Egyptian Journal of Anaesthesia

Vol. 41, 2025
ISSN: 1110-1849 (print))
ISSN: 1687-1804 (online)
DOI: 10.21608/EGJA.2025.367907.1031

CASE REPORT

When and How Can We Benefit from Applying ECCOR-2? Two Case Reports

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Introduction Chronic obstructive pulmonary disease (COPD) is a chronic condition characterized by frequent exacerbations, high mortality rates, and significantly reduced quality of life. Cystic fibrosis (CF) is an autosomal recessive disease affecting multiple systems, particularly the respiratory and digestive systems.

Aim The extracorporeal carbon dioxide removal system (ECCOR-2) can be utilized in patients with acute hypercapnic respiratory failure who do not respond adequately to mechanical ventilation. The treatment focuses on the patient's carbon dioxide (CO2) and pH levels. ECCOR is indicated for invasive respiratory failure and has been reported to reduce the need for mechanical ventilation support. It also serves as bridge therapy for transplantation candidates, including CF patients.

Discussion One of our cases was successfully weaned from invasive support and discharged without ECCOR-related complications. Another patient developed tension pneumothorax due to CF; despite treatment, the patient's condition deteriorated, resulting in death. ECCOR's ability to work alongside venovenous hemofiltration at low flow rates is a significant advantage. Supportive treatment continued post-ECCOR.

Conclusions ECCOR-2 effectively removes carbon dioxide and can complement invasive mechanical ventilation (IMV). It facilitated the weaning process in one patient with CO2 levels exceeding 150 mmHg and served as a bridge to transplantation in another.

Keywords Bullous lung, COPD, ECCOR-2, Hypercarbia.
Received: 13 March 2025, **Accepted:** 13 April 2025

INTRODUCTION

Acute respiratory failure (ARF) is a syndrome with high mortality that can impair multiple organs, including the heart, brain, and kidneys. COPD is a leading cause of ARF [1]. High tidal volume or ventilation pressure during invasive mechanical ventilation (IMV) can damage the lungs and increase mortality [2]. Low tidal volume ventilation has been shown to reduce mortality, though it poses challenges due to the risk of progressive hypercapnia [3].

Cystic fibrosis (CF) is a congenital condition where pneumothorax, particularly during infections, can be life-threatening. Effective management aims to prevent pneumothorax recurrence [4].

Extracorporeal Carbon Dioxide Removal (ECCO2R) is a promising therapeutic approach for managing hypercapnic respiratory failure, especially when traditional mechanical ventilation strategies fail.

Introduced by Gattinoni in the late 1970s, the ECCO2R method facilitates CO_2 removal using lower tidal volumes to minimize lung injury [5].

ECCO2R is an invaluable tool in modern critical care, particularly for patients with hypercapnic respiratory failure unresponsive to conventional ventilation [6]. Its ability to reduce CO_2 levels without high ventilatory pressures makes it especially useful when lung-protective strategies are paramount [7]. By enabling efficient CO_2 removal at lower tidal volumes, ECCO2R minimizes the risk of ventilator-induced lung injury while addressing severe acidosis. However, its effectiveness depends heavily on patient selection, timing, and the management of concurrent complications.

This report discusses two cases treated with ECCO2R, highlighting its clinical benefits and limitations.

CASE 1:

A 50-year-old female patient with a history of hypertension and Chronic obstructive pulmonary disease (COPD) presented to an external emergency department with shortness of breath. She received conservative treatment for an acute exacerbation of type 2 respiratory failure. After failing to improve with Bilevel Positive Airway Pressure (BIPAP), she was intubated and transferred to our intensive care unit.

Examinations revealed a C-reactive protein (CRP) level of 293(mg/dL), procalcitonin of 10.7(ng/Ml), a white blood cell (WBC) count of 26(mcL), and elevated glucose at 210(mg/dL), while other tests were normal. Chest radiography revealed infiltrates, and echocardiography showed a left ventricular ejection fraction (LVEF) of 55% with no significant valvular abnormalities (Figure 1). Pulmonary artery pressure (PAP) was measured at 55mmHg. The patient was diagnosed with pneumonia secondary to COPD and started on broad-spectrum antibiotics due to prior hospitalization.

On day 4 of invasive ventilation, lung-protective ventilation was applied in pressure control mode, with a PEEP top pressure of 28cm H_2O, a Pplat pressure of less than 30mmHg (FiO_2: 60%, PEEP: 12cm H_2O).

Arterial blood gas analysis revealed a pH of 6.92, a pCO2 of 151mmHg, and an pO2 of 105mmHg, prompting the decision to initiate venovenous (V-V) ECCO2R to mitigate complications associated with elevated pressure and CO2 levels.

A double-lumen 12F dialysis catheter (Ares-Medical) was placed in the right internal jugular vein under ultrasound guidance, with successful confirmation via chest radiography. The MultiECCO2R (FRESENIUS) device was connected, and the initial settings were blood flow at 200mL/min, sweep gas at 3L/min, and CO_2 removal at 80mL/min, with anticoagulation managed using citrate. Blood flow was adjusted based on CO_2 levels. Control blood gas results are summarized in Table (1). The patient's CO2 levels normalized within 12 hours, and she was extubated on day 11, subsequently transitioning to high-flow nasal oxygen support. Chest *X*-RAY was improved in second day (Figure 2).

During follow-up, the patient developed acute renal failure (ARF). A urine culture on day 16 confirmed the presence of VRE, while blood and urine cultures on day 23 identified Candida auris. Additionally, Acinetobacter baumannii was grown in urine on day 30. Antimicrobial Therapy: Broad-spectrum antibiotics were initiated due to prior hospitalization and severe infection. Subsequent cultures identified VRE (Vancomycin-Resistant Enterococcus), Candida auris, and Acinetobacter baumannii, necessitating targeted adjustments to antimicrobial therapy. During this period, (vancomycin, meronem, colistin, micafungin sodium).

The patient's condition improved by day 47, leading to her discharge on day 50.

CASE 2:

A 26-year-old female with bronchiectasis and cystic fibrosis presented to the emergency department with sudden shortness of breath during lung transplantation. Evaluations revealed bilateral pneumothorax (Figure 3). She underwent bilateral chest tube insertion and intubation, followed by placement of a left femoral hemodialysis catheter before being transferred to the intensive care unit.

In the ICU, the patient was placed on a mechanical ventilator in pressure control mode, achieving adequate tidal volume with settings of PEEP 7 and FiO2 60%. A right subclavian central venous catheter was also inserted. Due to the pneumothorax, the patient experienced hypotension (blood pressure 57/35mmHg), prompting the initiation of noradrenaline infusion, later supplemented with adrenaline. After treatment, blood pressure improved to 102/60mmHg, pulse was 105/min, and SpO2 was 95%.

Blood gas analysis showed: pH 6.9, pCO2 191mmHg, pO2 61mmHg, HCO3 21mmol/L, potassium 7.1mmol/L, sodium 137mmol/L, chloride 103mmol/L, ionized calcium 1.26mmol/L, glucose 155mg/dL, BE-3.1mmol/L, and lactate 0.4mmol/L. Based on these results, venovenous (V-V) ECCO2R treatment was initiated.

A double-lumen 12F dialysis catheter (Ares-Medical) was successfully placed in the right internal jugular vein under ultrasound guidance, confirmed via chest radiography. MultiECCO2R (Fresenius) was connected and activated with citrate anticoagulation. The initial settings included a blood flow of 200mL/min, a sweep gas of 3L/min, and CO_2 removal of 80mL/min. Blood flow was adjusted based on CO_2 levels. Control blood gas results are provided in Table (2).

Although a decrease in pCO2 value was observed with ECCO2R treatment, the patient's general condition worsened, and the patient, who received high-dose favorable inotrope treatment, suffered cardiac arrest in the 12th hour of hospitalization.

The patient was actively awaiting lung transplantation but developed acute respiratory failure due to pneumothorax. $ECCO_2R$ was attempted as a bridge to transplant, but she deteriorated due to refractory acidosis and hemodynamic instability. Despite 45 minutes of cardiopulmonary resuscitation (CPR), the patient did not respond, and asystole developed. In this situation, the patient died. Demographical data of these two patients were shown in Table (3).

Table 1: Case 1 Arterial Blood Gas Results Before and After ECCO2R:

Parameter	Before ECCO2R	After ECCO2R	4 Hours After ECCO2R	1 Day After ECCO2R	2 Days After ECCO2R
PH= 7,35-7,45	6,92	7,12	7,29	7,27	7,33
PCO2 (mmHg)	151	81,8	48,9	49,6	55
PO2 (mmHg)	105	140	143	150	150
HCO3 (mEq/L)	20	19,9	21,7	20,5	26,3
BE (mmol/L)	-1	-2,4	-2,4	-3,5	3,2
LAC (mmol/L)	0,6	1,1	1,3	0,6	1,2
SPO2 (%)	91,8	95	96	97	98

Table 2: Case 2 Arterial Blood Gas Results Before and After ECCO2R:

Parameter	Before ECCO2R	First 30 Minutes After ECCO2R	2 Hours After ECCO2R
PH	6,9	6,8	6,9
PCO2 (mmHg)	191	164	122
PO2 (mmHg)	61	68	75
SP02(%)	95	92	94
BE (mmol/L)	-3,1	-7,9	0,5
LAC (mmol/L)	0,4	7,4	2,4
HCO3(mEq/L)	21	13,4	19,6

Table 3: Demographical data:

	Case 1	Case 2
Age (years)	50	26
Gender	Female	Female
Primary Diagnosis	Acute exacerbation of COPD with pneumonia	Cystic fibrosis with bilateral pneumothorax
Comorbidities	Hypertension, COPD	Cystic fibrosis, bronchiectasis
Admission Symptoms	Shortness of breath	Sudden shortness of breath
Initial Blood Gas pH	6,92	6,90
Initial PCO2 (mmHg)	151	191
Initial PO2 (mmHg)	105	61
Initial HCO3 (mEq/L)	20	21
Ventilation Mode	IMV with lung-protective strategies	Pressure-controlled ventilation
ECCO2R Initiation	Day 4 of ICU stay	4th Hours of ICU stay
ECCO2R Duration	12 hours	<12 hours (died)
Outcome	Extubated on day 11, discharged on day 50	Cardiac arrest and death after 12 hours in ICU

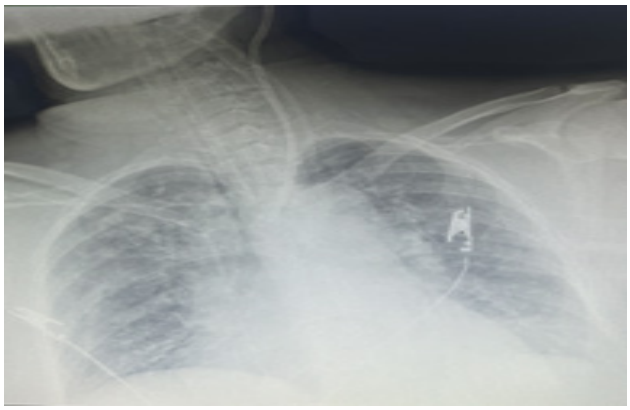

Fig. 1: Before ECCO2R.

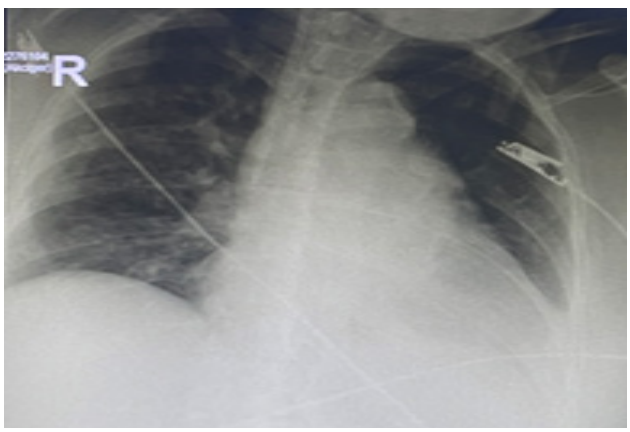

Fig. 2: Second day after ECCO2R.
Case 1: Chest *X*-Ray on 1st day of admission and before the After.

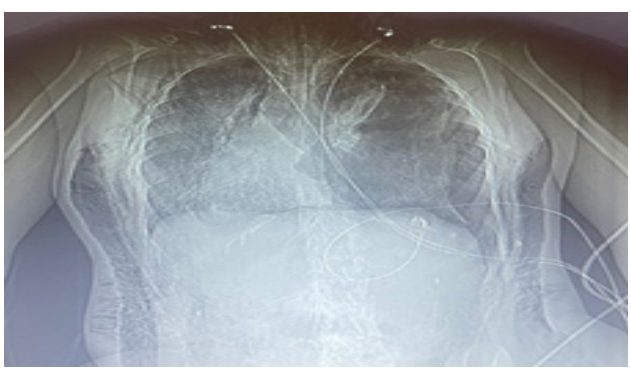

Fig. 3: Thoracic CT scan of Case 2 shows bilateral pneumothorax and cystic fibrosis-related lung changes.
Case 2: The patient's thorax CT will be uploaded to the system.

DISCUSSION

Extracorporeal Carbon Dioxide Removal (ECCO2R) is a vital supportive therapy for respiratory failure. Suitable candidates include patients with acceptable oxygenation but severe, uncompensated respiratory acidosis (e.g., pH <7.2), dynamic hyperinflation, or intrinsic positive end-expiratory pressure. It is also indicated for patients with barotraumas such as pneumothorax and those with acute or chronic hypercapnic respiratory failure due to end-stage lung disease, particularly lung transplant candidates. The most commonly utilized configuration is V-V ECCO2R [8,9].

Cystic fibrosis (CF) is an autosomal recessive disorder affecting multiple organs, especially the lungs and pancreas. Persistent microbial colonization leads to lung destruction, contributing to approximately 85% of mortality in these patients. Pneumothorax occurs in 50-90% of cases, with a significant chance of recurrence and contralateral occurrence [10,11]. Overall, ECCO2R emerges as an essential option in managing respiratory failure, particularly in complex conditions like CF. Selecting appropriate patients and timely intervention are crucial for maximizing the benefits of this therapy.

Treatment should focus on maintaining typical pH values rather than solely targeting CO2 levels, as chronic CO_2 elevation is standard in obstructive pulmonary disease. The sweep gas flow should be adjusted without metabolic issues to stabilize pH. With ECCO2R, there is an increased risk of alveolar collapse due to decreased minute ventilation, necessitating adjustments in mechanical ventilation settings to minimize airway pressure and potentially increasing FiO2 to counteract hypoxia [12]. Despite reduced carbon dioxide levels with ECCO2R, the patient's metabolic condition remained as metabolic and respiratory acidosis under Continuous Venovenous Hemodialysis (CVVHDF) treatment, leading to an ineffective response and ultimately the patient's death.

One critical consideration in the use of ECCO2R is the timing of initiation. A study discusses the potential use of ECCO2R as a bridging therapy until lung transplantation [13]. Facilitating the preparation of patients for the procedure. In the first case, early application allowed stabilization and avoided prolonged exposure to high ventilatory pressures.

Another important factor is integrating ECCO2R into a comprehensive management plan. In patients with multi-organ dysfunction, as seen in the second case, addressing underlying metabolic and cardiovascular derangements is essential for the therapy to be effective. ECCO2R should not be viewed as a stand-alone solution but as part of a multidisciplinary approach to managing critically ill patients [14].

In our first case, a patient with acute exacerbation of pneumonia-related COPD underwent invasive ventilation. Using ECCO2R helped manage high pressure and carbon dioxide levels, facilitating early extubation and mobilization. In cases of impaired gas exchange, such as severe respiratory failure, ECCO2R should be routinely considered alongside mechanical ventilation.

In our second case, a patient with cystic fibrosis developed bilateral tension pneumothorax. Intercostal tube drainage is crucial for treating large pneumothoraces, with correct placement being vital due to frequent air leakage from the upper lobes. We inserted bilateral chest tubes and confirmed placement with a chest radiograph. The patient's PC02 level was measured at 192, prompting the decision to apply ECCO2R (Extracorporeal Carbon Dioxide Removal). This approach aimed to mitigate carbon dioxide-related side effects while considering the patient's status as a transplant candidate.

Treatment targets in individuals with obstructive pulmonary disease should prioritize pH values alongside CO2 levels, especially for transplant candidates, as this strategy aids in managing acidosis. ECCO2R is a significant option for controlling carbon dioxide levels and correcting acidosis in complex cases such as cystic fibrosis. However, the timing and patient selection for ECCO2R are critical; improper timing can increase the risk of complications.

CONCLUSION

In conclusion, ECCO2R is a valuable adjunctive therapy for hypercapnic respiratory failure, particularly in patients with COPD or cystic fibrosis. Its success depends on timely initiation, patient selection, and therapy integration into a broader clinical management strategy. While it can dramatically improve outcomes in suitable candidates, as shown in the first case, its limitations are evident in patients with profound systemic instability, as illustrated in the second.

In summary, a multidisciplinary approach and individualized treatment plans are essential for improving clinical outcomes in these patients.

CONFLICT OF INTERESTS

There are no conflicts of interest.

FUNDING

The authors report no involvement in the research by the sponsor that could have influenced the outcome of this work.

AUTHORS' CONTRIBUTIONS

All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

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