Critical Care

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Management of severe ARDS due to SARS-CoV-2 pneumonia using low-flow extracorporeal CO_2 extraction

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Extracorporeal CO_2 extraction ($ECCO_2R$) is a technique that uses an extracorporeal device to extract excess CO_2 from the blood by passing it through an air exchange membrane using low blood flows and requiring systemic anticoagulation for its use. The main technical difference with extracorporeal membrane oxygenation system (ECMO) is the reduced blood flow (between 300 and 500 ml/min), achieving the elimination of most of the CO_2 produced by metabolism, thanks to the greater solubility of this gas in plasma.

This technique emerged from the need to decouple the oxygenation support from the ventilation support provided by ECMO with the main objective of optimising lung protection during mechanical ventilation (MV) [1]. There is currently no strong evidence regarding the benefit provided by the use of $ECCO_2R$ in this clinical context [2].

We present a series of 8 cases of patients with severe global respiratory failure due to COVID-19, admitted in ICU between December 2020 and May 2021. Regarding patients' characteristics, we highlight mean values of ICU stay of 45.8 days (± standard deviation 15.8), PaFi of 75.1 (± 10.4) and pH 7.25 (± 0.03), despite endotracheal intubation (ETI) and protective MV with Pplat 29.1 (± 1.61). Prone position was necessary in all cases, both before and after $ECCO_2R$ placement. The mean number of days in prone position prior to $ECCO_2R$ was 3.75 days (± 1.08). Mean number of days from the start of ETI to the start of $ECCO_2R$ was 14.5 days, PaO2/FiO2 of 75.1 and SOFA score 6.6. Transfer to ECMO was not possible in any of the 8 cases, following to the current recommendations of the receiving centres [3].

All cases had positive SARS-CoV-2 polymerase-chain-reaction detection and severe respiratory failure without severe dysfunction of other organs or documented infections.

During ICU admission, selected patients presented persistent hypoxaemia and hypercapnia refractory to lung protective measures (TV 6–8 ml/kg, Pplat < 30) and proning. $ECCO_2R$ support was considered then, preserving the level of lung protection and correcting the expected deterioration of ventilation with worsening respiratory acidosis obtained after achieving an increase in PEEP. Our objectives were also to decrease Pplat in a range of less than 28, to decrease respiratory rate under 25 bpm and to decrease TV (under 7 ml/kg).

Table 1 shows the respiratory status prior to initiation of therapy, and Table 2 shows the results obtained 12–24 h after initiation of the $ECCO_2R$.

The therapeutic objectives of ProLUNG® (blood flow 400 ml/min and air flow 15 L/min), with a rise in pH (7.32–7.35), were achieved in the first 12 h of treatment. Results are shown in Table 2. Regarding technical complications, thrombocytopenia not induced by heparin was observed in one of the cases, requiring withdrawal of treatment after 5 days.

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Table 1 Characteristics

N	Sex (F/M)	Age (yr)	BMI (kg/m^2)	Days Symp/ ECCO$_2$R	Days EIT/ ECCO$_2$R	Compliance (ml/cmH$_2$O)	PO$_2$/FiO$_2$	Days on ECCO$_2$R	ICU LOS after ECCO$_2$R	Out
1	F	53	33	26	15	17	64	5	47	a
2	F	55	37	25	11	13	70	7	33	a
3	M	74	28	53	13	34	96	1	24	d
4	M	67	33	29	19	8	71	6	23	d
5	F	61	32	16	21	28	61	4	12	a
6	M	69	36	20	9	42	78	3	20	d
7	M	69	36	23	14	35	81	5	8	a
8	M	64	25	23	14	14	80	8	1	d

N = Number of cases, F = female, M = male, Yr = years, BMI = body mass index, Days Symp/ECCO$_2$R = number of days from symptom onset to ECCO$_2$R placement, Days EIT/ECCO$_2$R = number of days from intubation to ECCO$_2$R placement, LOS = length of stay after ECCO$_2$R, Out. = outcome, a = alive, d = death

Table 2 Data before and after 24-h initiating ECCO$_2$R

	Before ECCO$_2$R						After ECCO$_2$R and PEEP trial					
N	TV (ml/kg)	Pplat (cmH$_2$O)	DP (cmH$_2$O)	PEEP (cmH$_2$O)	pCO$_2$	FiO$_2$	TV (ml/kg)	Pplat (cmH$_2$O)	DP (cmH$_2$O)	PEEP (cmH$_2$O)	pCO$_2$	FiO$_2$
1	6	32	24	8	75	0.8	4.5	30	16	14	63	0.6
2	6.4	27	16	6	71	1	4.5	23	10	10	59	0.75
3	7.2	28	20	8	81	1	5	28	18	10	67	0.85
4	7.8	31	18	12	65	1	4.6	28	13	14	57	0.9
5	5.6	28	16	12	84	1	5	28	10	18	51	0.7
6	6.7	28	11	14	66	0.9	6.5	25	9	16	51	0.7
7	5.1	29	17	12	87	1	4	28	12	16	64	0.65
8	6	30	18	8-	77	80	4.2	26	14	12	62	0.75

N = Number of cases, TV = tidal volume, DP = driving pressure

Regarding the outcome data on the ECCO$_2$R device, the mean duration of therapy was 5.25 days, with a mean blood flow of 400 ml/min and air flow of 12 lpm. Fifty percentage of the patients survived, with an ICU discharge of 25 days (average value) after disconnection from the ECCO$_2$R. Case number 8 died within a day after removal of the CO$_2$ extractor.

These cases, as in previous studies, show us the possible usefulness of applying ECCO$_2$R based on individual clinical and physiological criteria [4], without development of serious complications, although other known published series report relevant complications [5].

ECCO$_2$R system could be applied as a tool to optimise the degree of lung protection, essential in patients with severe ARDS. In our experience, ECCO$_2$R is a simple and feasible therapeutic option for patients with severe respiratory diseases in whom conventional treatment has been maximised. Further studies are needed to strengthen the scientific evidence in this context [6].

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Authors' contributions
RML did investigation, writing original draft; BLV was involved in writing—reviewing and editing. FG performed methodology, project administration, supervision and validation. All authors read and approved the final manuscript.

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Availability of data and materials
All data generated or analysed during this study are included in this published article.

Declarations

Ethical approval and consent to participate
Informed consent from patients or family member for the inclusion of medical data in our prospective ICU Registry was obtained. This study was conducted in accordance with the amended Declaration of Helsinki. Local institutional

review boards and independent ethics committees (Healthcare Ethics Committee of the Francisco de Vitoria University) approved the protocol, and written informed consent was obtained from all patients.

Consent for publication
Consent for publication was forwarded by next of akin / family member through informed consent.

Competing interests
Authors declare no potential financial or ethical conflicts of interest.

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References

1. Combes A, Auzinger G, Capellier G, et al. ECCO2R therapy in the ICU: consensus of a European round table meeting. Crit Care. 2020;24:490. https://doi.org/10.1186/s13054-020-03210-z.
2. Combes A, Schmidt M, Hodgson CL, et al. Extracorporeal life support for adults with acute respiratory distress syndrome. Intensive Care Med. 2020;46:2464–76. https://doi.org/10.1007/s00134-020-06290-1.
3. https:www.care-statement.org
4. Romay E, Ferre R. Eliminación extracorpórea de CO2: fundamentos fisiológicos y técnicos y principales indicaciones. Medicina Intensiva. 2016;40(1):33–8. https://doi.org/10.1016/j.medin.2015.06.001.
5. Combes A, Fanelli V, Pham T, et al. Feasibility and safety of extracorporeal CO2 removal to enhance protective ventilation in acute respiratory distress syndrome: the SUPERNOVA study. Intensive Care Med. 2019;45:592–600. https://doi.org/10.1007/s00134-019-05567-4.
6. Kearsley R, Daly Guris R, Miles LF, Shelton CL. Case reports in the COVID-19 pandemic: first responders to an emergency in evidence-based medicine. Anaesthesia Rep. 2021;9(1):1–7. https://doi.org/10.1002/anr3.12088.

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