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Rapid improvement of respiratory symptoms associated with fat embolism by high-dose methylpredonisolone: a case report

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Introduction

Fat embolism syndrome is a severe complication that is likely to occur after lower limb fractures [1] and during operations on the lower limbs [2–4]. It can manifest with various embolic symptoms, including respiratory failure, cardiovascular collapse, neurological disorders, petechial rash, pyrexia, thrombocytopenia, and so on [5]. Respiratory failure is an especially common and critical symptom; these patients manifest tachypnea, dyspnea, hemoptysis, hypoxemia, and hypercapnia with various degrees of severity [5]. Some patients with respiratory failure require long-term mechanical respiratory support. The usefulness of corticosteroid administration for the treatment of pulmonary dysfunction in fat embolism syndrome has been reported. Several studies showed improvement in respiratory symptoms [1,6–9]; however, other studies showed no beneficial effect [10] or found a risk of infection [9]. Thus, the benefit of corticosteroid administration for the treatment of acute lung injury by fat embolism is still controversial. In this report we present a case of respiratory failure associated with fat embolism occurring during hip arthroplasty, the symptoms of which were rapidly improved by a high dose of methylpredonisolone.

Case report

An 80-year-old woman, weighing 50 kg, was admitted to the hospital because of a right femoral neck fracture. The patient manifested mild hemoptysis 2 days after the admission; however, other symptoms of respiratory failure were not observed. Although preoperative laboratory values showed mild anemia (hemoglobin, 9.5 g·dl^{-1}; hematocrit, 29.8%) and thrombocytopenia (95 000 · mm^{-3}), the patient's general condition was considered acceptable for right hip arthroplasty under general anesthesia to be undertaken. Prior to induction of anesthesia, a 22-gauge cannula was inserted into the left radial artery for monitoring of direct arterial blood pressure and arterial blood sampling. Although blood gas analysis performed just before induction of anesthesia showed hypoxemia (pH, 7.45; Pa_{O_2}, 48 mmHg; Pa_{CO_2}, 40 mmHg; base excess, +4.9; Sa_{O_2}, 85% in room air), the patient did not manifest any other respiratory symptoms, such as tachypnea or dyspnea. The cardiovascular status was stable (arterial blood pressure, 132/60 mmHg; heart rate, 90 beats·min^{-1}), and the possibility of congestive heart failure was excluded. Anesthesia was induced by thiopental 250 mg and fentanyl 100 μg i.v. in divided doses, and vecuronium bromide 4 mg i.v. was used to facilitate endotracheal intubation. Anesthesia was maintained by nitrous oxide (50%) with oxygen, sevoflurane (1.0%–1.5%), and intermittent administration of fentanyl 50 μg i.v. To exclude the possibility of bronchial obstruction, we performed a bronchofiberscopic examination immediately after the endotracheal intubation, but failed to find any significant obstruction. Only a small amount of bloody sputum was observed. During maintenance of anesthesia, the patient was hemodynamically stable, and her arterial oxygen tension was acceptable for the operation to be continued (FI_{O_2}, 0.5; pH, 7.41; Pa_{O_2}, 82 mmHg; Pa_{CO_2}, 45 mmHg; Sa_{O_2}, 96%; PET_{CO_2}, 5.2%) in the left lateral position. Immediately after the insertion of bone cement and a long-stem femoral component, Sp_{O_2} and PET_{CO_2} decreased to 60% and 3.6%, respectively, without significant changes in blood pressure and waveform on the electrocardiogram. Even after the start of in-

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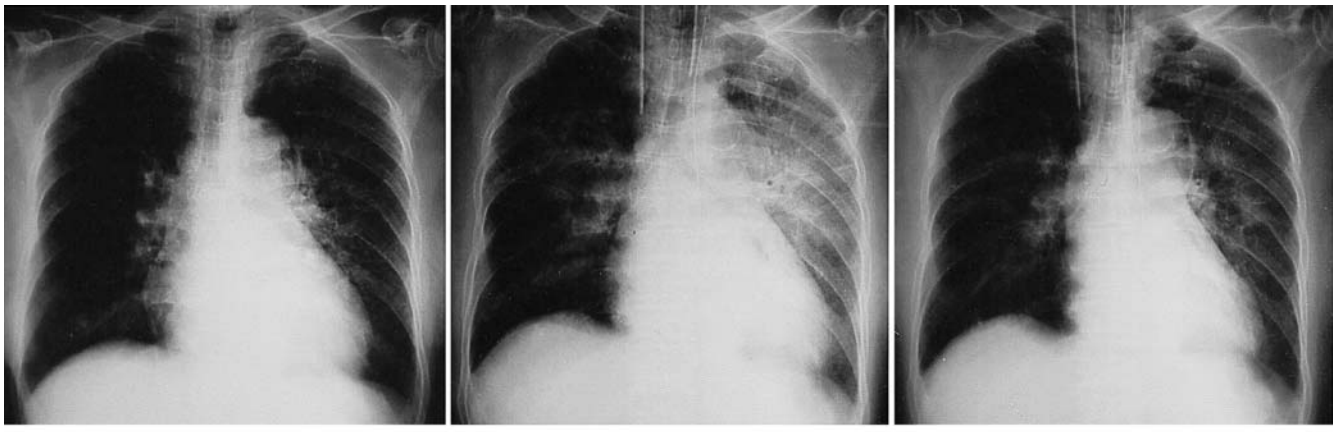

Fig. 1. Chest x-ray findings of the patient. The chest x-ray showed diffuse shadow of lung infiltration, especially in the left lung just after the operation, which was markedly improved on the next postoperative day

halation of 100% oxygen, blood gas analysis showed severe hypoxemia and carbon dioxide retention (Pa_{O_2}, 41 mmHg; Pa_{CO_2}, 50 mmHg; Sa_{O_2}, 74%). Although we carried out bronchofiberscopic examination again, we failed to find any bronchial obstruction or tracheal tube problems. Deterioration of the fat embolism syndrome was suspected, and methylpredonisolone 1500 mg was administered i.v. A portable chest x-ray film taken just after the operation (72 min) showed a bilateral diffuse patchy shadow, suggesting severe fat embolism syndrome (Fig. 1). The pulmonary infiltration was more obvious in the left lung than in the right lung. The patient was then transferred to the intensive care unit (ICU) where she underwent mechanical ventilation (pressure support ventilation, 10 cmH_2O; positive end-expiratory pressure [PEEP], 0), and pulmonary gas exchange was gradually improved. Twelve hours after admission to the ICU, blood gas analysis showed a marked improvement in oxygenation (FI_{O_2}, 0.5; Pa_{O_2}, 100 mmHg; Pa_{CO_2}, 32 mmHg). Further, a chest x-ray examination also suggested a marked improvement of pulmonary infiltration (Fig. 1). An additional 1000-mg dose of methylpredonisolone was administered i.v., and the trachea was extubated. The patient recovered uneventfully during her stay in the hospital.

Discussion

Fat embolism syndrome has been reported in various clinical situations, including major traumatic injuries, long bone fractures, and certain operations [11]. Femoral fracture and hip arthroplasty for its treatment are especially common causes of fat embolism syndrome. Although the incidence of fat embolism syndrome varies among reports, a recent review showed that the overall incidence in several prospective studies was around 11%–19% of trauma patients [5]. Furthermore, more sophisticated prospective studies using transesophageal echocardiography showed a higher incidence of fat embolism during orthopedic operations for fixation of long bone fractures. Significant emboli could be detected in 41%–87% of patients [5].

In the present case, the patient is thought to have already suffered from fat embolism syndrome preoperatively, which was suggested by preoperative hemoptysis, hypoxemia, and low platelet count. Although this patient did not have other important symptoms, such as petechial rash and neurological signs, the patient fulfilled Lindeque's criteria, which are based on respiratory insufficiency alone ($Pa_{O_2} < 60$ mmHg, $Pa_{CO_2} > 55$ mgHg or pH < 7.3, respiratory rate > 35 breaths·min^{-1}, and increased work of breathing) [1]. A patient with tibial or femoral fracture meeting at least one of Lindeque's criteria can be judged to have fat embolism syndrome. Furthermore, Bulger et al. [12] reported that hypoxemia was the most prominent manifestation, being present in 96% of patients and having a higher incidence than other symptoms, such as neurological sign (59%) and petechial rash (33%). Thus, pulmonary symptoms are considered the most important sign for a diagnosis of fat embolism syndrome.

Pulmonary function in this patient had already been impaired before the operation, and it reached a critical level to require mechanical respiratory support by surgical fixation. The contents of the bone marrow are forced into the circulation by an increase in intramedullary pressure at the time of insertion of the cement and prosthesis. In the present case, the pulmonary infiltration was more obvious in the dependent lung (left lung),

apparently due to the differences in pulmonary blood flow. In the left lateral position, the left lung receives more blood flow than the right lung. Thus, the left lung was thought to be more liable to fat embolism. In this case, we should have noted several surgical strategies for preventing further deterioration of the fat embolism syndrome. First, the timing of the operation is considered to be important. Several reports indicate that early fixation of fractures (within 24 h) improves the outcome and reduces pulmonary complications [13,14]. The surgical tools and methods used could affect the incidence of fat embolism syndrome. Blunt reamers, ultrasonic reamers, and their repeated use increase the intramedullary pressure [5]. Intramedullary lavage prior to cement and prothesis insertion could reduce the fat emboli [5]. Furthermore, it has been reported that a cemented implant causes much higher intramedullary pressure than a noncemented implant, resulting in significant cardiorespiratory changes, including decreased arterial oxygen tension and increased pulmonary artery pressure and pulmonary shunt fraction [2–4]. Thus, we should evaluate the ability of a patient to tolerate the operation and select the appropriate surgical methods.

The adverse effects of fat embolism on the lungs have two phases. The first phase is associated with mechanical microvascular obstruction. The second phase involves inflammatory changes in pulmonary capillary membrane as a result of the breakdown of fat globules into free fatty acids and the release of serotonin and histamine from platelet-coated emboli [11]. This chemical pneumonitis is manifested by various symptoms of respiratory failure. Theoretically, corticosteroids could suppress these reactions. They stabilize the pulmonary capillary membrane, inhibit excessive inflammatory responses, and retard platelet aggregation [5]. The beneficial effects of corticosteroids have been evaluated in several studies [1,6–10]. Shonfeld and colleagues [8] performed a prospective, randomized, double-blind study on high-risk patients with fractures of the long bones. They showed that administration of 7.5 mg·kg^{-1} of methylpredonisolone i.v. every 6 h was effective for prophylaxis of fat embolism without any complications. Lindeque et al. [1] also reported that high-dose methypredonisolone (30 mg·kg^{-1} i.v. every 4 h for two doses) had a significant effect in preventing the development of fat embolism syndrome in patients with tibial or femoral fracture. This treatment was 35% more effective in maintaining the Pa_{O_2} level than placebo. However, they also found that 38% of the patients who had a baseline Pa_{O_2} level between 60 and 70 mmHg dropped to hypoxemia ($Pa_{O_2} < 60$ mmHg) during the following 3 days, in spite of methylpredonisolone administration. Thus, the author concluded that any patient with baseline Pa_{O_2} less than 70 mmHg has a higher risk of developing fat embolism syndrome. In the present case, we administered methylpredonisolone 30 mg·kg^{-1} immediately after deterioration of oxygenation, resulting in fast and dramatic recovery from respiratory failure. The patient could be weaned from the ventilator about 12 h after the operation, without any complications of corticosteroids. A high dose of methylpredonisolone is thought to contribute to the rapid improvement in respiratory function by the mechanisms mentioned above. However, we should note some problems of corticosteroid therapy. Kallenbach et al. [9] reported that low-dose methylpredonisolone (1.5 mg·kg^{-1} i.v. every 8 h; total dose, 9 mg·kg^{-1}) was also effective in preventing fat embolism syndrome in traumatic patients. However, one steroid-treated subject died of a fulminant infection with *Clostridium perfringens* and *Staphylococcus aureus*. They conclude that the safety of steroid therapy will require considerable further evaluation. Mellor et al. [5] also pointed out some problems of past studies, including small sample sizes and inadequate laboratory data. Further work involving a large number of patients is required to determine the optimum timing, duration, and dose of steroids.

In conclusion, we have reported a case of rapid recovery from respiratory failure associated with fat embolism syndrome in a patient treated with high-dose methylpredonisolone. Its anti-inflammatory and stabilizing effects on pulmonary capillaries are thought to have contributed to the rapid improvement in pulmonary function. However, we should be careful in initiating steroid therapy, because the optimum method of administering the therapy remains controversial, despite several reports demonstrating the efficacy of corticosteroids.

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