Differential Lung Ventilation with HFPPV

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Abstract. A case of a 53 year old lady who developed a unilateral "white lung" of unknown etiology three weeks after injury is described. The clinical picture was suggestive of a pleural or extra-pleural hematoma, and she was operated upon twice. During the second thoracotomy it became evident that the lesion was in the lung parenchyma. The patient was treated with differential lung ventilation with application of a high continuous positive airway pressure, followed by high frequency positive pressure ventilation (HFPPV) of the diseased lung with low frequency continuous positive pressure ventilation of the other lung. This technique proved to be simple and successful.

Key words: Thorax trauma – Differential lung ventilation – CPAP – HFPPV

Introduction

The treatment of severe unilateral lung disease is difficult to perform, particularly where different levels of PEEP are necessary. We treated successfully a patient with acute unilateral pulmonary insufficiency utilizing not only selective end expiratory pressure to each lung, but also independent ventilatory frequencies. This technique, which proved to be efficient and simple, without complications, has not been previously reported.

Case Report

A 53 year old woman was admitted after a road accident. She had a blunt thoracic injury with 9 fractured ribs and severe contusion of the left lung. The patient was ventilated (PEEP 10 cm H_2O). Two days later, the diagnosis of traumatic aneurysm of the thoracic aortic was confirmed by angiography, and she was operated upon (reconstruction with graft).

Postoperatively she deleveloped acute renal failure, needing hemodialysis. On the 5th postoperative day a hematoma in the superior mediastinum appeared on the chest X-ray, probably caused by bleeding from the aortic graft during heparinisation for hemodialysis. She was reoperated upon and a clot around the graft was removed. The chest X-ray became normal. In the following weeks her condition improved gradually and weaning from the ventilator was considered.

On the 22nd day, after the insertion of a subclavian catheter on the left side, a chest X-ray showed an opacity at the left apex which increased progressively (Figs. 1 and 2). The blood gases deteriorated (Fig. 3). Although arteriography did not reveal any bleeding and the Hb did not change, a thoracotomy was performed to evacuate a suspected extrapleural hematoma due to the subclavian puncture. 700 ml of serous fluid were found inside the pleural cavity, and there was not evidence of an extra-pleural hematoma. The left lung was ventilating well although edematous and reddish.

The patient did not improve and 48 h after the operation, the left lung was completely white on the X-ray and in spite of increasing PEEP, the blood gases deteriorated further. Another surgical exploration was performed. This time, the whole of the left lung was stiff and non-ventilating.

No other abnormality was found. This situation of unilateral lung disease led to a rapidly progressive ventilatory insufficiency, because any attempt to increase the PEEP overdistended the right lung, and decreased the PaO_2.

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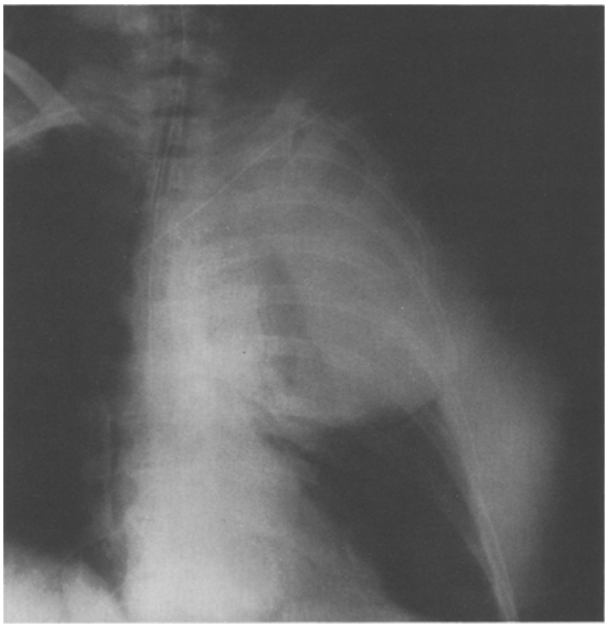

Fig.1. Chest X-ray showing a round white shadow in the left upper lobe, 3 h after insertion of a subclavian catheter

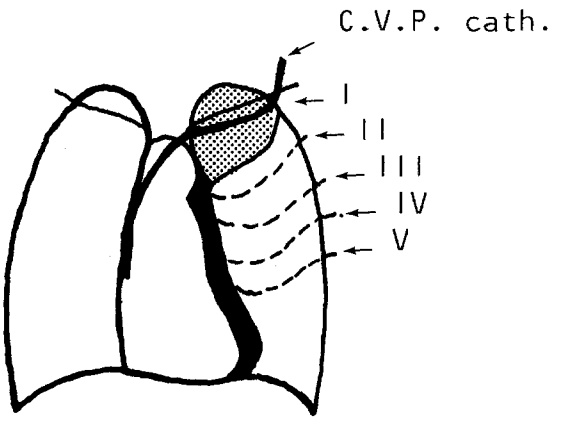

Fig. 2. Drawing of X-rays representing the opacity in the upper lobe of the left lung progressively increasing over the next 4 h (*II, III, IV, V*)

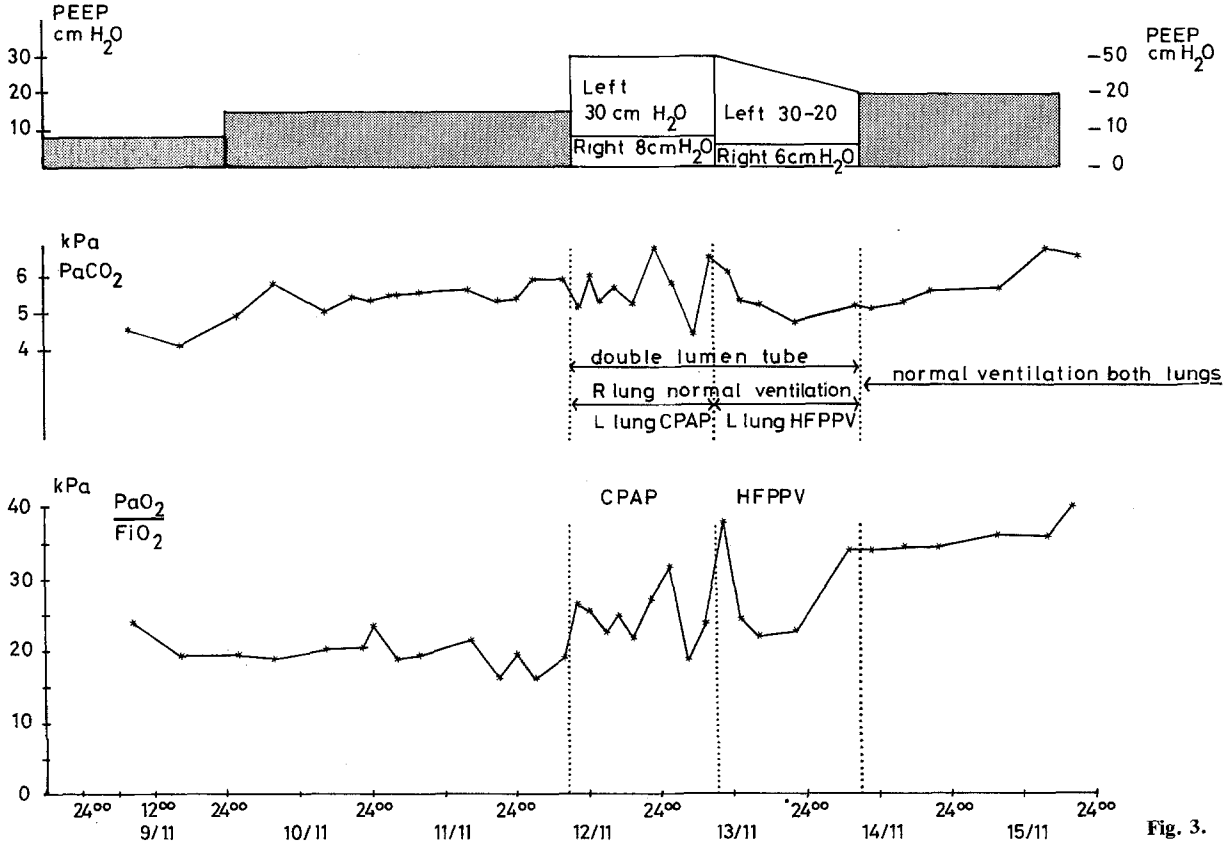

Fig. 3.

Differential lung ventilation was tried. A Robert-Shaw tube was inserted and, although we did not measure the static compliance of each lung, there was a marked difference between the left and the right, the left lung being virtually impossible to inflate by hand.

A continuous positive airway pressure (30 cm H_2O) was applied to the left lung (10.0 l/min FiO_2 0.5) without ventilation, while the right lung was ventilated with a Servo-ventilator 900B (6 l/min, freq. 18/min FiO_2 0.5, PEEP 8 cm H_2O). The patient was sedated and paralysed with pancuronium bromide in a continuous infusion. In the first 24 h the left lung expanded gradually except for the initial lesion in the apex (Figs. 2I). Although only one lung was ventilated, the PaO_2 did improve. Later the $PaCO_2$ started to increase, and we changed the CPAP for HFPPV (Amsterdam Infant ventilator, 10 l/min, freq. 60/min, I:E = 1:1, PEEP 25 cm H_2O).

During the 24 h that the HFPPV was in use, the $PaCO_2$ decreased, the left lung was then easy to inflate and it was possible to reduce the PEEP to 20 cm H_2O without a change in the chest X-ray. After two days of differential ventilation the improvement was such that CPPV with a standard nasotracheal-tube could be resumed (11 l/min, freq. 18/min, FiO_2 0.4, PEEP 20 cm H_2O).

After 46 days hemodialysis was discontinued. Thereafter weaning from the ventilator was started and 10 days later the endotracheal tube was removed. The subsequent clinical course was uneventful and she recovered completely. The chest X-ray, apart from an area of fibrosis at the place of the initial lesion, was normal.

Discussion

We have described a very unusual development of a "white" lung: starting as a round shadow in the left apex, and increasing in size very rapidly in concentric circles to involve the whole of the left lung. In this patient it was possible to improve the unilateral "white" lung by differential lung ventilation. The "healthy" lung was ventilated with a low frequency, and a low PEEP, while a continuous positive airway pressure (30 cm H_2O) without ventilation was applied to the diseased lung. After 24 h the $PaCO_2$ increased, suggesting an augmented blood flow to the diseased and non-ventilated lung, while the oxygenation improved, presumably because of diffusion oxygenation. The increase in $PaCO_2$ suggested the need for ventilation of the diseased lung as well.

Differential lung ventilation in unilateral lung disease has been described previously [1, 2, 4, 5, 7] using synchronous ventilation with one ventilator [1, 5, 7] or, two ventilators synchronized by a special device [2].

We chose HFPPV in combination with normal frequency ventilation to the other side, because the high frequency and the very small tidal volume (60 ml) provided the lowest possible mean intrapulmonary pressure [6] in presence of a high PEEP.

After institution of HFPPV the $PaCO_2$ decreased, demonstrating the effectiveness of this type of ventilation. We were also able to show that by utilizing this technique the need for synchronisation is eliminated.

In our opinion HFPPV, in combination with a high PEEP, is a useful tool in differential lung ventilation that merits further investigation. Furthermore we demonstrated that differential lung ventilation can be accomplished with different ventilatory frequencies in each lung.

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