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How to wean a patient from veno-arterial extracorporeal membrane oxygenation

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Abbreviations

CS	Cardiogenic shock
LVEF	Left ventricular ejection fraction
LV	Left ventricle
RV	Right ventricle
VA-ECMO	Veno-arterial extracorporeal membrane oxygenation

Introduction

Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) can rescue patients with medical, postcardiotomy, or post-cardiac arrest refractory cardiogenic shock (CS) [1, 2]. It can be used as a bridge to cardiac transplantation, to a long-term ventricular assist device (VAD), or until recovery of myocardial function. Weaning success from VA-ECMO is defined as device removal and no further requirement for mechanical support because of recurring CS over the following 30 days [3]. However, to date, only very few studies have reported weaning strategies and outcomes in VA-ECMO patients recovering from severe CS.

Outcomes of patients receiving VA-ECMO

Rates of refractory CS patients who survive after VA-ECMO support vary from 31 to 76 %, depending on underlying causes of CS, comorbidities, and severity of organ dysfunction at ECMO initiation [4–9]. In 81 patients who received VA-ECMO for various indications, our group showed that device insertion under cardiac massage, renal and hepatic failure, and female gender were associated with ICU death, while myocarditis as the cause of CS was associated with better outcomes [4]. Other studies also reported that older age, unsuccessful reperfusion of acute myocardial infarction patients, renal failure, lower Glasgow coma score, high serum butyrylcholinesterase, and high serum lactate were independent risk factors of mortality in VA-ECMO patients [5–10].

Among survivors of recent VA-ECMO series, only 30–70 % were weaned from ECMO support, others being bridged to transplantation or a VAD. Clinical, biological, or echocardiographic parameters may help predict those patients who might ultimately be weaned from ECMO. In 51 patients receiving VA-ECMO, we demonstrated that higher systolic arterial and pulse pressures, echocardiographic measurement of aortic velocity–time integral (VTI), left ventricular ejection fraction (LVEF), and tissue Doppler lateral mitral annulus peak systolic velocity

(TDSa) were associated with successful weaning [3]. In a series of 123 postcardiotomy VA-ECMO patients, Li et al. [10] demonstrated that initial lactate and early lactate clearance in the 12 h following ECMO initiation were independent predictors of successful ECMO weaning. In contrast, serum measurement of the N-terminal fragment of the B-type natriuretic peptide, troponin Ic, proatrial natriuretic peptide, proadrenomedullin, and copeptin on days 1, 3, and 7 after ECMO initiation did not predict cardiac recovery in another series of 41 patients receiving VA-ECMO [11].

Additionally, it should be noted that 20–65 % of patients weaned from VA-ECMO after myocardial recovery do not survive to hospital discharge [4–10], mainly because of severe neurological injuries, comorbidities, or multisystem organ failure. Therefore, only patients who survived more than 30 days after ECMO removal without subsequent need for mechanical support should be considered as successfully weaned from the device.

When should a VA-ECMO patient be considered for weaning?

The first consideration is that the etiology of cardiac failure must be compatible with myocardial recovery (Fig. 1) [1–3]. For example, patients with terminal dilated cardiomyopathy who need ECMO support should be bridged to cardiac transplantation or to a temporary VAD, unless a very specific decompensation factor (such as rapid supraventricular arrhythmia, severe septic shock) can be cured. Second, the patient should have recovered a pulsatile arterial waveform for at least 24 h, should be hemodynamically stable, with baseline mean arterial pressure greater than 60 mmHg in the absence or with low doses of catecholamines, and should have recovered from major metabolic disturbances [2, 3]. Third, pulmonary function should not be severely impaired. If PaO_2/FiO_2 is less than 100 mmHg when FiO_2 of the ECMO gas flow is set at 21 %, bridging the patient from VA- to VV-ECMO should be considered [12].

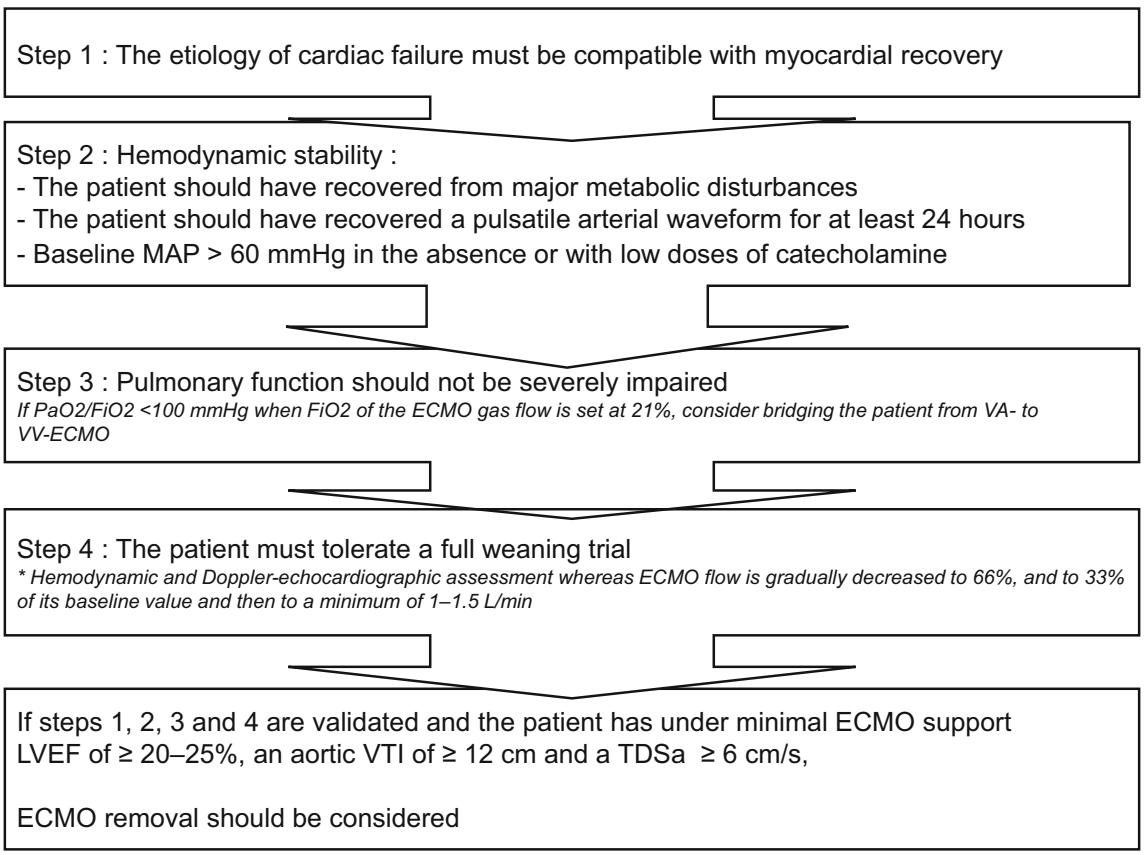

Fig. 1 Recommendations for successful weaning from VA-ECMO. *MAP* mean arterial pressure, *VTI* velocity–time integration, *LVEF* left ventricular ejection fraction, *TDSa* tissue Doppler lateral mitral annulus peak systolic velocity, *RV* right ventricle, *CI* cardiac index, *PCWP* pulmonary capillary wedge pressure, *CVP* central venous pressure

In general, it is unusual to attempt weaning in the first 72 h after VA-ECMO implantation. However, the duration of ECMO support may be shorter in case of drug intoxication or catecholamine-induced cardiomyopathy.

How to manage weaning

An ECMO weaning trial consisting in decreasing ECMO blood flow will result in an increase in RV preload and a decrease in LV afterload that will allow one to assess whether myocardial recovery will permit removal of the device [13]. We evaluated this strategy in 51 hemodynamically stable VA-ECMO patients who had recovered a pulsatile flow. ECMO flow was gradually decreased to 66 % and to 33 % of its baseline value and then to a minimum of 1–1.5 L/min [3]. If mean blood pressure dropped constantly less than 60 mmHg at any time during the trial, ECMO blood flow was returned to 100 % of its baseline value and the trial was stopped. Among the 51 patients, 38 tolerated the complete weaning trial, of whom 20 were ultimately weaned. Patients successfully weaned had aortic VTI of at least 10 cm, LVEF greater than 20–25 %, and TDSa of at least 6 cm/s at minimal ECMO flow support, while indices of LV-filling pressure (mitral E wave and TDI diastolic velocities) did not discriminate between ultimately weaned and not-weaned patients. In a more recent study of 22 patients undergoing load manipulations with the same weaning protocol, we demonstrated that unlike strain rate imaging measurements, TDSa was a load-independent marker of LV systolic function and may therefore be a more pertinent parameter for predicting successful ECMO weaning [13].

In a series of 21 patients, Cavarocchi et al. [14] evaluated a four-stage strategy—baseline (stage 1), half ECMO blood flow (stage 2), minimal ECMO flow and volume challenge (stage 3), and inotropic challenge (stage 4)—under continuous monitoring of heart rate, blood pressure, and RV and LV function under transesophageal echocardiography. ECMO was removed if both LV and RV functions tolerated volume challenge and demonstrated inotropic reserve. If LV or RV distension or significant hypotension occurred, the weaning trial was stopped and the ECMO support was returned to full flow. Although of potential interest, this strategy required IV sedation to tolerate transesophageal echocardiography throughout the weaning attempt (i.e., for several hours) and involved subjective assessment of RV and LV recovery.

Lastly, reporting on a small series of six VA-ECMO patients, Affronti et al. [15] suggested that pretreatment with levosimendan reduced the need for high-dose inotropes and facilitated weaning.

Conclusion

Successful weaning from VA-ECMO depends on the reversibility of the underlying cause of CS, comorbidities, and severity of organ dysfunction at ECMO initiation. A simple strategy based on a weaning trial consisting in ECMO blood flow reduction should be performed daily in patients with potentially reversible cardiomyopathy, as soon as they are hemodynamically stable and have recovered a pulsatile flow. Doppler echocardiography parameters were the most robust predictors of successful weaning in this setting. The proposed algorithm is largely empirical. Further prospective studies on larger populations of VA-ECMO patients are now needed to validate these simple and easy-to-acquire Doppler echocardiography parameters as predictors of subsequent ECMO-weaning success, and to explore the role of pharmacologic agents such as levosimendan in VA-ECMO patients recovering from severe CS.

Conflicts of interest The authors have no conflicts of interest to disclose.

References

1. Abrams D, Combes A, Brodie D (2014) What's new in extracorporeal membrane oxygenation for cardiac failure and cardiac arrest in adults? Intensive Care Med 40:609–612
2. Ghodsizad A, Koerner MM, Brehm CE, El-Banayosy A (2014) The role of extracorporeal membrane oxygenation circulatory support in the crash and burn patient: from implantation to weaning. Curr Opin Cardiol 29:275–280
3. Aissaoui N, Luyt CE, Leprince P, Trouillet JL, Léger P, Pavie A, Diebold B, Chastre J, Combes A (2011) Predictors of successful extracorporeal membrane oxygenation (ECMO) weaning after assistance for refractory cardiogenic shock. Intensive Care Med 37:1738–1745
4. Combes A, Leprince P, Luyt CE, Bonnet N, Trouillet JL, Leger P, Pavie A, Chastre J (2008) Outcomes and longterm quality-of-life of patients supported by extracorporeal membrane oxygenation for refractory cardiogenic shock. Crit Care Med 36:1404–1411

5. Smedira NG, Moazami N, Golding CM, McCarthy PM, Apperson-Hansen C, Blackstone EH, Cosgrove DM 3rd (2001) Clinical experience with 202 adults receiving extracorporeal membrane oxygenation for cardiac failure: survival at 5 years. J Thorac Cardiovasc Surg 122:92–102
6. Rastan AJ, Dege A, Mohr M, Doll N, Falk V, Walther T, Mohr FW (2010) Early and late outcomes of 517 consecutive adult patients treated with extracorporeal membrane oxygenation for refractory postcardiotomy cardiogenic shock. J Thorac Cardiovasc Surg 139:302–311
7. Sheu JJ, Tsai TH, Lee FY, Fang HY, Sun CK, Leu S, Yang CH, Chen SM, Hang CL, Hsieh YK, Chen CJ, Wu CJ, Yip HK (2010) Early extracorporeal membrane oxygenator-assisted primary percutaneous coronary intervention improved 30-day clinical outcomes in patients with ST-segment elevation myocardial infarction complicated with profound cardiogenic shock. Crit Care Med 38:1810–1817
8. Chen YC, Tsai FC, Chang CH, Lin CY, Jenq CC, Juan KC, Hsu HH, Chang MY, Tian YC, Hung CC, Fang JT, Yang CW (2011) Prognosis of patients on extracorporeal membrane oxygenation: the impact of acute kidney injury on mortality. Ann Thorac Surg 91:137–142
9. Distelmaier K, Winter MP, Rutzler K, Heinz G, Lang IM, Maurer G, Koinig H, Steinlechner B, Niessner A, Goliasch G (2014) Serum butyrylcholinesterase predicts survival after extracorporeal membrane oxygenation after cardiovascular surgery. Crit Care 18:R24
10. Li C, Wang H, Jia M, Ma N, Meng X, Hou X (2014) The early dynamic behavior of lactate is linked to mortality in postcardiotomy patients with extracorporeal membrane oxygenation support: a retrospective observational study. J Thorac Cardiovasc Surg 24:S0022–S5223
11. Luyt CE, Landivier A, Leprince P, Bernard M, Pavie A, Chastre J, Combes A (2012) Usefulness of cardiac biomarkers to predict cardiac recovery in patients on extracorporeal membrane oxygenation support for refractory cardiogenic shock. J Crit Care 27:7–14
12. Schmidt M, Zogheib E, Rozé H, Repesse X, Lebreton G, Luyt CE, Trouillet JL, Bréchot 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
13. Aissaoui N, Guerot E, Combes A, Delouche A, Chastre J, Leprince P, Leger P, Diehl JL, Fagon JY, Diebold B (2012) Two-dimensional strain rate and Doppler tissue myocardial velocities: analysis by echocardiography of hemodynamic and functional changes of the failed left ventricle during different degrees of extracorporeal life support. J Am Soc Echocardiogr 25:632–640
14. Cavarocchi NC, Pitcher HT, Yang Q, Karbowski P, Miessau J, Hastings HM, Hirose H (2013) Weaning of extracorporeal membrane oxygenation using continuous hemodynamic transesophageal echocardiography. J Thorac Cardiovasc Surg 146:1474–1479
15. Affronti A, di Bella I, Carino D, Ragni T (2013) Levosimendan may improve weaning outcomes in venoarterial ECMO patients. ASAIO J 59:554–557