ECMO bridging to Lung transplantation

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The History of Extracorporeal Membrane Oxygenation and the Development of Extracorporeal Membrane Oxygenation Anticoagulation Semin Thromb Hemost 2024;50:81–90.

Development of ECMO

- ECMO, extracorporeal membrane oxygenation
  - developed in the late 1960s and used for human since early 1970s by a team of Robert H. Bartlett
  - to achieve prolonged extracorporeal circulation by prevent the interface between air and blood in the original CPB system

Prolonged Extracorporeal Oxygenation for Acute Post-Traumatic Respiratory Failure (Shock-Lung Syndrome) — Use of the Bramson Membrane Lung
N Engl J Med 1972;286:629-634

Prolonged extracorporeal cardiopulmonary support in man
JTCVS 1974;68(6):918-932

Bartlett RH, Andrews AF, Toomasian JM, Haiduc NJ, Gazzaniga AB. Extracorporeal membrane oxygenation for newborn respiratory failure: forty-five cases. Surgery 1982;92(02):425–433

→ ECMO become standard treatment for pediatric cardiac & respiratory failure unresponsive to other treatment

Increasing role of ECMO in respiratory failure

- H1N1 influenza pandemic in 2009
  - improved outcomes in ARDS patients cared by ECMO [CESAR trial]

Efficacy and economic assessment of conventional ventilatory support versus extracorporeal membrane oxygenation for severe adult respiratory failure (CESAR): a multicentre randomised controlled trial *Lancet* 2009; 374: 1351–63

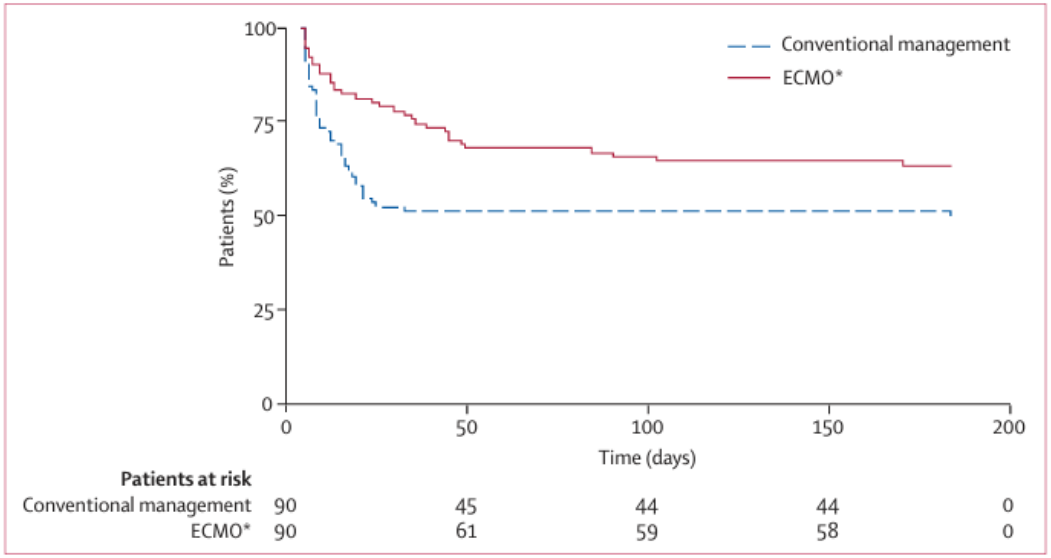


Figure 2: Kaplan-Meier survival estimates

➔ the number of patients supported on ECMO, opportunity to support critically ill patients grown dramatically

ECMO bridging- era of LAS

Effect of the lung allocation score on lung transplantation in the United States

J Heart Lung Transplant 2016;35:433–439

- Lung allocation score (LAS) era
  - adopted since 2005
  - priority based on waiting time → prioritization of sicker patients
  - decreasing waiting list time for patients with the most urgent need for transplant

➔ problems the transplant centers faced

1) how to maintain optimal status of sicker patients during waiting time
2) how to extend the lives of critically-ill patients at risk

ECMO bridging to lung transplant

- Considered as a risk factor for poor survival

Who is the high-risk recipient? Predicting mortality after lung transplantation using pretransplant risk factors

J Thorac Cardiovasc Surg 2009;138:1234-38

TABLE 1. Risk factor score model variables

	Points	OR	95% CI	*P* value
Risk score variables				
ECMO	6.9	6.937	2.391–20.127	.000

- RE-evaluate use of ECMO as a pre-transplant support modality
  - modern pumps, heparin-coated silicone membrane

Extracorporeal Membrane Oxygenation in Awake Patients as Bridge to Lung Transplantation

Am J Respir Crit Care Med Vol 185, Iss. 7, pp 763–768, Apr 1, 2012

TABLE 1. COMPARISON OF PATIENT CHARACTERISTICS AND OUTCOMES IN THE AWAKE ECMO GROUP AND THE MECHANICAL VENTILATION GROUP

	Mechanical Ventilation Group	Awake ECMO Group	*P* Value
Death after LuTx, n (% of transplant patients)	12 (50)	4 (20)	0.02
Days on ICU (survivors only), median (range)	39 (4–74)	18 (1–69)	0.07
Days in hospital stay (survivors only), median (range)	67 (23–90)	38 (20–87)	0.06

Awake Extracorporeal Membrane Oxygenation as Bridge to Lung Transplantation: A 9-Year Experience

Ann Thorac Surg 2017;104:412–9

Table 4. Survival Outcomes

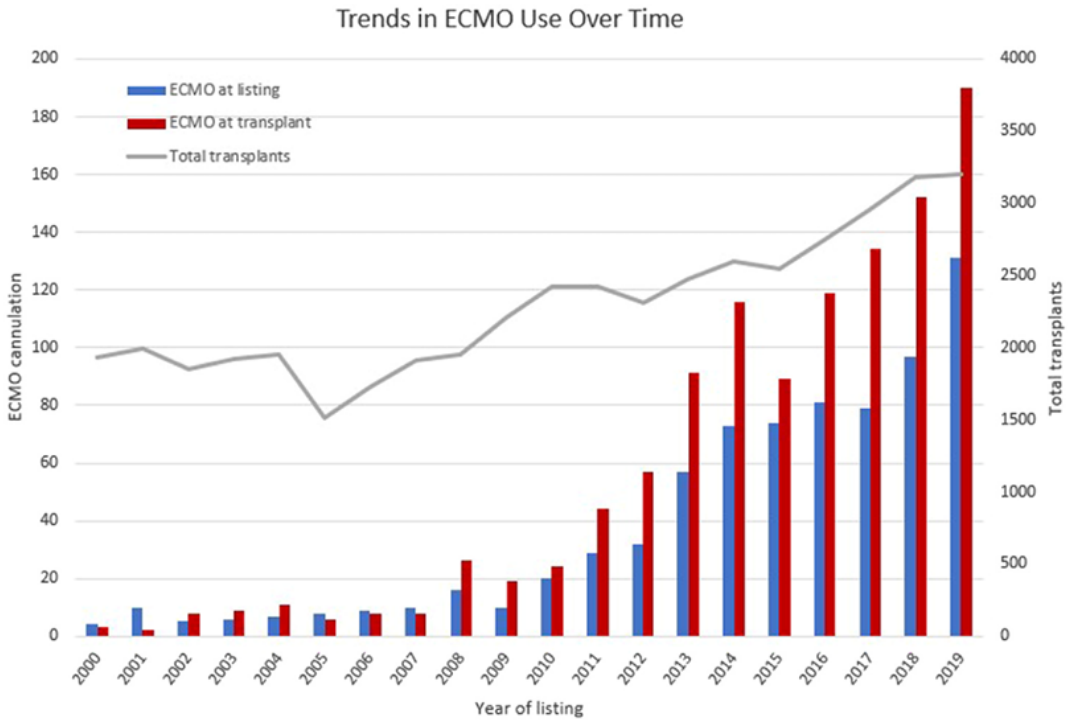
Outcomes	No./at Risk	Percentage (%)
All patients who underwent lung transplantation	n = 40	
To discharge	37/40	92.5%
1-year	28/31	90.3%
2-year	21/25	84.0%

ECMO bridging to lung transplant

- Increasing use of ECMO bridging

Extracorporeal membrane oxygenation as a bridge to lung transplantation: Practice patterns and patient outcomes

J Heart Lung Transplant 2024;43:77–84



Waitlist Mortality and Extracorporeal Membrane Oxygenation Bridge to Lung Transplant

(Ann Thorac Surg 2023;116:156-63)

April 2016 to December 2021, 445 bridged patients
In UNOS database

ECMO bridging to lung transplant

- Allocation in Korea
  - 응급도 0
    1. 호흡부전으로 intubation ventilator 적용 중인 환자
    2. **체외막형 심폐기 (ECMO) 가동 중인 환자**
  - 응급도 1
    1. NYHA IV 이면서 산소 투여 없이 ABGA PaO2 < 55mmHg
    2. NYHA IV이면서 mean PAP > 65mmHg or mean RAP > 15mmHg
    3. cardiac index < 2L/min/m^2 인 경우

응급도 2	응급도3
1. FEV1 < 25% 2. PaO2 < 60mmHg 3. mean RAP 10-15mmHg 4. mean PAP 55-65 mmHg 5. cardiac index < 2-2.5 L/min/min2	1. 단독 폐이식이 필요한 경우 2. 폐기종, 폐고혈압, DILD 3. FEV1 < 30% 4. 호흡부전으로 3번 이상 입원

Considerations for ECMO bridging

- Indication for ECMO bridging
- Configuration of ECMO
- Awakening
- Complications related to ECMO
- Duration of ECMO support

Considerations for ECMO bridging: indication

- Disease diagnosis and severity to determine allocation priority
- Functional, psychosocial, and nutritional status of the patient
- Other disease factors that might affect life expectancy pre- and post-transplant

→ Refractory hypoxemia or hypercarbia or right heart failure despite maximal medical management

Considerations for ECMO bridging: indication

Bridging to lung transplantation with extracorporeal circulatory support: when or when not? *J Thorac Dis* 2017;9(9):3352-3361

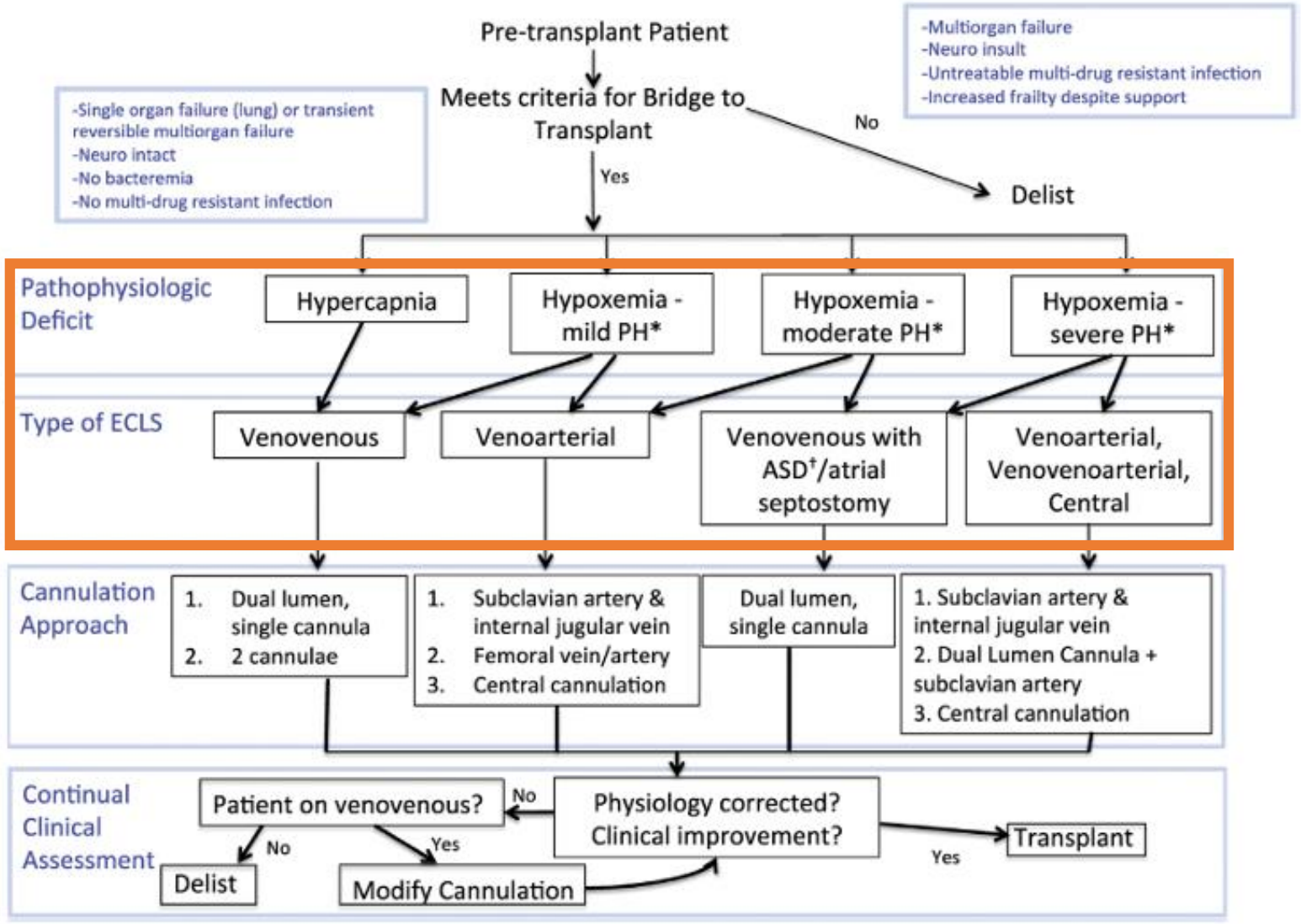
- Contraindications
  - Ineligibility for lung transplantation
  - Irreversible end-organ failure affecting multi organs
  - Sepsis and bacteremia
  - Contraindications to systemic anticoagulation
  - Uncontrolled metastatic disease
  - Acute intracerebral hemorrhage or stroke

→ Need multidisciplinary team approach

Considerations for ECMO bridging: indication & configuration

Awake Extracorporeal Membrane Oxygenation as Bridge to Lung Transplantation: A 9-Year Experience

Ann Thorac Surg 2017;104:412–9



Considerations for ECMO bridging: configuration

Table 1 Cannulation strategies for specific pre-lung transplant disease states

Mechanism of failure	Cannulation approach	ECMO parameters
Hypercapnic respiratory failure		
Cystic fibrosis, COPD	Small bore bicaval	Goal ECMO flow of 2.5 to 3.5 L/min Titrate sweep for goal $PaCO_2$ of 35–45 with no resting dyspnea
Hypoxic respiratory failure		
Idiopathic pulmonary fibrosis	Large bore bicaval or femoral-IJ	Goal ECMO flows of 3.5 to 5 L/min May require HFNC to maintain SpO_2 >90%
Right ventricular failure		
Group 1 pulmonary hypertension	Peripheral VA ECMO	Goal ECMO flows of 2.5 to 3.5 L/min to offload the right ventricle
Group 3 pulmonary hypertension	Large bore bicaval with atrial septostomy or RV bypass ECMO	Goal ECMO flows of >3.5 L/min or more as needed to maintain SpO_2 >90%

ECMO, extracorporeal membrane oxygenation; COPD, chronic obstructive lung disease; IJ, internal jugular; HFNC, high flow nasal cannula; VA, venoarterial.

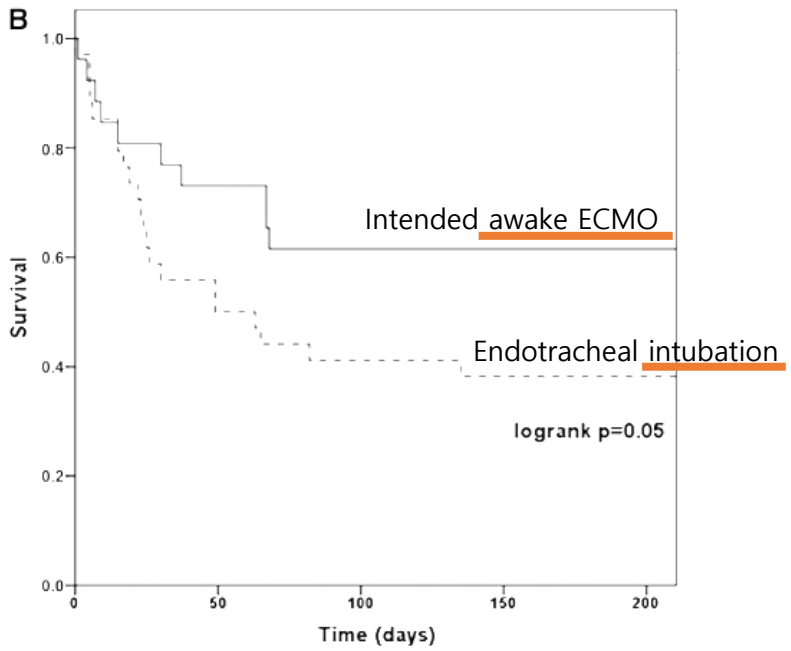
Ann Cardiothorac Surg 2020;9(1):29-41

Considerations for ECMO bridging: Awakening

- Awakening ECMO
  - Spontaneous breathing, non-sedated related to pre-transplant vitality and post-transplant survival

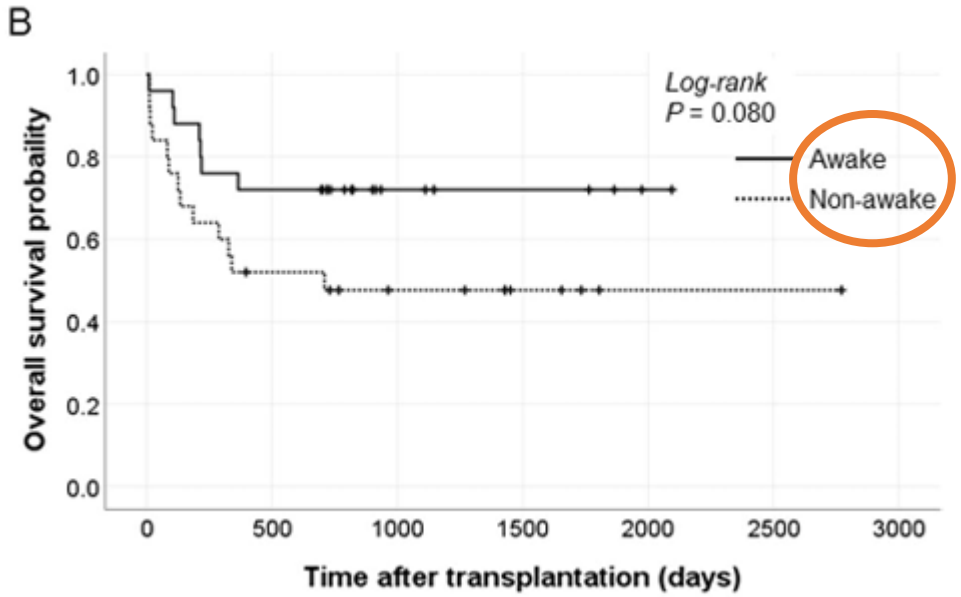
Extracorporeal Membrane Oxygenation in Awake Patients as Bridge to Lung Transplantation

Am J Respir Crit Care Med Vol 185, Iss. 7, pp 763–768, Apr 1, 2012



Long- and short-term clinical impact of awake extracorporeal membrane oxygenation as bridging therapy for lung transplantation

Kim *et al. Respiratory Research* (2021) 22:306



Considerations for ECMO bridging: Awakening

- Awakening ECMO

Awakening in extracorporeal membrane oxygenation as a bridge to lung transplantation

Acute and Critical Care 2022 February 37(1):26-34

Table 1. Advantages and disadvantages of awake ECMO

Status	Advantage	Disadvantage
Maintenance of physical activity	Maintain muscle mass and strength	Increase the risk of catheter dislocation
Spontaneous breathing	Maintain respiratory muscle and diaphragm function	Increase transpulmonary pressure and the risk of ventilator-induced lung injury
	Maintain the expansion of the chest wall and lungs	Increases oxygen consumption and CO_2 production
	Favor venous return and maintains cardiac filling	
Avoiding intubation	Reduce the risk of ventilator-associated pneumonia	Sometimes emergency intubation may be required.
Awake through reducing use of sedative and analgesic	Reduce the risk of delirium	Increase pain, discomfort, and anxiety
	Enhance communication between the medical staff and the patient	
	Allow participation in decision making	

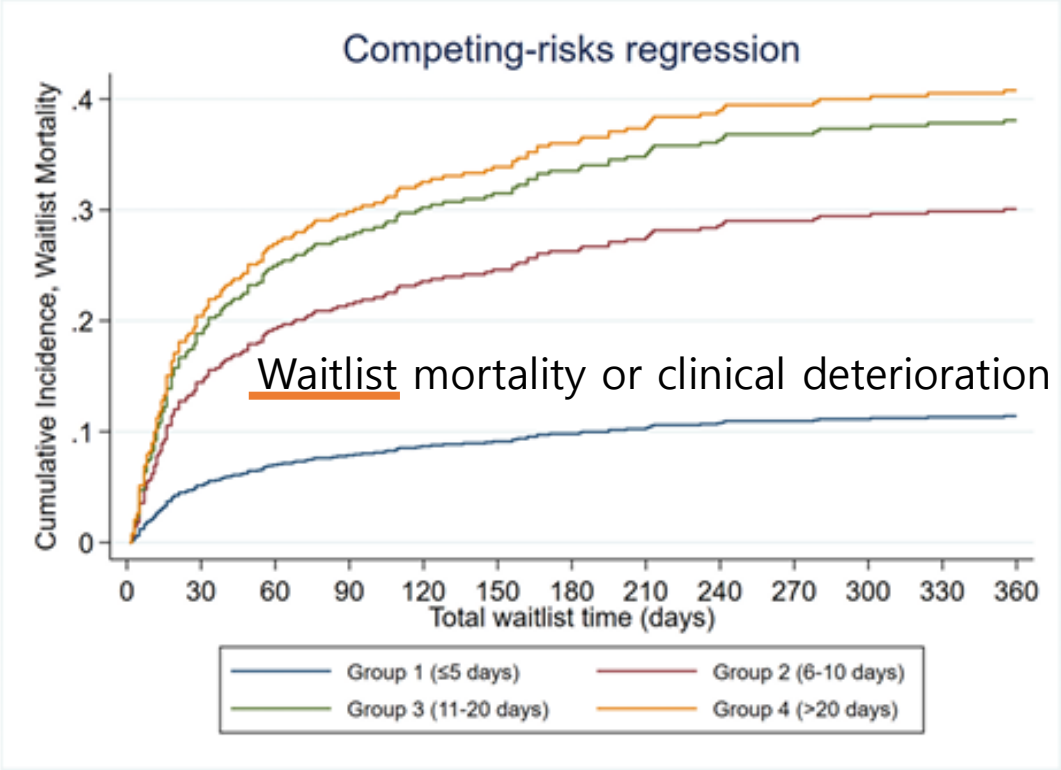
Table 2. Indications and contraindications of awake ECMO

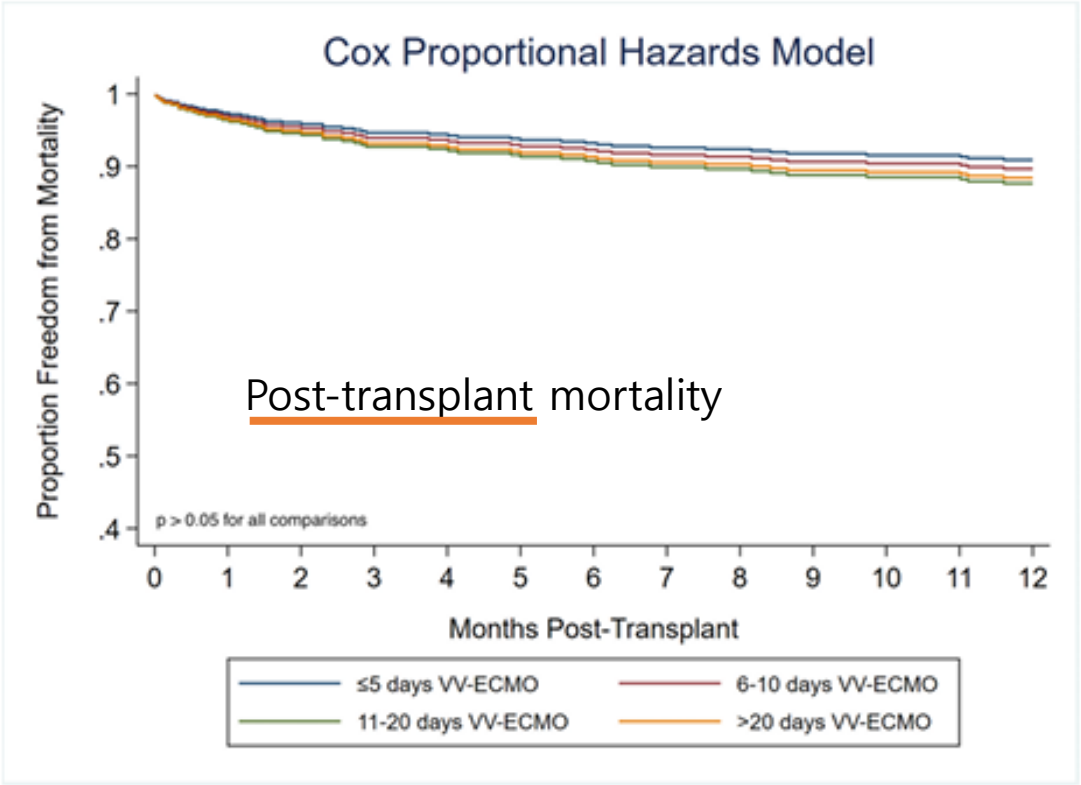
Awake ECMO
Indication
Ability to protect airways
Low dose or no vasoactive requirement
No need for high PEEP
Contraindication
Hemodynamic unstable (high dose of vasoactive drugs)
Deep sedation and muscle relaxation (RASS 3–4)
Active bleeding
Malignant arrhythmia
Brain injury
Unstable blood flow mechanics
Unexpected high respiratory rate or severe anxiety

Considerations for ECMO bridging: Duration of ECMO support

Impact of Extracorporeal Membrane Oxygenation Bridging Duration on Lung Transplant Outcomes

Ann Thorac Surg. 2024 May 11:S0003-4975(24)00361-8.





Considerations for ECMO bridging: complications of ECMO

- Related to circuit and cannula
- Bleeding complications
- Infection
- Multiorgan failure including acute renal failure requiring renal replacement therapy

TABLE 2 Causes of death in ECMO bridging

Deaths in bridging	Studies involved	n (deaths/ total)	%
Total	10	123/534	23.03
Right heart failure	3	11/137	8.03
Multiple organ failure	4	13/185	7.03
Bleeding (not Cranial)	2	5/107	4.67
Cranial bleeding	3	7/222	3.15
Sepsis	2	6/207	2.90
Cardiopulmonary resuscitation	1	2/87	2.30
Cerebrovascular accident	1	2/120	1.67
Massive haemolysis	1	1/87	1.15
Primary graft failure	1	1/120	0.83
Respiratory failure	1	1/120	0.83

Extracorporeal membrane oxygenation as a bridge vs. non-bridging for lung transplantation: A systematic review and meta-analysis

Clinical Transplantation. 2021;35:e14157.

Considerations for ECMO bridging: experience in Korea

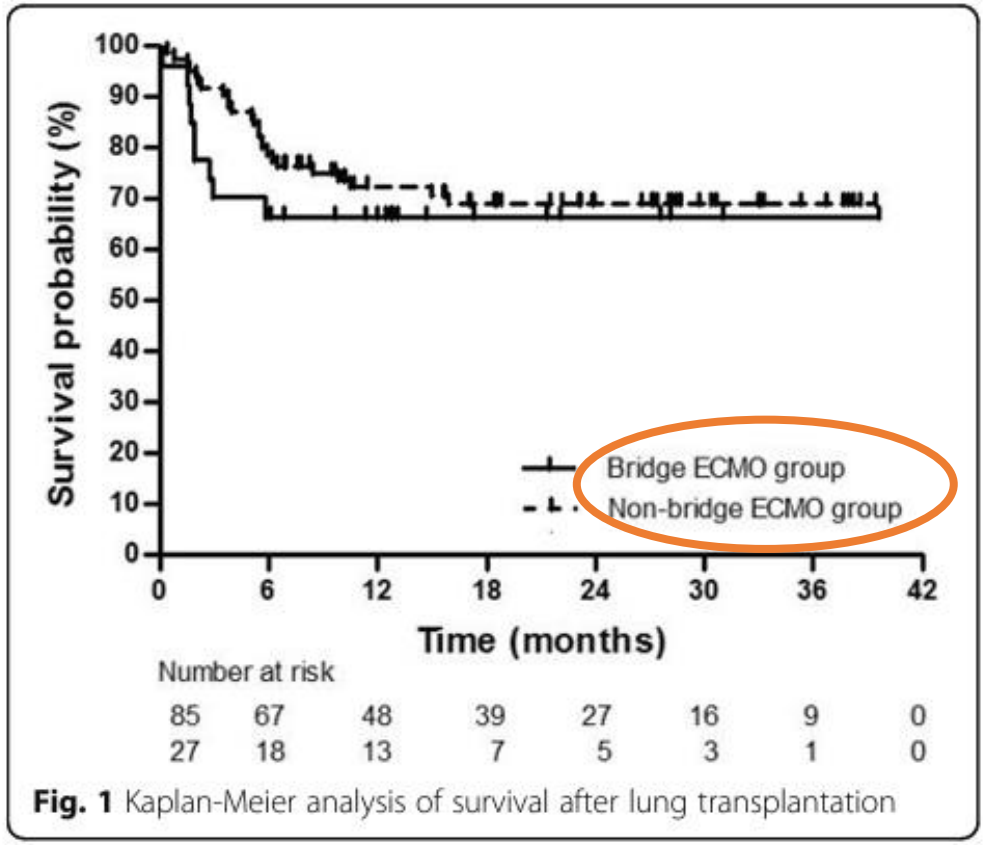
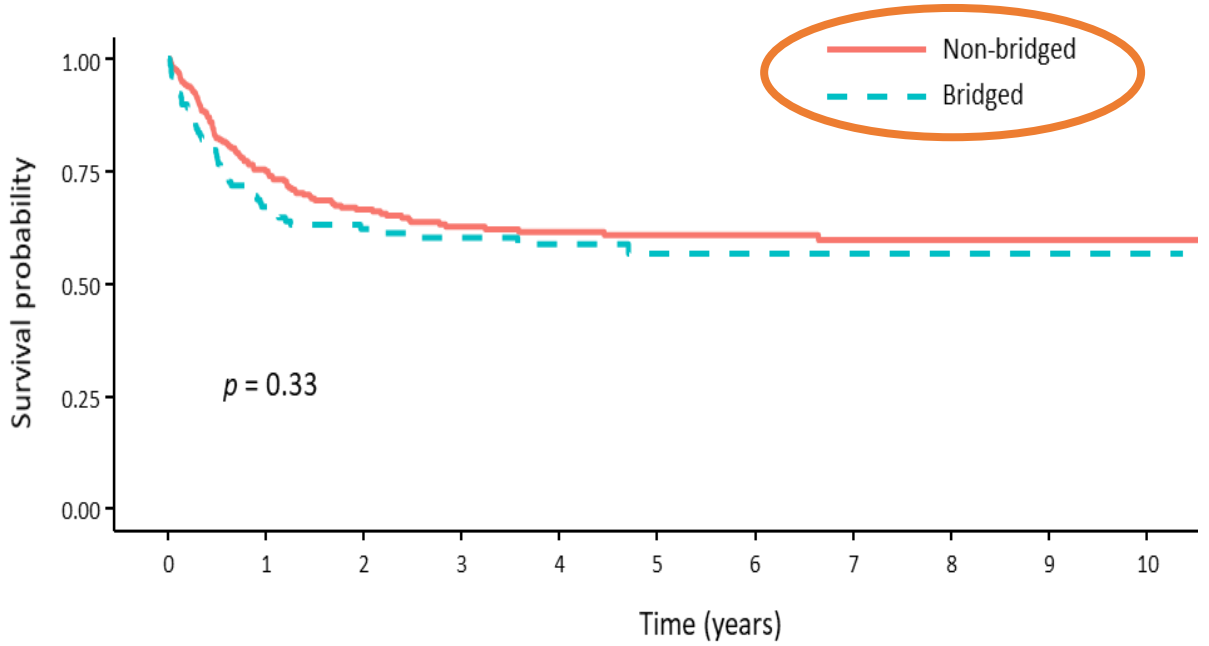


Fig. 1 Kaplan-Meier analysis of survival after lung transplantation

Extracorporeal membrane oxygenation as a bridge to lung transplantation: analysis of Korean organ transplantation registry (KOTRY) data

Ko *et al. Respiratory Research* (2020) 21:20



Number at risk

Non-bridged	277	204	153	117	97	78	66	45	32	19	6
Bridged	128	85	68	46	39	19	12	10	6	3	1

-non-published data, severance hospital Jan 2013 – Dec 2022
-a total of 405 BTT, ECMO-bridged 128 patients
-no survival difference between the groups

Current issues

- ECMO bridge to lung transplantation is feasible, for sure.

- ‘When, To whom, How, How long’
- Awakening strategy
- Proper duration for ECMO bridging

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