

# Ambulatory veno-venous extracorporeal membrane oxygenation

Jonas Andersson Lindholm

ECMO Centre, Department of Pediatric Perioperative Medicine and Intensive Care, Karolinska University Hospital, and Dept of Physiology and Pharmacology, Karolinska Institute, Stockholm, Sweden

*Correspondence to:* Jonas Andersson Lindholm, MD. ECMO Centre, Karolinska University Hospital, Eugeniavägen 23, 171 76 Stockholm, Sweden. Email: [Jonas.andersson-lindholm@sl.se](mailto:Jonas.andersson-lindholm@sl.se).

**Abstract:** Veno-venous extracorporeal membrane oxygenation (VV ECMO) is used for support in patients with severe respiratory failure. The method allows extracorporeal gas exchange and may replace the patient's lung function for weeks and even years. ECMO is not a contraindication for lung transplant. The most important factor for a good outcome is the physiological status of the patient when accepted for transplantation. Ambulatory ECMO makes it possible for the patient to exercise and walk, and provides the best outcome for high risk patients in severe respiratory failure. Ambulatory ECMO is safe in the hands of skilled personnel and prevents critical illness neuropathy and myopathy during prolonged treatments in the intensive care unit.

**Keywords:** Extracorporeal membrane oxygenation (ECMO); ambulatory; lung transplantation

Submitted Aug 16, 2017. Accepted for publication Feb 28, 2018.

doi: 10.21037/jtd.2018.03.42

**View this article at:** <http://dx.doi.org/10.21037/jtd.2018.03.42>

## Introduction

Veno-venous extracorporeal membrane oxygenation (VV ECMO) is commonly used in the industrialized part of the world to support patients with severe respiratory failure. The method allows the use of an extracorporeal gas exchanger to support or replace the patient's lung function for weeks and even years. Many of the 450 Extracorporeal Life Support Organization (ELSO) members (Ann Arbor, MI, USA), report to the ELSO Registry and the numbers of very long ECMO support extending over 100 days increase. The success rate of patients that have been lung transplanted while on ECMO are also increasing. Centers have developed different methods to prevent critical illness neuropathy and myopathy and loss of muscle mass due to inactivity and to maintain a good physical status of the patient. Intensified physiotherapy is very important in any patient that needs prolonged ECMO support, for time to recover, or for an improved chance to be accepted for a lung transplant (L-TX), with a good outcome. Physical activity is also a very important tool to keep the patient in a good mental state.

## Overview

It has been reported that various forms of ambulatory ECMO is superior to conventional ECMO.

And maybe even better than invasive ventilation to prepare the patient for L-TX. Ambulatory ECMO is essential for the increasing numbers of ECMO for pulmonary support extending beyond 100 days waiting for recovery or transplantation (1-5). VV ECMO may reduce the need for invasive ventilation or even replace invasive ventilation allowing for active and effective physiotherapy and rehabilitation, avoiding critical illness neuropathy and myopathy (6). One dual lumen cannula or two single lumen cannulas for dual site cannulation are both used in ambulatory ECMO. Avoiding a cannula in the groin makes walking and cycling easier but do not preclude active physiotherapy. VV ECMO is the most common mode for ambulatory ECMO, but veno-arterial ECMO in cases with pulmonary hypertension is also used in ambulatory ECMO. Bleeding at cannula site may be a problem. Thus, VV ECMO may be preferred since cannulas in low pressure vessels are known to carry less risk for bleeding problems (7-9).

### Ambulatory ECMO is safe

Ambulatory ECMO performed in high volume centers familiar with the risks involved seem to be safe (10-12). It should be noted that, when patients are doing active physiotherapy bedside or on the treadmill, there is a need for increased numbers of skilled staff in the ICU.

### Ambulatory ECMO can be cost effective

The cost for ambulatory ECMO is higher compared to “conventional” ECMO. Note that conventional ECMO nowadays is performed with the patient awake doing physiotherapy in the bed. By providing better active physiotherapy in the concept of ambulatory ECMO, the length of stay in the ICU after a for example a L-TX is shorter and the mortality lower. Thus, ambulatory ECMO can be more cost-effective by reducing the total cost (5,13,14).

### Lung transplantation outcome while on ambulatory ECMO

Immobilized patients in respiratory failure that require sedation and invasive ventilation or in combination with ECMO are known to have difficulty in recovering after L-TX. This results in a high posttransplant mortality rate. Reports to ELSO registry from several centers support the use of ECMO as a method to deliver oxygen while waiting for a L-TX (9). By supplying enough oxygen to allow the patient to be awake, standing and walking, ambulatory ECMO have been proven to increase survival post L-TX. The survival is still better in patients who are not in need for invasive ventilation support. However, survival after L-TX from ECMO is reasonable and ECMO should not exclude any patient from L-TX. Awake patients on ECMO and active with physiotherapy results in the best outcome for the population with severe respiratory failure (6,15,16).

### Ambulatory ECMO better than ventilator?

Reports suggest that ambulatory ECMO with spontaneous breathing is better than invasive ventilator support if it means that the patient can participate in active physiotherapy (3,5,10,17). A case report even suggests ambulatory ECMO as a protective strategy for primary graft dysfunction to minimize the use of invasive ventilation post L-TX. Such strategy will promote time for the lungs to

improve using minimum invasive ventilation, or even allow spontaneous breathing (18).

### Is ambulatory ECMO always necessary?

Not always. In acute respiratory failure ECMO is used when invasive ventilation does not provide enough support for oxygenation and or carbon dioxide clearance. In the beginning of an ECMO treatment the patient is usually sedated as a continuum of the previous sedative regime during invasive ventilation. Awake patients are necessary for active physiotherapy and for prevention of critical illness neuropathy and myopathy. After a few weeks, there should be a discussion and efforts made to get the patient out of the bed. Most patients though, recover lung function without having been out of bed walking (9). For patients, already on the waiting list for a L-TX who develop severe respiratory failure in need for ECMO support, the answer is probably “Yes” (3,5,6,10,15-17).

### Discussion

In prolonged respiratory insufficiency, it seems important to support the patient with enough oxygen to allow active physiotherapy, for physical and mental status. If this cannot be accomplished with invasive ventilation, ECMO should be considered, maybe even to replace the support of ventilation. Spontaneous breathing might be a goal but depending on pulmonary status a tracheal cannula for suctioning may still be needed. Patients who have walked around the bed have better survival after a lung transplant compared to patients that are not mobilized in the ICU. Not surprisingly, since the longer a patient is unable to do physiotherapy the risk for critical illness neuropathy and myopathy increases. Thus, the patient is also submitted to an increased risk for secondary infections. If the patient suffers from chronic pulmonary disease and is waiting for L-TX, it might be better to start ECMO very early if ventilator support does not offer enough oxygenation to enable physiotherapy.

In the light of the very “prolonged” ECMO run with the aim to support the patient to recover, the method to assist an awake patient with enough oxygen to enable physical activity may be the better way to treat respiratory failure, compared to suppressing the patient’s need of oxygen by sedation. Unfortunately, opting to use an ECMO machine instead of a ventilator is not as safe due to ECMO related complications reported by the ELSO Registry (9). ECMO

treatment is too complex to be used and handled by every ICU (12).

Today there are patients on support with artificial heart pumps and dialysis machines in their own homes. However, there is still need for major improvements in simplicity and safety before ECMO may be used in every ICU for respiratory support. With the changing dynamics of physiology during lung disease, gas exchange in the lungs, and a constant risk of pulmonary hypertension leading to acute heart failure, a wide competence and broad range of resources are required which means that respiratory support with ECMO for a widespread use is a contentious issue.

### Conclusions

Priority for patients in respiratory failure waiting for transplantation should be active physiotherapy. If that cannot be allowed using invasive ventilation ambulatory ECMO should be considered. Ambulatory ECMO and spontaneous breathing might even be better than ventilator support. Ambulatory ECMO should also be considered as protective treatment in primary graft dysfunction post lung transplantation. If performed in high volume centers ambulatory ECMO is safe.

### Acknowledgements

None.

### Footnote

*Conflicts of Interest:* The author has no conflicts of interest to declare.

### References

- Hartwig MG, Zanotti G, Rehder K, et al. 149 Ambulatory ECMO provides a superior bridge to lung transplantation compared to conventional ECMO. *J Heart Lung Transplant* 2012;31:S59.
- Turner DA, Rehder KJ, Bonadonna D, et al. Ambulatory ECMO as a bridge to lung transplant in a previously well pediatric patient with ARDS. *Pediatrics* 2014;134:e583-5.
- Hayes D Jr, Kukreja J, Tobias JD, et al. Ambulatory venovenous extracorporeal respiratory support as a bridge for cystic fibrosis patients to emergent lung transplantation. *J Cyst Fibros* 2012;11:40-5.
- Garcia JP, Iacono A, Kon ZN, et al. Ambulatory extracorporeal membrane oxygenation: A new approach for bridge-to-lung transplantation. *J Thorac CardioVasc Surg* 2010;139:e137-9.
- Nosotti M, Rosso L, Tosi D, et al. Extracorporeal membrane oxygenation with spontaneous breathing as a bridge to lung transplantation. *Interact Cardiovasc Thorac Surg* 2013;16:55-9.
- Lehr CJ, Zaas DW, Cheifetz IM, et al. Ambulatory extracorporeal membrane oxygenation as a bridge to lung transplantation: walking while waiting. *Chest* 2015;147:1213-8.
- Camboni D, Philipp A, Mueller T, et al. An important step toward ambulatory veno-venous extracorporeal membrane oxygenation. *J Thorac CardioVasc Surg* 2012;144:282-3.
- Schmidt F, Jack T, Sasse M, et al. Back to the roots? Dual cannulation strategy for ambulatory ECMO in adolescent lung transplant candidates: An alternative? *Pediatr Transplant* 2017;21:e12907.
- Extracorporeal Life Support Organization, ELSO registry. Available online: <https://www.else.org>
- Turner DA, Cheifetz IM, Rehder KJ, et al. Active rehabilitation and physical therapy during extracorporeal membrane oxygenation while awaiting lung transplantation: a practical approach. *Crit Care Med* 2011;39:2593-8.
- Polastri M, Loforte A, Dell'Amore A, et al. Physiotherapy for Patients on Awake Extracorporeal Membrane Oxygenation: A Systematic Review. *Physiother Res Int* 2016;21:203-9.
- Combes A, Brodie D, Bartlett R, et al. Position paper for the organization of extracorporeal membrane oxygenation programs for acute respiratory failure in adults. *Am J Respir Crit Care Med* 2014;190:488-96.
- Rehder KJ, Turner DA, Hartwig MG, et al. Active rehabilitation during ECMO as a bridge to lung transplantation. *Respiratory Care* 2013;58:1291-8.
- Bain JC, Turner DA, Rehder KJ, et al. Economic outcomes of extracorporeal membrane oxygenation with and without ambulation as a bridge to lung transplantation. *Respir Care* 2016;61:1-7.
- Inci I, Klinzing S, Schneider D, et al. Outcome of Extracorporeal Membrane Oxygenation as a bridge to lung transplantation: An Institutional Experience and Literature Review. *Transplantation* 2015;99:1667-71.
- Hoopes CW, Kukreja J, Golden J, et al. Extracorporeal membrane oxygenation as a bridge to pulmonary transplantation. *J Thorac Cardiovasc Surg* 2013;145:862-7; discussion 867-8.

17. Salam S, Kotloff R, Garcha P, et al. Lung transplantation after 125 days on ECMO for severe refractory hypoxemia with no prior lung disease. *ASAIO J* 2017;63:e66-8.
18. Hayes D Jr, Galantowicz M, Yates AR, et al. Venovenous

ECMO as a bridge to lung transplant and a protective strategy for subsequent primary graft dysfunction. *J Artif Organs* 2013;16:382-5.

**Cite this article as:** Lindholm JA. Ambulatory venovenous extracorporeal membrane oxygenation. *J Thorac Dis* 2018;10(Suppl 5):S670-S673. doi: 10.21037/jtd.2018.03.42