CASE REPORT

Managing Hypercapnia in a Coronavirus Disease 2019 Acute Respiratory Distress Syndrome with Extracorporeal Carbon Dioxide Removal Using Continuous Renal Replacement Therapy Machine: A Case Report

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Abstract

Coronavirus disease-2019 (COVID-19) acute respiratory distress syndrome (ARDS) management remains challenging for intensivists, especially during limited resource availability. We report a COVID-19 ARDS case who had hypercapnia in spite of appropriate ventilatory management. This case was successfully managed with the use of extracorporeal carbon dioxide removal ($ECCO_2R$) device with attaching pediatric oxygenator with continuous renal replacement therapy (CRRT).

Keywords: Acute respiratory distress syndrome, Continuous renal replacement therapy, Extracorporeal carbon dioxide removal, Pediatric oxygenator.

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Introduction

The coronavirus disease-2019 (COVID-19) has been associated with high mortality due to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), however, the treatment is grossly restricted to supportive therapies due to lack of specific treatment.

Pathologically ARDS may lead to diffuse alveolar damage (DAD) which is initially an acute inflammatory phase causing edema, hyalinization, and interstitial inflammation. The next phase is an organizing phase with fibroblast proliferation in the alveolar septa and hyperplasia of pneumocytes.[1] Finally, the ARDS may progress to pulmonary fibrosis, however, a protective lung ventilation strategy may reduce this risk and abnormal radiographic findings following ARDS.[2]

The dysregulated immune response in the form of cytokine storm enhances the risk for progression to pulmonary fibrosis. The release of various inflammatory mediators may lead to epithelial and endothelial injury during the acute phase of ARDS. The fibroblasts and myofibroblasts proliferation and accumulation of collagen enhance the chance of pulmonary fibrosis.[3]

So far, no specific treatment for the virus has been proven its efficiency. The current management is aimed at giving supportive care to the lungs.

Case Description

A 54-year-old male, a known hypertensive, who presented with shortness of breath and fever was evaluated and RTPCR tested positive for COVID-19 around 15 days back. He was managed initially with oxygen, low-molecular-weight heparin, methylprednisolone along with other supportive therapies, however, oxygen requirement and work of breathing kept increasing and he required non-invasive ventilation. In spite of increasing support his oxygen saturation kept worsening and he required intubation and mechanical ventilation with proning 2 days before shifting to our hospital. We initiated a lung protective ventilatory strategy with positive end expiratory pressure (PEEP) 12. He remained hemodynamically stable and was maintaining oxygen saturation (SpO_2) around 90–92%; however, his arterial blood gas showed hypercapnia in spite of appropriate ventilatory settings, [arterial blood gases (ABG) pH 7.35, PaO_2 68; $PaCO_2$ 54]. In the next few hours, patients became hemodynamically unstable with tachycardia and hypotension, a fluid bolus and vasopressors did not improve the hemodynamics much and urine output started falling. Two-dimensional echocardiography was unremarkable with normal ejection fraction (55%); however, ABG showed severe respiratory acidosis ($PaCO_2$ > 115 and pH 6.82), ensuring adequate sedation,

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Table 1: Effect of ECCO$_2$R using CRRT along with pediatric oxygenator on hemodynamics, arterial blood gases, and ventilatory setting

Time (hour)	*HR*	*BP*	*pH*	*PaCO$_2$*	*PaO$_2$*	*Minute ventilation*	*RR*	*IP*	*Mode*	*Vasopressor*
0	146	86/43	6.86	109	64	12.6	36	32	Bilevel	High doses
6	118	104/52	7.18	84	58	12.2	36	32	Bilevel	Reduced
	12	128/68	7.24	63	76	13.2	28	28	Bilevel	Reduced
	18	122/64	7.50	49	67	11.9	24	28	Bilevel	Reduced
24	92	144/80	7.30	53.2	74	10.4	16	22	Bilevel	Stopped
36	88	156/74	7.32	47	76	9.8	14	20	Bilevel	No

BP, blood pressure; HR, heart rate; IP, inspiratory pressure; RR, respiratory rate

normothermia, patency of airway and ruling out other causes, the minute ventilation was increased by increasing both tidal volume and ventilation rate further. This also did not improve the respiratory acidosis and PaCO$_2$ remained high (108 mm Hg, pH 6.86 with PaO$_2$ 59) and vasopressors requirement further increased. The family was reluctant to venovenous (VV) extracorporeal membrane oxygenation (ECMO) support. We initiated extracorporeal carbon dioxide removal (ECCO$_2$R) by connecting a pediatric oxygenator in series with continuous renal replacement therapy (CRRT) circuit using a Prismaflex® machine (Baxter India Ltd). Also, ECCO$_2$R was initiated using M100 set with blood flow of 300 mL/minute and sweep gas flow of 1000 mL/minute; however, CRRT was kept on (slow continuous ultrafiltration) SCUF with zero balance. Anticoagulation was maintained using heparin infusion. Hemodynamic parameters and respiratory acidosis started improving followed by ventilatory parameters (Table 1). The ECCO$_2$R with CRRT was stopped after 36 hours. Percutaneous tracheostomy was performed and further weaning from mechanical ventilation was initiated. Decannulation was done after successful weaning. The total duration of mechanical ventilation was 24 days and was discharged from the hospital after 30 days. His HRCT showed significant lung fibrosis prior to discharge. However, the patient required 2–3 L/minute oxygen at the time of discharge.

Discussion

The COVID-19 mainly involves the respiratory system. There is high prevalence of progression to ARDS in elderly patients especially with comorbidities. Timely management and intervention can avoid and circumvent the fatal morbidity and mortality in these high-risk patients. Various institutions have released showing various management protocols on lung protective ventilation low tidal volume, prone positioning, use of high flow nasal cannula, and use of higher PEEP by using existing data on ARDS management but there is limited data available on the use of carbon dioxide removal methods despite its proven efficacy in the management. ECCO$_2$R is basically a method that artificially removes the CO$_2$ from the blood through an extracorporeal circuit connected with a gas exchange device.

In our patient, early implementation of an ECCO$_2$R therapy prevented further acceleration of the invasiveness of therapy requiring the need for ECMO. This was integrated along with CRRT support and showed effective results in settling down the hypercapnia and improving oxygenation by lowering the ventilator requirement in our patient.

The progression of ARDS has been evaluated through 159 autopsies showing DAD and they found that these DADs may either recover to normal lung tissues or may lead to fibrosis.[4] The low-flow extracorporeal carbon dioxide removal has been used in patients with moderate ARDS receiving ultraprotective ventilation in patients and has been found safe, effective, and feasible in preventing carbon dioxide retention due to low tidal volume (4 mL/kg) ventilation in these patients.[5] Similarly, Parrilla et al.[6] also evaluated the use of ultralow tidal volume ventilation along with use of Hemolung® RAS as low flow CO$_2$ removal device in ARDS patients and concluded ECCO$_2$R will be helpful in preventing respiratory acidosis with ultralow tidal volume ventilation strategy.[5]

In another study with a group of 15 patients where ECCO$_2$R was used, the aim was to avoid intubation in 5 patients, which was achieved in 4 patients; the other 10 patients were supported with ECCO$_2$R and managed successfully with lung-protective ventilation. The average requirement of the ECCO$_2$R device was 5 days (range: 3–7 days). The pH and PCO$_2$ could be stabilized within 6 hours of initiating ECCO$_2$R, even with a significant reduction in minute ventilation. The results were encouraging with 67% survival to hospital discharge, though 93% of patients were weaned from ECCO$_2$R and 73% were discharged from ICU. The author concluded ECCO$_2$R can be used safely and effectively in this group of patients.[6–9]

Conclusion

COVID-19 ARDS management is a challenging task for intensivists as the extent of fibrosis of the lung involved goes undetermined. Clinical trials still undergoing to find out any effective treatment and so far have failed to show any specific drug. Furthermore, ECMO may be a standing practice to manage the severe cases, however, with limited resources; this can be managed with protective lung ventilation along with carbon dioxide removal artificially using cheaper options in crisis situations. As the mortality due to COVID ARDS is higher more and more studies and clinical trials are needed to target the efficacy of various lung protective ventilation strategies along with the use of carbon dioxide removal

References

1. Cardinal–Fernández P, Lorente JA, Ballén–Barragán A, et al. Acute respiratory distress syndrome and diffuse alveolar damage. New insights on a complex relationship. Ann Am Thorac Soc 2017;14(6):844–850. DOI: 10.1513/AnnalsATS.201609-728PS.
2. Burnham EL, Janssen WJ, Riches DWH, et al. The fibroproliferative response in acute respiratory distress syndrome: Mechanisms and clinical significance. EurRespir J 2014;43(1):276–285. DOI: 10.1183/09031936.00196412.
3. George PM, Wells AU, Jenkins RG. Pulmonary fibrosis and COVID-19: The potential role for antifibrotic therapy. Lancet Respir Med 2020;8(8):807–815. DOI: 10.1016/S2213-2600(20)30225-3.
4. Thille AW, Esteban A, Fernández–Segoviano P, et al. Chronology of histological lesions in acute respiratory distress syndrome with

diffuse alveolar damage: A prospective cohort study of clinical autopsies. Lancet Respir Med 2013;1:395–401. DOI: 10.1016/S2213-2600(13)70053-5.
5. Fanelli V, Ranieri MV, Mancebo J, et al. Feasibility and safety of low-flow extracorporeal carbon dioxide removal to facilitate ultra-protective ventilation in patients with moderate acute respiratory distress syndrome. Crit Care 2016;20:36. DOI: 10.1186/s13054-016-1211-y.
6. Parrilla F, Bergesio L, Aguirre–Bermeo H, et al. Ultra-low tidal volumes and extracorporeal carbon dioxide removal (Hemolung® RAS) In ARDS patients: A clinical feasibility study. Intensive Care Med Exp 2015;3(Suppl. 1):A7. DOI: 10.1186/2197-425X-3-S1-A7.
7. Kalbhenn J, Neuffer N, Zieger B, et al. Is extracorporeal CO_2 removal really "safe" and "less" invasive? Observation of blood injury and coagulation impairment during $ECCO_2R$. ASAIO J Am Soc Artif Intern Organs 2017;63:666–671. DOI: 10.1097/MAT.0000000000000544.
8. Moss CE, Galtrey EJ, Camporota L, et al. A retrospective observational case series of low flow veno-venous extracorporeal carbon dioxide removal use in patients with respiratory failure. ASAIO J 2016;62(4):458–462. DOI: 10.1097/MAT.0000000000000386.
9. Combes A, Fanelli V, Pham T, et al. Feasibility and safety of extracorporeal CO_2 removal to enhance protective ventilation in acute respiratory distress syndrome: The SUPERNOVA study. Intensive Care Med 2019;45(5):592–600. DOI: 10.1007/s00134-019-05567-4.