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Ten situations in which ECMO is unlikely to be successful

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Extracorporeal membrane oxygenation (ECMO) used for respiratory or cardiac support is frequently considered a rescue therapy when "conventional" management fails. Although the prognoses of these patients have steadily improved over the last decade, the technique is still marred by high mortality (30–70 %). Moreover, ECMO is expensive—in supplies, human resources, and time—which encourages restraining its use for patients who are more likely to survive. Efforts have recently been made to identify the main risk factors associated with ECMO failure for both acute respiratory distress syndrome (ARDS) (Table 1) and refractory cardiogenic shock. We describe below ten situations in which ECMO is unlikely to be successful.

Table 1 Main pre-ECMO risk factors of in-hospital mortality for severe ARDS

Increasing age [6–8, 13]
Increasing SOFA score [8, 13]
Immunocompromised status [6–8, 13]
≥7 days of mechanical ventilation [7, 8]
ARDS diagnosis [7, 13]
Elevated plateau pressure [7, 8]
Multiorgan dysfunctions [6, 7]

1. Wrong choice of ECMO configuration

Before cannulation, evaluation of cardiac function is crucial to decide which configuration, namely venoarterial (VA-ECMO) or venovenous (VV-ECMO), is most appropriate. Major cardiac dysfunction, associated or not with pulmonary failure, requires VA-ECMO. On the other hand, peripheral VA-ECMO is not indicated for ARDS with preserved cardiac function and may further worsen pulmonary and cardiac functions for several reasons. First, the return flow through the ascendant aorta generates flow competition between the heart and the ECMO pump, and increases left ventricular afterload, which may, in turn, increase the risk of myocardial damage and stunning. Second, impaired lung function may lead to the "Harlequin" syndrome, with deoxygenated blood in the upper part of the body and hyperoxygenated in the lower part. Third, use of ultraprotective ventilation prevents the lung from resting. Lastly, it exposes the patient to severe associated arterial line complications, e.g., leg ischemia, arterial embolism, and arterial hemorrhage.

2. Chronic respiratory or cardiac disease with no hope of recovery or transplant

Because it can prolong a patient's life for days or weeks in the ICU with sophisticated and resource-intensive technology, ECMO should only be considered if there is real hope for a transplant, recovery, or long-term cardiac-assist device. If not, ECMO should be considered a futile "bridge to nowhere" [1]. The most common example of this situation is refractory shock due to end-stage dilated cardiomyopathy with no obvious precipitating factor, in a patient not eligible for heart transplantation or long-term assist device.

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3. Out-of-hospital cardiac arrest with prolonged low blood flow

Data from clinical studies investigating ECMO use in out-of-hospital cardiac arrest patients are scarce and limited to small case series or case reports. By focusing on more critically ill patients (i.e., refractory cardiac arrest), the burden of out-of-hospital cardiac arrest patients receiving ECMO–CPR after cardiopulmonary resuscitation lasting more than 50 min is, in this context, very high. Indeed, reported overall survival ranged between 4 and 36 % [2, 3], with 4–27 % having favorable neurological outcomes [2, 3]. To date, ECMO use in patients with out-of-hospital cardiac arrest and prolonged low blood flow (profound hypothermia and cardiotoxic drug-overdose excluded) must still be considered experimental, as no robust data support using ECMO–CPR in a pre-hospital setting.

4. Severe aortic regurgitation or type-A aortic dissection

More than moderate aortic regurgitation is a contraindication for ECMO because the risk of ventricular overloading is too high. However, for mild-to-moderate aortic regurgitation, ventricular venting is always preferable during ECMO support to prevent ventricular distension.

In the case of type-A aortic dissection, femoral artery cannulation is associated with a risk of potential further aggravation of the dissection throughout the rest of the aorta and a risk of retrograde dissection of arteries supplying the brain. In the absence of axillary artery dissection, its cannulation decreases the risk of vascularizing the false lumen, which would worsen the dissection. However, the axillary surgical approach is more difficult and, therefore, appears to be less suitable for emergency cannulation.

5. Refractory septic shock in adults with preserved left ventricular function

In recent published studies, most of the enrolled septic shock patients with unfavorable outcomes on ECMO paradoxically had preserved left ventricular function [4]. Thus, ECMO might be of little value for adults with a distributive shock pattern with low systemic vascular resistance and refractory hypotension, despite preserved cardiac index. However, ECMO can be used to support decreased cardiac output in patients with cardiogenic septic shock unresponsive to very high catecholamine doses [5].

6. Allogeneic stem cell transplantation (ASCT)

Although consistently associated with poorer survival [6–8], ECMO treatment of immunocompromised patients can yield reasonably good outcomes in many instances [9]. However, ASCT recipients are an exception, as they have dismal outcomes in this setting [10, 11]. Notably, the four adults with hematological malignancies included in a recent cohort [11], who had undergone ASCT and received ECMO support for acute respiratory failure, died. Similar reports on pediatric patients stressed the negative prognostic impact of ASCT on critical illness with an overall hospital discharge rate of 10 % [12].

7. Advanced age in ARDS

Age was consistently retained as an independent risk factor of mortality in all models predicting survival on ECMO for ARDS. For example, being younger than 45 years old was associated with a better prognosis, according to the PRESERVE score [8] and the score of Roch et al. [13], while an age of at least 60 years markedly impacted survival in the RESP score [7]. In our opinion, denying ECMO support to anyone over 70 years old with severe ARDS may be a wise limit.

8. ARDS with multiorgan failure

The number of organ dysfunctions, especially extrapulmonary, must be considered before initiating ECMO for ARDS. A high number of pre-ECMO organ failures, as assessed with the sepsis-related organ failure assessment (SOFA) score [8, 13] or by detailed individual organ dysfunction [6, 7], have consistently been associated with poor outcomes of ECMO-treated ARDS populations.

9. Prolonged pre-ECMO mechanical ventilation

The authors of several studies suggested an influence of the timing of ECMO on prognosis. A lower predicted chance of survival for each extra-cardiac-associated organ failure at ECMO onset illustrates the crucial impact of ECMO timing for both respiratory [6–8, 13] and cardiac indications. For patients with severe ARDS, mechanical ventilation lasting at least 7 days before ECMO initiation has been associated with a poorer outcome [7, 8].

10. Center inexperienced with ECMO

Recent analyses of large pediatric and adult databases suggested a strong association of higher hospital-level ECMO volume and lower mortality [14, 15]. Expert centers treating sufficient numbers of patients might provide better prevention and management of severe complications, which might occur during long ECMO runs [16].

Compliance with ethical standards

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References

1. Abrams DC, Prager K, Blinderman CD, Burkart KM, Brodie D (2014) Ethical dilemmas encountered with the use of extracorporeal membrane oxygenation in adults. Chest 145:876–882
2. Le Guen M, Nicolas-Robin A, Carreira S, Raux M, Leprince P, Riou B, Langeron O (2011) Extracorporeal life support following out-of-hospital refractory cardiac arrest. Crit Care 15:R29
3. Maekawa K, Tanno K, Hase M, Mori K, Asai Y (2013) Extracorporeal cardiopulmonary resuscitation for patients with out-of-hospital cardiac arrest of cardiac origin: a propensity-matched study and predictor analysis. Crit Care Med 41:1186–1196
4. Park TK, Yang JH, Jeon K, Choi SH, Choi JH, Gwon HC, Chung CR, Park CM, Cho YH, Sung K, Suh GY (2015) Extracorporeal membrane oxygenation for refractory septic shock in adults. Eur J Cardiothorac Surg 47:e68–e74
5. Brechot N, Luyt CE, Schmidt M, Leprince P, Trouillet JL, Leger P, Pavie A, Chastre J, Combes A (2013) Venoarterial extracorporeal membrane oxygenation support for refractory cardiovascular dysfunction during severe bacterial septic shock. Crit Care Med 41:1616–1626
6. Enger TB, Philipp A, Videm V, Lubnow M, Wahba A, Fischer M, Schmid C, Bein T, Muller T (2014) Prediction of mortality in adult patients with severe acute lung failure receiving veno-venous extracorporeal membrane oxygenation: a prospective observational study. Crit Care 18:R67
7. Schmidt M, Bailey M, Sheldrake J, Hodgson C, Aubron C, Rycus PT, Scheinkestel C, Cooper DJ, Brodie D, Pellegrino V, Combes A, Pilcher D (2014) Predicting survival after extracorporeal membrane oxygenation for severe acute respiratory failure. The Respiratory Extracorporeal Membrane Oxygenation Survival Prediction (RESP) score. Am J Respir Crit Care Med 189:1374–1382
8. Schmidt M, Zogheib E, Roze H, Repesse X, Lebreton G, Luyt CE, Trouillet JL, Brechot N, Nieszkowska A, Dupont H, Ouattara A, Leprince P, Chastre J, Combes A (2013) The PRESERVE mortality risk score and analysis of long-term outcomes after extracorporeal membrane oxygenation for severe acute respiratory distress syndrome. Intensive Care Med 39:1704–1713
9. Gow KW, Heiss KF, Wulkan ML, Katzenstein HM, Rosenberg ES, Heard ML, Rycus PT, Fortenberry JD (2009) Extracorporeal life support for support of children with malignancy and respiratory or cardiac failure: the extracorporeal life support experience. Crit Care Med 37:1308–1316
10. Gupta M, Shanley TP, Moler FW (2008) Extracorporeal life support for severe respiratory failure in children with immune compromised conditions. Pediatr Crit Care Med 9:380–385
11. Wohlfarth P, Ullrich R, Staudinger T, Bojic A, Robak O, Hermann A, Lubsczyk B, Worel N, Fuhrmann V, Schoder M, Funovics M, Rabitsch W, Knoebl P, Laczika K, Locker GJ, Sperr WR, Schellongowski P (2014) Extracorporeal membrane oxygenation in adult patients with hematologic malignancies and severe acute respiratory failure. Crit Care 18:R20
12. Di Nardo M, Locatelli F, Palmer K, Amodeo A, Lorusso R, Belliato M, Cecchetti C, Perrotta D, Picardo S, Bertaina A, Rutella S, Rycus P, Di Ciommo V, Holzgraefe B (2014) Extracorporeal membrane oxygenation in pediatric recipients of hematopoietic stem cell transplantation: an updated analysis of the extracorporeal life support organization experience. Intensive Care Med 40:754–756
13. Roch A, Hraiech S, Masson E, Grisoli D, Forel JM, Boucekine M, Morera P, Guervilly C, Adda M, Dizier S, Toesca R, Collart F, Papazian L (2014) Outcome of acute respiratory distress syndrome patients treated with extracorporeal membrane oxygenation and brought to a referral center. Intensive Care Med 40:74–83
14. Barbaro RP, Odetola FO, Kidwell KM, Paden ML, Bartlett RH, Davis MM, Annich GM (2015) Association of hospital-level volume of extracorporeal membrane oxygenation cases and mortality. Analysis of the extracorporeal life support organization registry. Am J Respir Crit Care Med 191:894–901
15. Karamlou T, Vafaeezadeh M, Parrish AM, Cohen GA, Welke KF, Permut L, McMullan DM (2013) Increased extracorporeal membrane oxygenation center case volume is associated with improved extracorporeal membrane oxygenation survival among pediatric patients. J Thorac Cardiovasc Surg 145:470–475
16. Combes A, Brodie D, Bartlett R, Brochard L, Brower R, Conrad S, De Backer D, Fan E, Ferguson N, Fortenberry J, Fraser J, Gattinoni L, Lynch W, MacLaren G, Mercat A, Mueller T, Ogino M, Peek G, Pellegrino V, Pesenti A, Ranieri M, Slutsky A, Vuylsteke A, International ECMO Network (ECMONet) (2014) Position paper for the organization of extracorporeal membrane oxygenation programs for acute respiratory failure in adult patients. Am J Respir Crit Care Med 190:488–496