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Acute respiratory distress syndrome (ARDS) treated successfully by veno-venous extracorporeal membrane oxygenation (ECMO) in a nearly drowned patient

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Abstract This report highlights about one acute respiratory distress syndrome (ARDS) case after near-drowning resuscitated using extracorporeal membrane oxygenation (ECMO). Few cases have been reported about ECMO use for near-drowning and in most of these cases, ECMO was initiated within the first week. However, in our report, we would like to emphasize that seemingly irreversible secondary worsening of ARDS after nearly drowned patient was successfully treated by ECMO use more than 1 week after near-drowning followed by discharge without home oxygen therapy, social support, or any complication. This is probably due to sufficient lung rest for ventilator-associated lung injury during ECMO use. Based on our case's clinical course, intensive care unit physicians must consider ECMO even in the late phase of worsened ARDS after near-drowning.

Keywords Drowning · Extracorporeal membrane oxygenation · Acute respiratory distress syndrome

Introduction

Several cases have been reported about extracorporeal membrane oxygenation (ECMO) use for near-drowning but in most of these cases, ECMO were initiated within the first week. Our report highlights about one acute respiratory distress syndrome (ARDS) case after near-drowning successfully treated by ECMO initiation 14 days after near-drowning followed by discharge without any complications. Intensive care unit (ICU) physicians must consider ECMO even in seemingly irreversible late phase of worsened ARDS after near-drowning.

Case report

This case is that of a 62-year-old man brought into the emergency department in a comatose state with decerebrate rigidity after unknown duration of submersion in a bathtub with hot water. On arrival, elevated blood pressure (216/90 mmHg), tachypnea (respiratory rate 30, oxygen saturation 75 % on room air), and elevated body temperature (39.3 °C) were observed. His medical history showed only diabetes mellitus with no medication. Blood tests were normal except for hypoxia (pO_2 92.0 mmHg on arterial blood gas at FiO_2 100 %), elevated lactate (3.9 mmol/L), and hyponatremia (Na 127 mEq/L). Chest X-ray and chest-plain computed tomography (CT) revealed bilateral dorsal consolidation surrounded by patchy ground glass opacity compatible with near-drowning ARDS.

Endotracheal intubation and mechanical ventilation were introduced. The patient was admitted to the ICU. The PaO_2/FiO_2 ratio (P/F ratio) was improved. Then extubation was performed on day 2. However, ARDS was exacerbated after extubation. Noninvasive positive pressure ventilation (NPPV) was necessary to maintain appropriate oxygenation with subsequent re-intubation on day 9 because of progressive hypoxia and respiratory acidosis. There was no evidence of increased pleural effusion or bacterial infection

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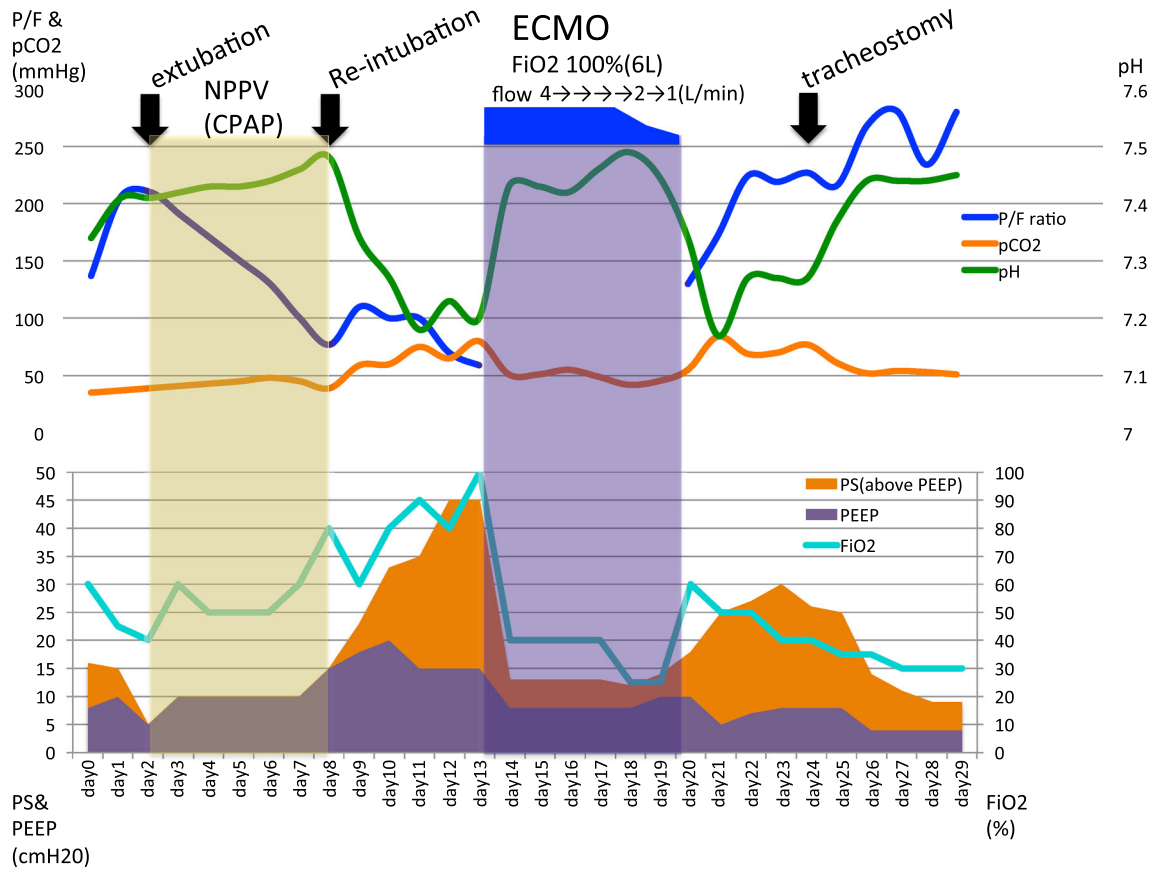


Fig. 1 Clinical course schema of this patient. *Upper part*: changes of arterial blood gas during clinical course. *Lower part*: ventilator settings during clinical course. After first extubation, oxygenation had worsened rapidly followed by re-intubation. Then, lung compliance had also worsened leading to respiratory acidosis and ECMO had been initiated. During ECMO use, ventilator setting was lung protective and lung compliance had markedly increased after ECMO removal. *P/F* arterial O2 pressure (mmHg)/fraction of inspired oxygen (FiO2) ratio, *NPPV* noninvasive positive pressure ventilation, *CPAP* continuous positive airway pressure, *FiO2* fraction of inspired oxygen, *PS* pressure support, *PEEP* positive end-expiratory pressure

at this point. After re-intubation, FiO_2 more than 80 % and positive end-expiratory pressure (PEEP) of around 10–20 cmH_2O were necessary to maintain PaO_2 higher than 60 mmHg. In addition, plateau airway pressure had increased markedly to 35 cm H_2O or more and arterial pH had decreased to around 7.2 because of CO_2 retention during 5 days after re-intubation due to reduced lung compliance. Consequently, ECMO was initiated on day 14. Moreover, no evidence indicated that the condition was exacerbated by bacterial infection because blood and sputum culture were negative. Veno-venous mode was chosen for respiratory support because of the stable hemodynamic status with less than 0.1 μg/kg/min norepinephrine use. Percutaneous 24 Fr blood removal cannula and 20 Fr blood sending cannula were placed from left and right femoral vein, respectively. Lung resting ventilation (FiO_2 0.4, respiratory rate 5/min, PEEP 4 cm H_2O, P_{peak} less than 15 cm H_2O), intravascular volume control using furosemide, and bilateral chest tube placement for increased pleural effusion were performed during ECMO support. ECMO flow was 4.5 L/min at first, then tapered. P/F ratio increased straightly while this tapering of ECMO support, and chest X-ray became clear significantly. On day 20, ECMO was terminated and temporary tracheostomy was performed on day 23. Although lung consolidation attributable to ARDS seemed irreversible, it improved gradually. After respiratory rehabilitation, he fully recovered. He was discharged to his home with no respiratory or social support on day 46 (Fig. 1).

Discussion

Reportedly, near-drowning ARDS cases typically worsen twice during their courses. This worsening is designated as *secondary drowning* and is said to result from alveolar surfactant inactivation or damage to surfactant-producing cells [1–3]. Two lessons from this case are that (1)

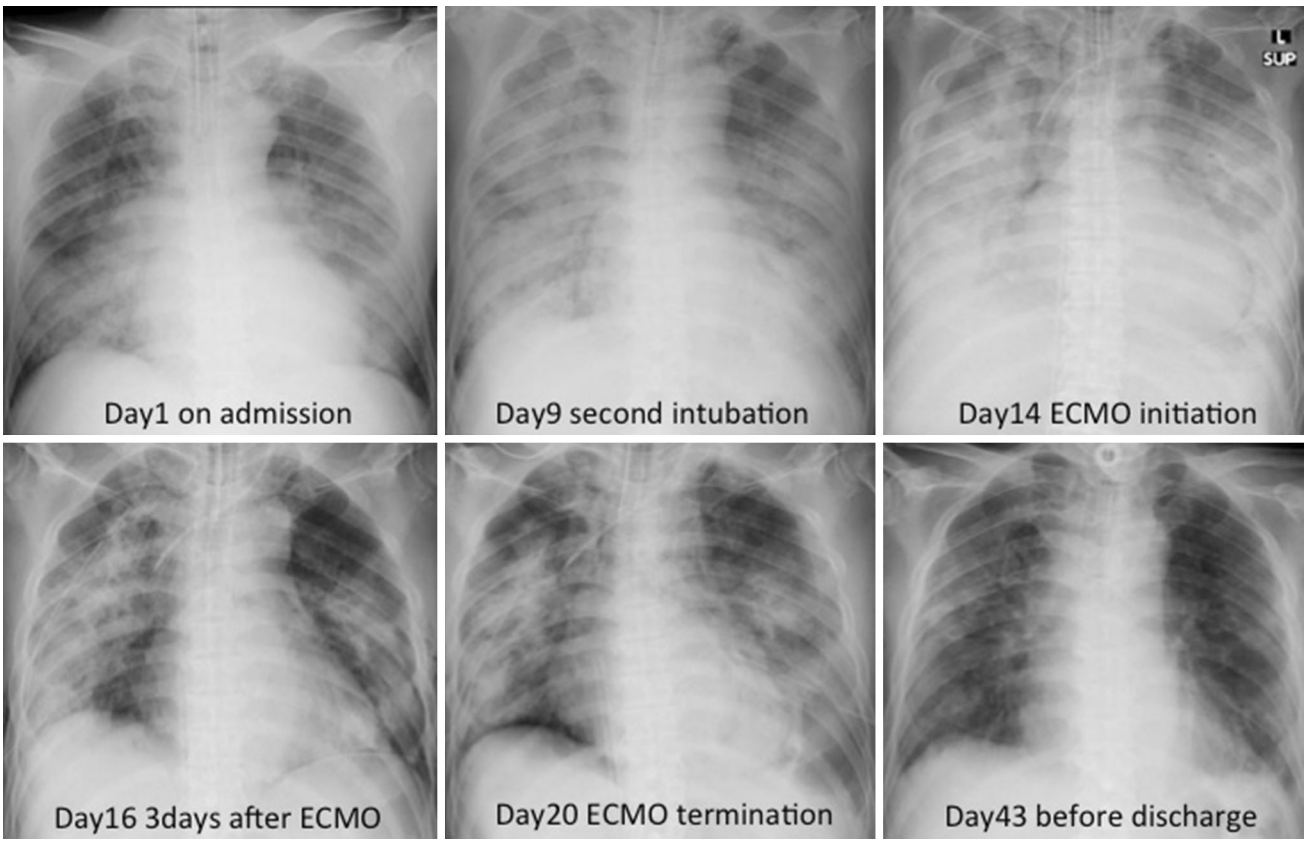
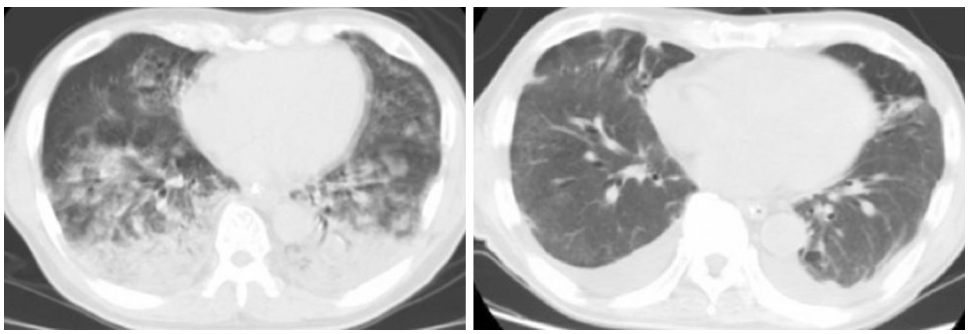


Fig. 2 Chest X-rays of each time

Fig. 3 Chest plain CT before and after ECMO



secondary drowning can be a life-threatening phenomenon, and (2) veno-venous ECMO can be a treatment tool of choice under such circumstances. However, several conditions such as pneumonia, ventilator-associated lung injury (VALI), oxygen toxicity, and pleural effusion should be assessed when ECMO introduction is considered [1]. Furthermore, in our case, ARDS improved once but worsened again within the first week. Therefore, we recommend that, in near-drowning ARDS cases, not to extubate even when respiratory conditions are apparently improved in the first several days [2].

Second, near-drowning ARDS can be a good indication for ECMO, but cases using ECMO for near-drowning ARDS are rarely reported. In addition, in most such cases, ECMO was performed within the first week. No cases were reported in which ECMO was effective even when the initiation was late, as in our case, probably because most physicians believe that it is futile to start ECMO in secondary drowning ARDS because changes in the lungs are apparently irreversible in this phase (Fig. 2). It is particularly important to have a multi-disciplinary team discussion related to the

indication of ECMO among intensivists, perfusionists, and cardiothoracic surgeons. According to current guidelines [4–6], ECMO initiation 7 or more days after near-drowning is relative contraindication based on recent studies [7–9], which have reported that not only a primary cause of ARDS but also VALI because of high PEEP or high FiO_2 causes irreversible lung damage in the late phase. However, considering our patient's clinical course, which includes ECMO support 14 days after near-drowning episode, we emphasize that secondary drowning can be treated if lung-protective ventilation is performed appropriately using ECMO support. ECMO support enables lung-protective ventilation which helps to avoid further lung damage due to high PEEP or high pressure support and gives the patient time to recover from initial lung damage. This hypothesis is supported by our patient's changes in chest X-ray during ECMO support and lung compliance reduction before and after ECMO support. Consequently, it is necessary for ICU physicians to consider ECMO as a treatment option, even in cases of secondary drowning ARDS, as described herein, which are seemingly quite severe (Fig. 3).

ECMO devices: Blood pump: Rotaflow centrifugal pump (MAQUET), Artificial lung: Biocube 6000 (NIPRO), Cannulas: DVFEM 20Fr and 24 Fr (Edwards Lifesciences).

Conflict of interest The authors declare that they have no conflict of interest.

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