

Extracorporeal Membrane Oxygenation in Adults: A Brief Review and Ethical Considerations for Nonspecialist Health Providers and Hospitalists

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Given the pace, distribution, and uptake of technological innovation, patients experiencing respiratory failure, heart failure, or cardiac arrest are, with greater frequency, being treated with extracorporeal membrane oxygenation (ECMO). Although most hospitalists will not be responsible for ordering or managing ECMO, in-hospital healthcare providers continue to be a vital source of patient referral and, accordingly, need to understand the rudiments of these technologies so as to co-manage patients, counsel families, and help ensure that the provision of ECMO is consistent with patient preferences and appropriate goals

of care. In an effort to prepare hospitalists for these clinical responsibilities, we review the history and technology behind modern-day ECMO, including venoarterial extracorporeal membrane oxygenation (VA-ECMO) and venovenous extracorporeal membrane oxygenation. Building upon that foundation, we further highlight special ethical considerations that may arise in VA-ECMO, and present an ethically grounded approach to the initiation, continuation, and discontinuation of treatment. *Journal of Hospital Medicine* 2014;9:808–813. © 2014 Society of Hospital Medicine

As the distribution and utilization of technology in critical care medicine expands, patients experiencing respiratory failure, heart failure, or cardiac arrest are increasingly being treated with extracorporeal membrane oxygenation (ECMO). Although not customarily responsible for managing ECMO, hospitalists need to understand the rudiments of this technology and its associated ethical issues to assure that ECMO use is consistent with patient preferences and goals of care. This review aims to help prepare hospitalists for these clinical responsibilities. Following a brief review of modern-day ECMO, including both venoarterial extracorporeal membrane oxygenation (VA-ECMO) and venovenous extracorporeal membrane oxygenation (VV-ECMO), we highlight special ethical considerations that may arise with VA-ECMO and present an ethically grounded approach to the initiation, continuation, and discontinuation of treatment.

Many of the questions regarding the use of ECMO will be familiar. Certainly, similar questions arise with other life-sustaining therapies; however, the general

hospitalist may be a bit unfamiliar with ECMO and its unique ethical challenges. For example, ECMO is only provided transiently and generally while patients are in an intensive care unit. Unlike mechanical ventilation, which may be provided long-term via tracheostomy, there is no comparable, enduring form of ECMO. Next, patients requiring ECMO are utterly dependent on the machine for their survival. If they do not recover and are not candidates for a ventricular assist device (VAD) or transplantation, there are no other therapies to offer. In this scenario, terminal discontinuation is the only option.

Informed hospitalists, who bring to counseling sessions both an understanding of the patient and family, and technical knowledge and background information on ECMO, will be far better equipped to help patients and families facing these difficult choices. As the use of ECMO becomes more prevalent, hospitalists must be prepared to address questions related to this evolving technology.

TECHNICAL AND HISTORICAL BACKGROUND

Extracorporeal life support (ECLS) involves the use of mechanical devices when native organ function fails.¹ ECMO involves the application of ECLS to provide a replacement form of cardiac and/or pulmonary function. An illustrative figure of the ECMO circuit may be seen at The Extracorporeal Life Support Organization (ELSO) (<http://www.elsonet.org>). ECMO is similar to a cardiopulmonary bypass machine.² Venous blood is drained from the body via catheters implanted through either transthoracic or percutaneous cannulae into the

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circuit where gas exchange occurs across a semipermeable membrane. Oxygenated blood is then returned to circulation.³ There are 2 types of ECMO. VA-ECMO replaces native cardiac function and is generally used for patients with heart failure. Here, oxygenated blood is mechanically pumped back into the arterial circulation, bypassing the diseased heart.⁴ With VV-ECMO, generally used for patients with respiratory failure but intact cardiac function, oxygenated blood is returned to venous circulation for the patient's own heart to circulate.⁵ Patients on ECMO receive systemic anticoagulation to prevent thromboembolic complications. Major complications include stroke (1%–11%), bleeding (7%–34%), thrombosis (8%–17%), and infection.⁶ A detailed description of the different ECMO machines and circuitry, the indications for ECMO, and the outcomes including rates of complications are beyond the scope of this article, but available in several review articles.^{5–8}

Encouraging outcomes of clinical trials have ushered in enthusiasm for adult ECMO in the United States.⁹ For example, the Conventional Ventilation or ECMO for Severe Adult Respiratory Failure (CESAR) trial, a prospective study of adult VV-ECMO for respiratory failure conducted in the United Kingdom from 2001 to 2006, demonstrated a measurable survival benefit. Patients with severe adult respiratory failure randomized to an ECMO center (75% received ECMO) had a 63% 6-month survival without severe disability, versus 47% for patients managed conventionally at a tertiary care center.¹⁰ Similarly, data from the 2009 H1N1 flu virus epidemic in Australia and New Zealand suggested a benefit when patients with acute respiratory distress syndrome, who had failed mechanical ventilation, were treated with ECMO; 76% survived, which was an improvement over previously reported mortality rates of 30% to 48%.¹¹

With respect to VA-ECMO, recent studies and case reports out of Taiwan, Germany, and France propose a survival benefit when ECMO is used in patients with cardiac failure.^{12–15} Patients with in-hospital cardiac arrest refractory to cardiopulmonary resuscitation (CPR) in Taiwan had close to a 20% increase in survival to hospital discharge when treated with VA-ECMO.¹² A retrospective study of 1764 patients who had cardiac surgery from 2002 to 2006 in Taiwan demonstrated that, of the nearly 3% who required ECMO for postoperative cardiogenic shock, 53% were successfully weaned from ECMO and had a 1-year survival approaching 30%.¹³ A 2003 to 2006 study of 5750 patients undergoing cardiac surgery in Germany found that of the 0.8% of patients requiring VA-ECMO for refractory cardiogenic shock, 29% survived to discharge, and 22% were alive at 1 year.¹⁴ In France, among 81 patients who received ECMO for refractory cardiogenic shock from 2002 to 2006, 42% survived to hospital discharge.¹⁵

The survival benefit associated with adult ECMO is thought to stem both from improvements in circuit design (advancements in the pump and oxygenator), as well as from better patient selection. Further, antithrombotic circuit tubing has allowed for lower levels of anticoagulation and less risk of fatal bleeding.¹⁶ According to the ELSO, a group that maintains an active registry of data from medical centers providing ECMO, in 2013 there were approximately 223 ECMO centers, a significant increase from the 83 centers present in 1990; there were nearly 4400 ECMO cases (all ages) in 2013.¹⁷

Although the number of physicians, patients, and families who consider ECMO as a treatment option have all expanded considerably in recent years and continue to rise, the use of the technology is often discretionary, and decisions as to whether and when to initiate and discontinue ECMO are not always clear-cut either clinically or ethically.

TREATMENT WITH ECMO

Typically ECMO is initiated not as a treatment itself, but rather as a means to support a patient with cardiopulmonary failure, in order to “buy time”. Time for an intervention that may serve to fix the underlying organ defect, or time to allow the organ to heal on its own. As such, ECMO is often considered either a bridge to recovery or a bridge to a definitive and longer-term treatment option (ie, VAD, heart or lung transplantation).^{16,18} ECMO is especially valuable given that the mechanical oxygenation and perfusion provide time for additional workup and intervention, which would not otherwise be feasible for a patient suffering from acute cardiopulmonary collapse.

There are 3 possible clinical outcomes for patients treated with ECMO: (1) native cardiopulmonary recovery and successful weaning off ECMO; (2) failure to recover, with ECMO serving as a bridge to a longer-term circulatory support device or heart or lung transplantation; or (3) death.

Presently, ECMO may only be provided in an intensive care setting and only temporarily. Patients on VV-ECMO may be maintained on the machine for weeks to months in some cases, and may be awake, walking, and talking, potentially allowing for these individuals to directly participate in discussions about goals of care.^{19,20} In contrast, adult patients on VA-ECMO historically have only been maintained for days to weeks on the machine, intubated and typically sedated, making their participation in goals of care discussions generally more difficult, if not impossible.⁷ As collective expertise in adult VA-ECMO grows, however, patients awaiting heart or heart/lung transplants are similarly finding support for longer periods of time, enabling wakefulness and the ability to participate in decision making. Generally speaking, if a patient on ECMO neither recovers nor is a candidate for a longer-term support device or transplantation,

TABLE 1. Ethical Issues Across the Venoarterial Extracorporeal Membrane Oxygenation Treatment Trajectory

Treatment Phase	Ethical Issues	Suggested Ethical Theories
Initiation	Informed consent	Emergency presumption Goals of Care Proportionality
	Religious or cultural objection to terminal discontinuation of life-sustaining therapy	Preventive ethics Justice Proportionality
Continuation	On-going consent	Goals of care Proportionality Autonomy
Discontinuation	Informed consent	Goals of care Autonomy
	Futility disputes	Preventive Ethics Respect for persons Mediation
	Religious or cultural objection to terminal discontinuation of life-sustaining therapy	Proportionality Goals of care

the risks of thromboembolic and infectious complications from continuing the treatment will eventually outweigh any real benefit. Accordingly, ELSO recommends that ECMO “should be discontinued promptly if there is no hope for healthy survival (severe brain damage, no hope of heart or lung recovery, and no hope of organ replacement by VAD or transplant).”²¹

Given that approximately 32% of adults treated with ECMO for cardiac failure and 47% treated for respiratory failure will survive to hospital discharge, many patients and families will be forced to make difficult, end-of-life decisions with ECMO.²² ECMO is different from other life-sustaining therapy (LST), such as mechanical ventilation, in that it may only be provided in an intensive care setting. Furthermore, unlike patients who cannot wean from a ventilator and thus are transitioned to a tracheostomy, there is no long-term treatment option with ECMO. Terminal discontinuation is the sole option for patients on VA-ECMO who do not recover and are not candidates for VAD or transplantation.

The remainder of this article will examine the ethical issues that emerge with ECMO. We will focus more specifically on VA-ECMO, although certainly issues described and the guidance offered are relevant to VV-ECMO. VA-ECMO presents some unique issues, however, as patients are generally (although not uniformly) intubated, sedated, and thus incapacitated and unable to participate in goals of care discussions once treatment is initiated. Thus, the hospitalist can help ensure, preemptively, that the provision of VA-ECMO is consistent with patient preferences and goals of care. In addition, VA-ECMO is also unique in that some patients suffering from cardiac arrest refractory to cardiopulmonary resuscitation and

advanced cardiac life support may be successfully oxygenated and perfused with VA-ECMO; thus, VA-ECMO extends the boundaries of what we commonly consider to be the limits of cardiac resuscitation, perhaps suggesting a need to reframe do not resuscitate (DNR) discussions.

VA-ECMO: ETHICAL CONSIDERATIONS

Ethical concerns and difficult decisions may arise at any time during treatment with VA-ECMO. For teaching purposes, we have conceptualized the treatment trajectory as consisting of 3 phases: (1) initiation, (2) continuation, and (3) discontinuation, each with its own set of issues (Table 1). Clinically, however, each phase of treatment is intrinsically linked to the others, and in reality clinicians must look forward, anticipate upcoming decisions to the extent possible, and prepare families for what lies ahead. Before we attend to each phase, we will briefly review who makes these decisions.

Who Decides?

Central to contemporary Western medicine is the principle of autonomy, manifested in most medical encounters as allowing patients to decide for themselves what should be done to and for them.²³ When patients are incapacitated, however, others must decide for them. Physicians must be prepared to guide families, with limited knowledge and familiarity with VA-ECMO, through this process, providing information so that they truly can make informed decisions.²⁴

In the absence of a patient-designated healthcare agent or proxy, we turn to the surrogate of highest priority to assist with decision making. Although this may vary by jurisdiction, the typical hierarchy for surrogate decision making is as follows from highest to lowest priority: a court-appointed guardian or committee, a spouse or domestic partner, an adult son or daughter (>18 years old), a parent, a sibling, and then other relatives or close friends.²⁵ It should be noted that all adult children, regardless of age or birth order, should have equal standing as surrogate decision makers. In addition, if the surrogate of highest priority is unavailable or unwilling to make decisions, he or she may not simply delegate decision making to another person; we instead turn to the next individual in the hierarchy presented above.

Initiation of VA-ECMO

VA-ECMO is often initiated in emergencies, leaving little time for customary informed consent prior to treatment. Given that the need for VA-ECMO might be anticipated earlier in the course of illness, however, in patients with chronic heart failure, those undergoing heart surgery, or those at risk for myocardial infarction, there may be an opportunity to initiate the consent process earlier. When possible, for patients or for families/surrogates, the consent process should

include a full discussion of the risks, benefits, and goals of the VA-ECMO, to allow for consideration of both the benefits and burdens of this treatment. This process should occur in conjunction with an exploration of goals of care and current or prior expressed wishes about medical and/or end-of-life care. As such, the hospitalist, particularly a hospitalist who may have had a longitudinal relationship with the patient, is integral to this process.

The hospitalist can help patients to clarify goals of care and elucidate whether a trial of VA-ECMO, should it be medically indicated, is consistent with goals and wishes. Anticipating the need for ECMO and discussing it in advance will be advantageous, regardless of the ultimate decision, for if the patient loses capacity at any point during the course of treatment, documentation from these prior discussions about goals of care and attitudes toward various treatment modalities may serve as an advance directive to guide treatment decisions. Looking forward, as the use of VA-ECMO becomes increasingly more commonplace, discussions about advance directives may expand accordingly, routinely integrating discussions of VA-ECMO as a vital topic for consideration and reflection.

Continuation of VA-ECMO

Once a patient is stabilized on VA-ECMO, an opportunity emerges to engage in more comprehensive discussions about prognosis, treatment benefit and burdens, and goals of care. If VA-ECMO was started emergently, there may not have been an opportunity to obtain informed consent prior to treatment initiation, and this vital task must now be assumed. Regardless of the circumstances, once VA-ECMO is underway, we recommend that physicians regularly engage in discussions of on-going consent.

We find this term to be helpful as a reminder that, although the patient is already receiving treatment, frequent discussions regarding prognosis, burdens and benefits of treatment, and goals of care remain essential. Clinically, it is important to monitor cardiopulmonary recovery and also renal function and neurologic status. As previously discussed, VA-ECMO will not serve to fix the underlying cardiopulmonary pathology, and in fact, complications related to VA-ECMO may be expected to grow over time.⁷ Proportionality, a careful analysis of the benefits of continuing treatment, balanced with the risks and burdens imposed, will allow for thoughtful consideration about whether continuation is in the patient's best interest and consistent with the goals of care.

Discontinuation of VA-ECMO

Three primary clinical indications may prompt the recommendation to discontinue VA-ECMO: (1) there may be sufficient recovery and cardiopulmonary support is no longer needed, (2) there may be insufficient

recovery with plans to transition to a VAD or transplantation, (3) or there may be insufficient recovery and recommendation for terminal discontinuation.

The procedure for discontinuing VA-ECMO may vary with the clinical circumstances and institution. To anticipate the likely outcome with VA-ECMO removed, prior to decannulation (the removal of the ECMO cannulas), support might be weaned down with echocardiography used to assess cardiac function. Should indications point to decannulation, this process may take place in the operating room or catheters may be removed at the bedside.⁷ In cases of terminal discontinuation, the VA-ECMO may be stopped (assuming the patient is adequately sedated), the patient will then be allowed to die, with the cannulas subsequently removed.

Analogous to discontinuation of other cardiac devices, such as a pacemaker or defibrillator, ceasing VA-ECMO may result in: (1) no clinical consequences, as the patient has recovered sufficiently; (2) immediate declaration of death; or (3) the emergence of new symptoms, for example symptoms of heart failure, which may precede death.²⁶ So as to prospectively account for this variability, a full discussion of the rationale behind discontinuation, as well as the range of expected outcomes, should precede cessation. Similarly, clinicians should implement a plan for symptom management and palliation. In cases of expected recovery, a contingency plan should be developed in case the patient unexpectedly decompensates upon or shortly after cessation. In sum, it remains essential to understand the prospective course, as the lack of anticipatory planning may precipitate confusion, distress, and conflict for patients, family members, and the clinical team.

DNR on VA-ECMO?

Hospitalists accustomed to writing DNR orders may be distressed to find that, in our opinion, DNR orders are not appropriate for patients who are maintained on VA-ECMO.⁹ (It should also be noted that patients on VV-ECMO, a device that only provides pulmonary function, could suffer a cardiac arrest necessitating CPR; thus, DNR may be relevant in this clinical context.) VA-ECMO provides more effective oxygenation and perfusion than traditional advanced cardiac life support with CPR. Thus patients on VA-ECMO will generally not receive CPR and, consequently, there is effectively no clinical meaning to a DNR order for a patient on VA-ECMO. That said, when discontinuing VA-ECMO (and at times VV-ECMO), depending on the goals of care, a DNR may be useful to prevent further aggressive treatment should the patient arrest following cessation of ECMO.

The clinician will be wise to recognize that if families request a DNR order for a patient on VA-ECMO, they are asking for something. Although a request not to resuscitate may not make medical sense in this

context, clinicians must take the time to explore what is intended by this request. For many families, DNR is a stepping stone toward de-escalation of treatment and a first move toward withdrawal of life-sustaining therapies.^{27,28} A nuanced understanding of what a family hopes to accomplish by the suggested order, and specifically whether and how goals of care may have changed, is vital toward the maintenance of an appropriate, timely, and evolving treatment plan.

Terminal Discontinuation of VA-ECMO

Among clinical ethicists, some of the most distressing conversations and meetings we have had with families have emerged in the context of terminal discontinuation of VA-ECMO. Unlike mechanical ventilation, which theoretically may be continued indefinitely via tracheostomy, VA-ECMO is only a temporary measure and, according to ELSO, should “be discontinued promptly if healthy survival” is not anticipated with “the possibility of stopping for futility explained to the family before ECLS is begun.”²¹ Given the time constraints for what may have been an emergency procedure, and given the frequent reluctance of families and surrogates to discontinue life-sustaining therapies, how does a clinician or institution ethically enact these guidelines? With respect to practical guidance, we offer 3 suggestions for directing these conversations.

First, we suggest physicians discuss the possibility and potential rationales of terminal discontinuation early and often, ideally as part of the initial consent process. Second, informed consent conversations should address potential complications (stroke, hemorrhage, and thrombosis) and their sequelae alongside discussions with patients and surrogates about their wishes in the context of such an event. Finally, we also recommend frequently revisiting the goals of care with the surrogate throughout the course of treatment.²⁸ Thus, when goals of care can no longer be achieved by continuing VA-ECMO, either: (1) because the patient has no chance for recovery; (2) because VA-ECMO no longer serves its intended purpose; or (3) owing to harm from complications, families may be able to appreciate that continuation of the intervention has become ethically disproportionate, and ECMO is now more burdensome than beneficial. Continuous and open dialogue should build a strong foundation of trust and knowledge that allows the surrogate to understand and accept the rationale behind a recommendation to terminally discontinue treatment, should the clinical course necessitate such.²⁹

CONCLUSION

With indications for and utilization of ECMO in adult patients expanding, hospitalists may be expected to encounter these technologies with greater frequency and guide patients and families with medical decision-

making. Although the ethical issues reviewed are certainly not exclusive to ECMO, specific facets of ECMO, as discussed, may precipitate unique challenges or exacerbate common ones. Hospitalists can help to uphold patient autonomy by providing information that enables patients and surrogates to actively participate in goal setting and decision-making. As the utilization of this technology grows, further research will need to address decision-making in the context of ECMO to ensure that the process remains optimally patient- and family-centered.

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