Acute exacerbation of chronic obstructive pulmonary disease treated by extracorporeal carbon dioxide removal

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To the Editor: Acute exacerbation of chronic obstructive pulmonary disease (AECOPD) patients often required mechanical ventilation support. But ventilator-related side effects are still inevitable, leading to treatment failure. The extracorporeal carbon dioxide removal ($ECCO_2R$) technique drains blood to artificial membrane lungs, performing oxygenation and removing carbon dioxide without mechanical ventilation. $ECCO_2R$ has been widely used outside China, but there is no official report of its use in China. Recently, we treated two AECOPD patients using $ECCO_2R$.

A 69-year-old male patient with a 20-year history of chronic obstructive pulmonary disease (COPD) was hospitalized in March 2017. The patient underwent two times of endotracheal intubation and invasive positive pressure ventilation (IPPV). Arterial blood gas analysis (fraction of inspiration O_2 [FiO_2] 0.4): pH 7.25, arterial partial pressure of carbon dioxide ($PaCO_2$) 92 mmHg, arterial partial pressure of oxygen (PaO_2) 90 mmHg, HCO_3^- 45.8 mmol/L, and base excess (BE) 15.4 mmol/L. After failure of non-invasive positive-pressure ventilation (NPPV) for 8 days, the patient underwent IPPV for 4 days and endotracheal tube was removed. However, the $PaCO_2$ increased to 130 mmHg at 12 h after the end of IPPV, so IPPV was given again. In order to meet the requirements of patients to remove endotracheal intube, $ECCO_2R$ was performed to assist with removal of IPPV and early rehabilitation exercise [Figure 1].

The patient received placement of a 22F double-lumen venous catheter (Nova-twin, Germany) in the right internal jugular vein, and the insertion depth was 17 cm. The catheter was connected to the extracorporeal membrane oxygenation (ECMO) (Maquet, Rotaflow, Germany). The pump blood flow was adjusted to 1.0 to 1.5 L/min, and the gas flow was 4 L/min. During the $ECCO_2R$ treatment, heparin (400–600 U/h) was given for anti-coagulation. The activated partial prothrombin time was maintained for 60 s, and activated clotting time was about 160 s. After 1 h of treatment, the peripheral arterial $PaCO_2$ was decreased to 45.8 mmHg, and the pH rose to 7.42. At the same time, the patient's ventilation parameters were reduced (pressure support 10 cmH_2O, FiO_2 0.4, and positive end-expiratory pressure [PEEP] 5 cmH_2O), sedation and analgesia were stopped and the endotracheal tube was removed the next day. Meanwhile, NPPV was given intermittently, and airway clearance was used to assist sputum drainage. The patient was also asked to begin exercise with assistance. The gas flow was gradually reduced (from 4 L/min to 500 mL/min) and NPPV was gradually restored to the usual support level (IPAP 18–20 cmH_2O, EPAP 14 cmH_2O, FiO_2 0.4) during the treatment of $ECCO_2R$. Five weeks later, $ECCO_2R$ was removed. No obvious complications occurred during the treatment.

An 81-year-old male patient was hospitalized in April 2017. The patient had a history of COPD for 20 years without regular treatment. Fifteen days before admission, the patient had severe dyspnea, accompanied by obvious cough and expectoration, bilateral pneumothorax for 5 days. Extensive subcutaneous emphysema was felt from the neck to the chest, abdomen, waist, and bilateral upper limbs. A thoracic drainage tube was placed in the right thoracic fourth intercostal space. Arterial blood gas analysis (FiO_2 0.35) showed pH 7.43, $PaCO_2$ 46 mmHg, PaO_2 73 mmHg, HCO_3^- 31.2 mmol/L, and BE 5.6 mmol/L.

After admission, the patient's dyspnea and subcutaneous emphysema were aggravated. Arterial blood gas analysis (FiO_2 0.5) showed pH 7.26, $PaCO_2$ 66 mmHg, and PaO_2 120 mmHg. Then, $ECCO_2R$ was given (the process and anti-coagulation requirements were the same as the 69-year-old male patient). Meanwhile, NPPV (IPAP 6 cmH_2O, EPAP 4 cmH_2O, FiO_2 0.4) was also given. However, endotracheal intubation and IPPV was given to the patient because of weak cough and hypoxemia. The endogenous positive end-expiratory pressure (PEEPi) was

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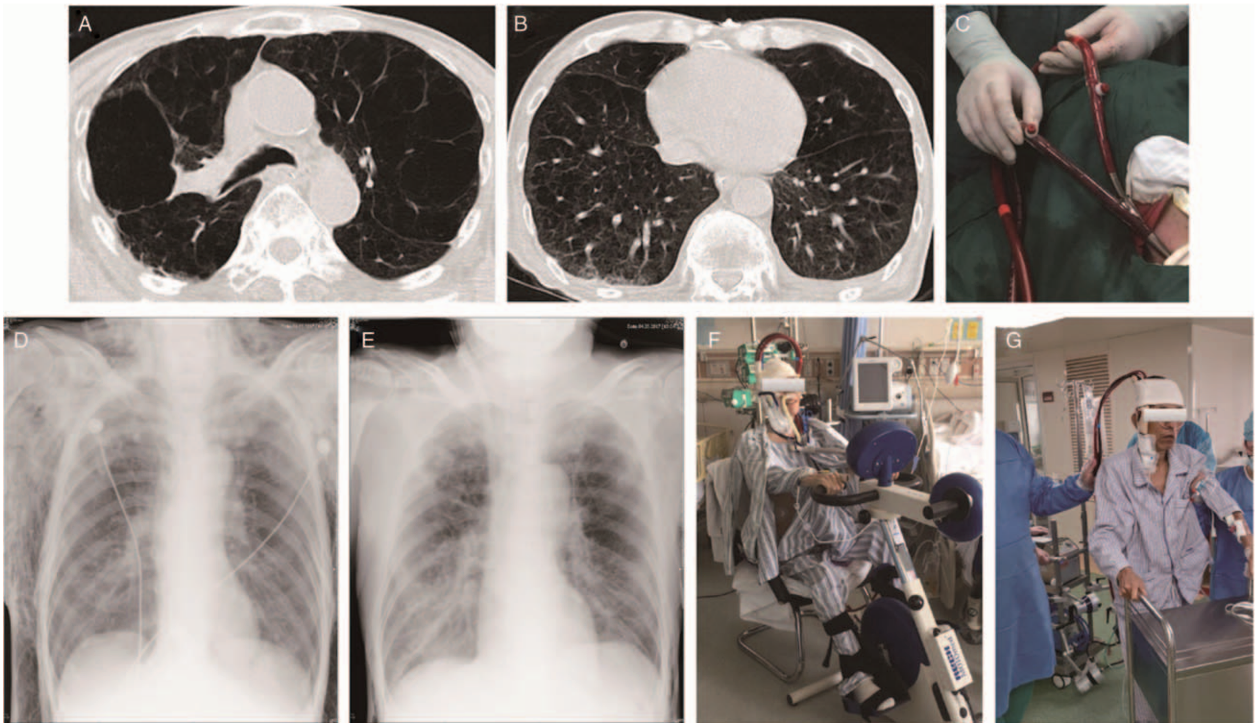

Figure 1: (A, B) Chest computed tomography before $ECCO_2R$ of patient 1. (C) The procedure of $ECCO_2R$. (D) Extensive subcutaneous emphysema of patient 2 before $ECCO_2R$. (E) The barotrauma of patient 2 was effectively improved with the 9 days' treatment of $ECCO_2R$. (F) Treadmill exercise during $ECCO_2R$-assisted period. (G) Rehabilitation exercise during $ECCO_2R$-assisted period. $ECCO_2R$: Extracorporeal carbon dioxide removal.

measured at 19 cmH_2O. The progression of the symptoms was probably due to the patient's lung infection, the gas entrapment was obvious, and the intrathoracic pressure increased significantly. IPPV parameters were A/C mode, tidal volume 170 mL, respiratory rate 15 times/min, PEEP 3 cmH_2O, and FiO_2 0.35. Four days later, the subcutaneous emphysema was relieved. The PEEPi was reduced to 8 cmH_2O. The patient's pH was maintained at 7.43 to 7.51, and $PaCO_2$ was maintained at 35 to 45 mmHg. After 11 days of effective treatment, the endotracheal tube was removed, and $ECCO_2R$ was successfully ended 2 days later [Figure 1]. During treatment, the patient developed a slight increase in transaminase and bilirubin, and also subcutaneous congestion at the puncture site.

Traditional mechanical ventilation has shown many problems, including NPPV treatment failure, barotrauma, and ventilator weaning failure.[1] New treatments are needed to avoid endotracheal intubation and ventilation related complications. With advances in technology, the current $ECCO_2R$ system is simpler *in vitro* life support technology with lower risk.[2] Based on current domestic equipment conditions, we chose a 22F double-lumen venous catheter to establish vascular access and connect ECMO. This also met the $ECCO_2R$ treatment requirements and facilitated early rehabilitation for the patient.

The purposes of $ECCO_2R$ treatment for AECOPD patients include avoiding intubation and assisting the removal of IPPV.[3-5] The criteria for NPPV failure and intubation were: (1) worsening respiratory acidosis ($PaCO_2$ >55 mmHg, or pH <7.25), (2) worsening oxygenation, (3) increasing respiratory rate (>30 breaths/min), and (4) clinical signs suggestive of respiratory muscle fatigue and/or increased work of breathing. $ECCO_2R$ was also used to assist the removal of IPPV for patients who had either failed two or more weaning attempts or failed weaning attempt and did not wish to continue IPPV. The first patient in this report successfully weaned IPPV with the help of $ECCO_2R$, carried out rehabilitation exercise. For the second patient, the support conditions of IPPV were reduced during $ECCO_2R$-assisted period, and barotrauma was effectively improved. Both patients were finally successfully ended $ECCO_2R$.

However, $ECCO_2R$ still has some limitations. Tracheal intubation sometimes cannot be avoided because of expectoration difficult and low hypoxemia, increased incidence of bleeding, and in need of effective respiratory therapy. Therefore, it is very important to grasp the appropriate indications for the treatment of $ECCO_2R$. Rational selection of $ECCO_2R$ for AECOPD patients can effectively improve their prognoses. $ECCO_2R$ can also be used as a bridge-treatment for lung transplantation, and it provides a new respiratory support strategy and treatment.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the article. The patients understand that their names and initials will not be published and due efforts will be made to conceal the identity of the patient, although anonymity cannot be guaranteed.

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Conflicts of interest

None.

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