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Review

Veno-arterial-ECMO in the intensive care unit: From technical aspects to clinical practice

Arthur Le Gall [a,d,e], Arnaud Follin [a,c], Bernard Cholley [a,c], Jean Mantz [a,c], Nadia Aissaoui [b,c], Romain Pirracchio [a,c,*]

[a] Anaesthesiology and Intensive Care Department, European Hospital Georges-Pompidou, Paris, France
[b] Medical Intensive Care Unit, European Hospital Georges-Pompidou, Paris, France
[c] Paris Descartes University, Sorbonne Paris Cité, Paris, France
[d] INRIA Paris-Saclay University, Palaiseau, France
[e] LMS, Paris-Saclay University, Palaiseau, France

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ABSTRACT

The use of veno-arterial extracorporeal membrane oxygenation (VA-ECMO) as a salvage therapy in cardiogenic shock is becoming of current practice. While VA-ECMO is potentially a life-saving technique, results are sometimes mitigated, emphasising the need for selecting the right indication in the right patient. This relies upon a clear definition of the individual therapeutic project, including the potential for recovery as well as the possible complications associated with VA-ECMO. To maximise the benefits of VA-ECMO, the basics of extracorporeal circulation should be perfectly understood since VA-ECMO can sometimes be detrimental. Hence, to be successful, VA-ECMO should be used by teams with sufficient experience and initiated after a thorough multidisciplinary discussion considering patient's medical history, pathology as well the anticipated evolution of the disease.

1. Introduction

Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) or extracorporeal life support (ECLS) are two terms that designate devices originally created to replace heart and lung functions. Both denominations are synonymous and we will keep the term "VA-ECMO" throughout this review for the sake of consistency. While VA-ECMO was initially dedicated to cardiac surgery (i.e. cardiopulmonary bypass), technical evolutions such as pump miniaturisation, better circuit biocompatibility and easier cannulation have enabled this technique to enter the intensive care unit (ICU). VA-ECMO was tested in various indications [1–7]. Nevertheless, because of inconsistent success rates [1–7], significant complications, and high-related costs, it is of paramount importance to accurately identify the patients in whom VA-ECMO may be reasonably initiated.

The goal of this article is to describe some key technical aspects of VA-ECMO, to present a literature overview on the use of VA-ECMO in critically ill patients and ultimately to help the intensivist to identify the appropriate indications for VA-ECMO.

2. Principles and technical aspects

The principle is directly derived from extracorporeal circulation techniques used during cardiac surgery (Table 1). Venous deoxygenated blood is mechanically suctioned, from a large central vein through a venous cannula, by a centrifugal pump. It is then oxygenated, warmed and restored into systemic circulation through an arterial cannula. Hence, VA-ECMO is used to assist the heart by insuring part or all the systemic blood flow (Fig. 1).

2.1. Vascular access – peripheral versus central VA-ECMO

Among VA-ECMO circuits, a distinction has to be made between those inserted centrally or peripherally.

* Corresponding author at: Department of Anaesthesia and Critical Care Medicine, Hôpital Européen Georges-Pompidou, 20, rue Leblanc, 75015 Paris, France.
E-mail address: romain.pirracchio@aphp.fr (R. Pirracchio).

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Table 1
Summary of studies per VA-ECMO indication.

Authors	Year	Type	Cohort size	VA-ECMO Sample size	Mortality	Favouring treatment
Acute coronary syndrome						
Fujimoto [64]	2001	Retrospective, observational		9 pts	56%	Not given
Chen [63]	2006	Prospective, observational		36 pts	33%	Not given
Sheu [65]	2010	Retrospective, observational	71 pts	46 pts	72%	No
Cardiac arrest						
Chen [88]	2003	Retrospective, observational		57 pts	68%	Not given
Sung [89]	2006	Retrospective, observational		22 pts	54%	Not given
Megarbane [2]	2007	Prospective, observational		17 pts	86%	Not given
Ruttmann [90]	2007	Retrospective, observational	59 pts	25 pts	72%	Not given
Chen [1]	2008	Propensity-matched	172 pts	46 pts	67%	No
Chen [91]	2008	Retrospective, observational		135 pts	66%	Not given
Lin [48]	2010	Propensity-matched	118 pts	27 pts	71%	No
Le Guen [92]	2011	Prospective, observational		59 pts	96%	Not given
Liu [93]	2011	Retrospective, observational		11 pts	64%	Not given
Shin [94]	2011	Propensity-matched	406 pts	60 pts	68%	Yes
Avalli [46]	2012	Retrospective, observational		42 pts	74%	Not given
Haneya [95]	2012	Retrospective, observational		85 pts	66%	Not given
Sakamoto [3]	2012	Retrospective, observational		64 pts	72%	Not given
Wu [96]	2012	Retrospective, observational		40 pts	65%	Not given
Leick [97]	2013	Retrospective, observational		28 pts	61%	Not given
Maekawa [98]	2013	Propensity-matched	162 pts	24 pts	69%	Yes
Schopka [50]	2013	Retrospective, observational		103 pts	72%	Not given
Chou [47]	2014	Retrospective, observational	66 pts	43 pts	65%	No
Johnson [99]	2014	Prospective, observational		26 pts	85%	Not given
Kim [100]	2014	Propensity-matched	499 pts	52 pts	85%	No
Park [49]	2014	Retrospective, observational		152 pts	68%	Not given
Sakamoto [101]	2014	Prospective, observational	454 pts	260 pts	88%	Yes
Sawamoto [53]	2014	Retrospective, observational		26 pts	62%	Not given
Wang [102]	2014	Prospective, observational		230 pts	68%	Not given
Han [103]	2015	Retrospective, observational		37 pts	81%	Not given
Choi [51]	2016	Propensity-matched	36,227 pts	320 pts	82%	No
De Chambrun [59]	2016	Retrospective, observational		94 pts	73%	Not given
Bougouin [60]	2017	Retrospective, observational		52 pts	73%	No
Lamhaut [52]	2017	Prospective, observational	156 pts	156 pts	87%	Not given
Fulminant myocarditis						
Maejima [68]	2004	Retrospective, observational		8 pts	25%	Not given
Rajagopal [67]	2010	Retrospective, observational		255 pts	39%	Not given
Mirabel [4]	2011	Retrospective, observational		41 pts	34%	Not given
Septic myocarditis						
Bréchot [5]	2013	Retrospective, observational		14 pts	39%	Not given
Huang [70]	2013	Retrospective, observational		52 pts	85%	Not given
Park [71]	2015	Retrospective, observational		32 pts	81%	Not given
Post-cardiotomy						
Doll [6]	2004	Prospective, observational		219 pts	76%	Not given
Rastan [72]	2009	Prospective, observational		517 pts	75%	Not given
Ma [15]	2014	Retrospective, observational		54 pts	61%	Not given
Primary graft dysfunction						
Mihaljevic [77]	2010	Prospective, observational		53 pts	57%	Not given
Listijono [7]	2011	Retrospective, observational	124 pts	17 pts	18%	No
Stehlik [73]	2011	Retrospective, observational	10,271 pts	180 pts	RR = 3.32	No
Hartwig [76]	2012	Prospective, observational		28 pts	18%	Not given
Lima [78]	2015	Prospective, observational		11 pts	67%	Not given
Bridge to destination therapy						
Pagani [79]	1999	Retrospective, observational		14 pts	50%	No
Chung [80]	2009	Retrospective, observational		31 pts	39%	Not given
Marasco [81]	2015	Retrospective, observational	58 pts	23 pts	13%	Not given

VA-ECMO: veno-arterial extracorporeal membrane oxygenation; pts: patients; RR: relative risk.

2.1.1. Peripheral ECMO

The typical configuration for peripheral VA-ECMO involves blood drainage from a femoral venous access and reinfusion through a femoral arterial cannula. With this configuration, the reinfusion cannula generates a retrograde flow up in the aorta that may encounter the anterograde flow generated by the left ventricle [8].

For peripheral VA-ECMO configurations, percutaneous ultrasound guided femoro-femoral access is usually a quick and efficient way of insertion [9], even though it can become more difficult in case of profound arterial hypotension or haemostasis disorders for instance. The alternative is a surgical insertion that allows for a direct visualisation of the vessels as well as a simultaneous insertion of the reperfusion cannula (see below) but depends upon the availability of the surgical team.

Whatever the insertion technique chosen, peripheral VA-ECMOs carries specific complications. First, peripheral VA-ECMO may lead to an obstruction of the common femoral artery that can cause lower limb ischemia [10–13]. It is thus advised to place a reperfusion catheter in the ipsilateral superficial femoral artery [11]. Another drawback of peripheral VA-ECMO is the competition between the retrograde flow generated by the VA-ECMO and the native anterograde flow [8]. This competition may induce or worsen 2 types of complications: