



Extracorporeal membrane oxygenation in an awake patient as a bridge to lung transplantation

Spencer Marcantonio Camargo^{1,a}, Stephan Adamour Soder^{1,b},
Fabiola Adelia Perin^{1,c}, Douglas Zaione Nascimento^{1,d}, Sadi Marcelo Schio^{1,e}

TO THE EDITOR:

Lung transplantation (LTx) is an established treatment modality for advanced lung disease. Although the number of lung transplants is on the rise worldwide,⁽¹⁾ there is a risk of underlying disease progression in patients awaiting LTx, especially those with interstitial lung disease that progresses to respiratory failure requiring ventilatory support. Invasive mechanical ventilation (IMV) is the most common method of providing ventilatory support until LTx. However, IMV increases the risk of infections and can cause muscle failure as a result of patient immobilization and sedation drug use. Therefore, the use of an alternative method can increase the chances of successful LTx.

Although the use of extracorporeal membrane oxygenation (ECMO) as a bridge to LTx is common in transplant centers in North America and Europe, it remains limited in Brazil. ECMO is indicated for patients presenting with deterioration of respiratory function and hypoxemia or severe hypercapnia; in such cases, venovenous ECMO can maintain adequate gas exchange and acid-base balance. Although ECMO is mostly used in patients on IMV, the use of ECMO in patients who are awake and not receiving mechanical ventilation is an interesting and increasingly used alternative.⁽²⁾

Here, we report the case of a 41-year-old male patient diagnosed with systemic lupus erythematosus and pulmonary fibrosis secondary to connective tissue disease. The patient had been receiving continuous oxygen therapy for six months when he was referred for lung transplant evaluation. His FEV₁ was 2.01 L (56% of predicted), his FVC was 2.07 L (43% of predicted), and his DLCO was 31%. A few months after being added to the waiting list for LTx, the patient sought emergency room treatment, presenting with worsening dyspnea and hypoxemia. Initial management included supplemental oxygen via a nonrebreather mask and empirical antibiotic therapy. Test results showed disease progression, the patient being bedridden with severe hypoxemia. He was placed on noninvasive mechanical ventilation (NIMV) at high oxygen flow rates (an FiO₂ of 100%), and, given the imminent need for ventilatory support, the decision was made to start venovenous ECMO, the patient remaining awake. Inflow cannulation was performed in the right jugular vein, and outflow cannulation was performed in the right femoral vein, a coated circuit being used (Maquet,

Rastatt, Germany). A request was made to the technical subcommittee to prioritize the patient on the waiting list for LTx. The ECMO settings were as follows: blood flow, 4 L/min; FiO₂, 100%; and gas flow, 4-5 L. Anticoagulation with heparin was used in order to maintain an activated clotting time of 180-220 s. The patient remained awake, was fed orally, and underwent physiotherapy. He was initially placed on intermittent NIMV, being subsequently switched to a nasal cannula (Figure 1). On postadmission day four, a compatible organ, from a 37-year-old donor (PaO₂, 240 mmHg), became available.

The patient underwent bilateral LTx, having remained on ECMO throughout the procedure, without reversal of anticoagulation. He was extubated on post-transplant day one and remained on ECMO until postoperative day three. The patient was discharged from the ICU on postoperative day ten and from the hospital on postoperative day 22, requiring no supplemental oxygen and ambulating. Pre- and post-transplant blood gas variables are shown in Table 1.

The management of patients awaiting LTx and presenting with respiratory dysfunction constitutes a



Figure 1. Patient awake and receiving extracorporeal membrane oxygenation.

1. Grupo de Transplante Pulmonar, Irmandade Santa Casa de Misericórdia de Porto Alegre, Porto Alegre (RS) Brasil.

a. <http://orcid.org/0000-0003-0626-9063>; b. <http://orcid.org/0000-0003-4771-6308>; c. <http://orcid.org/0000-0003-3481-2675>;

d. <http://orcid.org/0000-0001-7590-8513>; e. <http://orcid.org/0000-0001-7750-9225>

Table 1. Arterial blood gas variables and activated clotting time before and after extracorporeal membrane oxygenation and lung transplantation.

Variable	Pre-ECMO	Post-ECMO	IPOP	LTx + ECMO	LTx (Post-ECMO)
pH	7.41	7.41	7.48	7.47	7.42
PaCO ₂ , mmHg	60.5	42.9	41	30	44.8
PaO ₂ , mmHg	58.5	87.4	111	123	115
HCO ₃ ⁻ , mmol/L	37.6	26.9	31	21.7	28.7
BE, mmol/L	10.3	2.5	0.5	-1.0	4.3
SaO ₂ , %	90	93	99	99	99
ACT		185	190	158	

ECMO: extracorporeal membrane oxygenation; IPOP: immediate postoperative period (with the use of ECMO and mechanical ventilation); LTx: lung transplantation; HCO₃⁻: bicarbonate; BE: base excess; and ACT: activated clotting time.

challenge. Although IMV provides life support, its side effects reduce the chances of successful LTx and have a negative impact on patient outcomes. The use of ECMO in spontaneously breathing patients awaiting LTx constitutes a modern and efficient approach that allows patients to undergo active physiotherapy and feed normally while waiting for a compatible lung.

ECMO was first used as a bridge to LTx in 1975; however, up until the mid-2000s, ECMO had not yielded consistent results. The modernization of the ECMO membrane and circuit greatly improved the efficiency of the system, improving gas exchange and reducing the need for anticoagulation.

Toyoda et al.⁽³⁾ reported their experience of pre-transplant ECMO at the University of Pittsburgh, comparing a group of patients in whom ECMO was used as a bridge to transplantation (the ECMO group; n = 24) with a group of patients who required no ECMO support before transplantation (the control group; n = 691). Primary graft dysfunction rates were higher and hospital stays were longer in the ECMO group than in the control group; however, one- and two-year survival rates were similar between the two groups (74% vs. 83% and 74% vs. 74%, respectively).

Fuehner et al.⁽⁴⁾ studied 60 patients undergoing LTx between 2006 and 2011 and requiring a bridge to transplantation; of those 60 patients, 26 underwent ECMO and 34 underwent IMV. Six-month survival was 80% in the ECMO group and 50% in the IMV group, the postoperative hospital stay being shorter in the ECMO group. These differences might be due to ventilator-associated pneumonia and ventilator-induced diaphragmatic dysfunction. This hypothesis is supported by studies showing that IMV-induced diaphragmatic rest, even for brief periods, results in diaphragmatic dysfunction caused by varying degrees of muscle atrophy, delaying weaning from IMV.⁽⁵⁾

In the case reported here, the use of ECMO allowed our patient to undergo active physiotherapy and receive oral feeding while waiting for a compatible lung. ECMO allowed early extubation (on postoperative day one), being withdrawn on postoperative day three. This resulted in a short ICU stay, having a positive impact on the overall cost of transplantation. At this writing, it had been three years since the procedure was performed, and our patient had preserved lung function.

This was the first case in which our team used ECMO as a bridge to LTx, and the excellent result is consistent with the literature.

REFERENCES

- Yusen RD, Edwards LB, Dipchand AI, Goldfarb SB, Kucheryavaya AY, Levvey BJ, et al. The Registry of the International Society for Heart and Lung Transplantation: Thirty-third Adult Lung and Heart-Lung Transplant Report 2016; Focus Theme: Primary Diagnostic Indications for Transplant. *J Heart Lung Transplant.* 2016;35(10):1170-84. <https://doi.org/10.1016/j.healun.2016.09.001>
- Schechter MA, Ganapathi AM, Englum BR, Speicher PJ, Daneshmand MA, Davis RD, et al. Spontaneously Breathing Extracorporeal Membrane Oxygenation Support Provides the Optimal Bridge to Lung Transplantation. *Transplantation.* 2016;100(12):2699-2704. <https://doi.org/10.1097/TP.0000000000001047>
- Toyoda Y, Bhama JK, Shigemura N, Zaldonis D, Pilewski J, Crespo M, et al. Efficacy of extracorporeal membrane oxygenation as a bridge to lung transplantation. *J Thorac Cardiovasc Surg.* 2013;145(4):1065-70; discussion 1070-1. <https://doi.org/10.1016/j.jtcvs.2012.12.067>
- Fuehner T, Kuehn C, Hadem J, Wiesner O, Gottlieb J, Tudorache I, et al. Extracorporeal membrane oxygenation in awake patients as bridge to lung transplantation. *Am J Respir Crit Care Med.* 2012;185(7):763-8. <https://doi.org/10.1164/rccm.201109-1599OC>
- Jaber S, Jung B, Matecki S, Petrof BJ. Clinical review: ventilator-induced diaphragmatic dysfunction—human studies confirm animal model findings! *Crit Care.* 2011;15(2):206. <https://doi.org/10.1186/cc10023>